Department of Interior North Central Climate Science Center Foundational Science Area FY'13 activities

NORTH CENTRAL CLIMATE SCIENCE CENTER

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1. Introduction to Foundational Science Areas of ReVAMP

This document builds on the Foundational Science Area implementation plan to describe the specific activities within the three foundational science areas using FY'13 funds, but extending to work through 2015. In addition, recent discussions with stakeholders and partner agencies highlight the broad concern over drought events faced across the region provided a central theme to address across the region for these research activities.

The North Central Climate Science Center efforts have been framed as a Resource for Vulnerability, Adaptation, and Mitigation Planning (ReVAMP). **The vision for the NC CSC is a coordinated and integrated regional science approach for the management of the nation's land, water, fish and wildlife, and cultural heritage -- resources that utilize the best possible understanding of past, present, and future climate to inform decision processes.** The NC CSC is working to provide the understanding and information needed by decision makers and managers in the region so that a more complete understanding of potential impacts and adaptation strategies for a broad range of natural, cultural, energy, and other resource management activities will be available.

In the 2013 to 2015 time frame the NC CSC will develop and document the management framework, client service model, and decision support system(s) for ReVAMP. Work within the foundation science areas will provide the scientific basis for those activities.

The National Research Council (2009) suggests that government agencies organize their climate-related decision support efforts around six principles:

1) begin with user's need in mind (decision makers, communities, and other stakeholders)
2) give priority to process over products
3) link information producers and users
4) build connections across disciplines and organizations
5) seek institutional stability and
6) design-process for learning.

The objective of ReVAMP is to develop a regional resource for managers to access and utilize the best available climate science and synthesis to inform their strategic planning and management decisions. The NC CSC staff with the foundational science team will take the lead on defining and operationalizing the ReVAMP. This development will include close collaboration with the funded NC CSC projects and this collaboration will be facilitated through a set of activities and access to research tools and analyses. These include:

- A team approach (including land managers and scientists from the funded projects, representatives from the foundation science areas, and NC CSC staff)
- Easy access to a full suite of climate data
- Transparency on input data and modeling procedure
- Visual output to reveal climate contribution to ecological model and/or management simulation results and
- The ability to quickly explore "what if" scenarios

Fundamental Science for the ReVAMP

The ReVAMP concept will serve as a centralizing theme to coordinate research done through the NC CSC and will also provide the mechanism by which the NC CSC can help serve stakeholder needs (NC CSC Science Strategy, 2013). The NCUC efforts are organized around three foundation research themes, which are meant to form an integrated approach to inform resource managers and researcher in our region:

- Understanding and quantifying drivers of regional climate changes,
- Assessing impacts of climate change on the natural resources of the region and the resulting vulnerability of social-ecological system components, initial activity will be focused on ecosystem elements with development of strategy to expand to the integrated system; and
- Characterizing vulnerabilities, adaptive capacity, and management response options of communities and natural resource

The Foundational Science Areas as described in the ReVAMP framework provide a rationale for integrated science delivery to scientific and management communities across our region. The overall goal of the ReVAMP activity is to develop a platform to enhance integration across the foundational areas and to facilitate the synthesis and integration of research approaches and tools to understand and to respond to climate change effects on natural resources in our region.

In order to implement this framework, a focal research theme will be used to structure the integration and cross-linkages across the foundational areas and to serve as a vehicle to engage the funded research projects. Across the north central domain, a dominant climate feature affecting natural resources is drought, and the funded projects of the NC CSC have aspects of drought impacts to consider within their projects. The joint research activities will work toward the development of an analytical framework and information to determine the various underlying climate factors leading to drought conditions and how these may be different in the future, evaluating the impacts and consequences of different drought situations affecting different management decisions across our domain, and to assess adaptive capacities and response strategies in the management communities. This 2013-2015 implementation plan builds on that foundation and describes some explicit activities that help extend the foundational science areas and establish the ReVAMP concept.

The proposed centralizing drought theme for the foundation science areas for 2013-2015 is an effort to provide a synthesis on drought across the domain and to develop a climate science guidance document on how science integration across the foundational areas (i.e., climate, impacts, and adaptation) need to be carried out to meet research and management needs. This set of activities will also contribute to our further understanding of how drought comes about, how impacts are manifested, the drought response capacities of DOI managers, and what considerations need to be included in understanding and informing local or regional response strategies to adapt to these climate stressors. This effort will contribute to the development of ReVaMP as well as to its implementation. Based on this document, the funding here will support a coordinated drought analysis incorporating aspects of the foundational areas and provide guidance to the funded projects regarding drought related climate characteristics, impacts, and development of response options.

The currently funded projects include:

1. White Bark Pine management strategies in the Greater Yellowstone Area
2. Surrogate species for wetland-dependent birds in the prairie pothole region
3. Building Social-Ecological-Climate System Resilience in Southwestern Colorado

(Detailed information for each project will be posted on the NC CSC web site upon final negotiation.)

Each of these funded projects represents different drought considerations and will serve as useful case studies for the foundational science areas to develop integrative analytical tools to address their considerations. For instance, the Montana case in the Greater Yellowstone area faces periods of extended drought due to reduced precipitation levels and increased warming resulting in reduced soil moisture conditions. This reduction in soil moisture during the white bark pine growing season has contributed to an increased vulnerability to pine bark beetle and other pathogens affecting this population of trees. In the other projects, drought conditions have some similar, but some differently expressed drought characteristics, impacts and management capacities and responses. The response strategies in these areas will also be developed differently due not only to the natural resource impact, but due to the social and institutional contexts and capacities of the respective management entities.

The role of the Foundational Science Teams in the NC-CSC differs from that of Funded Projects. The Teams will engage in the development the ReVamp framework to support the present and future activities of the NC-CSC through the collaborative development and integration of datasets, tools, and guidance. The Teams will provide synthesis of science, impacts and vulnerabilities, and adaptation management challenges and strategies across the NC-CSC region, and develop and document the use of these tools through interactions with the Funded Projects. We propose to focus many our team efforts on the theme of Drought: Drivers, Impacts, and Adaptation for the duration of this plan.

While the individual Funded Projects focus on specific management objectives, the Foundational Teams will work to generalize the methods and experience of individual management problems. The Adaptation Team, through the Drought Risk and Adaptation in the Interior (DRAI) project, will be documenting management-related issues across the NC-CSC in relation to drought. DRAI activities will inform the work of the Climate and Impacts teams, including an understanding of NC CSC science outcomes (e.g., data, tools, guidance documents, etc.) that would be helpful to managers. The Climate Team will benefit from the knowledge gained from the stakeholder networks in the funded projects as well as direct interaction with LCCs through conference calls and attendance at LCC-wide meetings.

Integrated Foundational Science Research Effort

A dominant climate feature across the north central region of the US is the recurrent drought conditions which affect the natural resource base across the region. Drought across the region has expressed itself in response to periods of low precipitation, to periods of extended elevated temperatures, or to a combination of these climate conditions. Future scenarios across the region suggest that temperature increases will exacerbate environmental conditions, which would lead to greater drought effects, through increased evapotranspiration, for example, despite the level of changes in

precipitation taking place. The notable exception is the Red River of the North area in North Dakota where saturated soils and increased spring rainfall have been leading to floods in recent years.

Given the pervasive nature of drought across most of the region and the complex interactions associated with climate conditions leading to drought, the differential sensitivity which different species and ecosystems express to these conditions, and the varied capacity to respond and to mange for drought we plan a set of coordinated research and analysis to better understand the nature and impacts of drought across the region.

The objectives are:

1) Evaluation and synthesis of climate conditions in different regions of the North Central domain which would lead to drought condition (e.g., extended heat conditions, extended periods of low, or a combination of both) and the large-scale climate drivers of these local conditions, evaluation of climate products that are related to drought (for example, evapotranspiration datasets), and synthesis of existing information on drivers of drought in the North Central domain.
2) Assess the sensitivity to the range of drought conditions (i.e., climate-related drought exposure) affecting biodiversity and ecosystems across the region.
3) Assess the range of adaptive capacities and response strategies of different managers.

2. Understanding and Quantifying Drivers of Regional Climate Changes

The 2013 activities of the climate team will focus on the climatic drivers of drought and related climatic processes in the North Central region. The drought focus will guide the climate team in its evaluation of recent climate conditions and in the development of various scenarios of future climate conditions across the region. The process of evapotranspiration will receive attention, including how it is derived from observed climate data and how it is represented in models. The future scenarios will encompass both anticipated warming trends and changes in precipitation patterns, as well as the large multi-decadal climate variability that is seen in this region. These climate scenarios will facilitate a more estimation of climate exposure related to a reduction in water availability across the region on seasonal, annual and multi-decadal time scales. This climate analyses will contribute to building the data-model framework for climate information, including the development of new datasets, the synthesis of existing knowledge, and the pursuit of focused research.

The overall goals of the climate team to build the data-model framework are:

- Integration across time scales: use of climate information at various historic and future scenarios to evaluate climate patterns contributing to drought.
- Salience at spatial scales: Development of a high-resolution historical evapotranspiration product and related indices, as well as the evaluation of other downscaled climate products for inclusion in ReVAMP.
- Credibility in modeling of climate processes: Evaluation of the processes that are represented in constructing historical evapotranspiration (ET) products and ET projections.

- Evaluation, comparison, and translational guidance in the use of products and in methods for including climate information into impacts studies: This goal includes the development of synthesis documents and user guidance for specific applications.
- Uncertainty and Risk: Integrating with impacts and adaptation team, incorporating knowledge from stakeholders, to guide the choice and use of climate information.

Climate Team funding to build on the existing work of the foundational science area, NCA, and the NCPP pilot projects

In 2012 the Climate Team funded three projects, a paleo-environmental database, downscaled climate products focused on evapotranspiration (ET), and ultra-high-resolution climate modeling. Because of the increased focus on drought, and also on more direct applicability of these projects to building ReVAMP, only the ET project will retain considerable funding. The paloe-environment database will transition to use in support of one if the impacts projects. A new integrative effort to support funded projects and the drought theme will be developed (see below).

Paleo-environment database

Dr. Whitlock is in the process of developing a paleo-environmental database as part of the previous year's funding. This dataset allows the evaluation of paleo-proxies to assess historical frequency of certain drought indicators in various regions of the domain. This information will serve as a long-term baseline of past drought events across the region. Climate reconstructions where available will provide additional information on the potential large-scale climate conditions. Dr. Whitlock is funded under the Whitebark Pine project to include a more detailed analysis of paleo-environmental proxies in that project, but will be available to consult with others in the climate team to develop other uses of this database.

Downscaled historical climate product with ET and other derived products

The "ET product" and database developed by Dr. Running will be brought to completion through directed funding in Year 2, with emphasis on integration into ReVAMP, interaction with funded projects and use by climate team. This will include enhancements to the ET and derived products.

Drought analysis and further integrative support with the three main funded projects and inform the ReVAMP concept.

Interaction of the Climate Team with the funded projects will entail the development of guidance for the selection of climate model projections and downscaled products. Analysis and interpretation of the water balance in historical and projected CMIP5 model output as well as downscaled products, and on the development of climate indicators relevant to management objectives in the funded projects. We will also work with Dr. Running's project to evaluate and integrate the use of their ET and related products in to the funded projects (through the ReVAMP framework). Detailed analysis of ET and climate conditions leading to drought conditions will be evaluated across the domain and are essential to connecting climatic drought to ecosystem stress across the region.

Specific collaborative goals include the following:

- Whitebark Pine (GYE) – Provide guidance on the use climate model output at appropriate scales (paleo - future), and downscaled projections and datasets. Identify gaps or areas for improvement in the climatic datasets for use in the impacts modeling for this project. Synthesize the climate literature on large-scale drivers of drought in this area.
- Southwest Colorado - work with scenario development, comparison and evaluation of downscaled climate products including hydrological simulations. Provide narratives that consider multiple sources of data, as appropriate, focusing on drought indicators that are relevant for this project.
- Surrogate Species – develop appropriate climate/drought indicators (in coordination with impacts and adaptation teams), and generate scenarios and narratives of future climate/drought, as appropriate for the management objectives of this project.

Conduct additional collaboration and activities to help meet the two objectives listed above.

The Climate Team will support a post-doctoral fellow at CU to focus on climate forcing related to evapotranspiration (ET) and drought in the NCCSC region from global climate models and downscaled data. A high priority will be the integration of wind and radiation information from observed data and climate models as predictors (in addition to temperature and precipitation). We will encourage co-mentoring from other NC-CSC consortium members.

The Team Lead (Dr. Barsugli) will be funded to collaborate with the climate, impacts and adaptation teams to develop guidance and synthesis documents on the drivers of drought in the region, and on use of CMIP5 climate projections and related hydrologic projections in impacts modeling and adaptation strategies. Coordinate with NCPP's development of evaluation and translational information about climate projections (including downscaled climate projections), and with Western Water Assessment and National Drought Mitigation Center (NDMC) efforts in this region. The Climate Team will build off of synergies with NOAA/NIDIS (Mike Hobbins) and USGS/NIDIS (Jim Verdin) scientists who are experts in the development and use of ET and drought-related products.

We will bring in an initial focus on drivers of drought and the role of climate variability in drought. We will work closely with the three funded projects to develop drought-related climate scenarios, including the development of drought indicators and projections for these indicators into the future based on the CMIP5 climate model runs. We recognize that drought is not the only concern in the region, however, this focus on drought will guide the improvements of ET products and on the water balance analyses of climate projections in the region. This information will benefit ecological impacts modeling for a broad array of purposes.

The connection to management objectives will be through support of post-docs and climate team lead to travel to stakeholder meetings of the funded projects, to LCC meetings, and through helping to fund coordinating activities among NC-CSC post-docs such as post-doc workshops or a retreat.

We envision the following outcomes and products resulting from the activities described above:

- User guidance material for the use of climate projections for the various types of ecosystem challenges faced by managers in the North Central domain. These will be more geographically specific than the National Climate Assessment, and include case studies from the region as they are developed.

- Data and tool sets for ReVAMP that can be used by impacts modelers and stakeholders. These include downscaled climate projections and the high-resolution ET dataset.
- Synthetic analysis the literature on climatic drought and ET drivers across the North Central domain, providing the larger scale context for drought in the region.
- Publication on the drought and climate change analyses done for the region, along with methodological details of the dataset development.

MODIS NPP/GPP and ET Model Enhancements

Dr. Running's group will concentrate on improving the MOD17 and MOD16 models for regional application at the 1km scale and is warranted, at the 250-m scale. His group will determine the main landscape-scale controls on NPP/GPP and ET within the region and implement these within the model. For instance, the global MOD17 model currently does not have a soil moisture constraint on GPP, a potentially important factor to consider when estimating productivity at fine scales. Additionally, since MOD17 and MOD16 both use remotely-sensed leaf area index (LAI) and fraction of photosynthetically active radiation (FPAR) as inputs, we will also develop a fine scale LAI/FPAR product for the region. Lastly, we will use a more regionally-specific land cover classification and conduct model validation and parameter optimization by land cover type with flux tower and weather station observations.

3. Impacts and Vulnerability: Connecting Climate Drivers to Management Targets

Drought impacts on biodiversity and across different ecosystems represent a complex set of sensitivities to climate conditions. These impacts are also further complicated by direct and indirect feedbacks in the environment which can be influenced by pests, diseases, or disturbance effects, such as fire events or by past resource management practices. Understanding the sensitivity of species and ecosystems to drought conditions across the region provides an opportunity to develop a more integrated climate-impact analysis platform. This effort will build on the species distribution modeling effort initiated by the NC CSC and also incorporate ecosystem level analysis of drought conditions on key ecosystem services, such as net primary production, forage availability, soil carbon levels, soil moisture dynamics, and evapotranspiration.

The roles of the impacts team in drought assessment are:

- Evaluate the sensitivities of ecosystem processes and biodiversity to the various forms of drought and the indirect feedbacks that can emerge.
- Work with the drought scenarios from the climate team to hypothesize which elements of ecosystem and biodiversity are likely to be most vulnerable to which forms of drought across the ecoregions of the CSC.
- Conduct simulation experiments to test these hypotheses
- Synthesize the results to provide guidance to the Adaptive Capacity team on key drought related vulnerabilities and locations.

Build on the existing work of the foundational science area, NCA, and the NCPP pilot projects

In 2012, the impacts group focused on developing the capacity to conduct rigorous species distribution modeling under climate change and using the models to assess vulnerability within four ecoregions of the NC Area. The results of these modeling efforts provide a basis for assessing the sensitivities of ecosystem processes and biodiversity to drought.

- We will host a workshop with the impacts team to synthesize knowledge on sensitivities of ecosystem processes and biodiversity and derive hypotheses on which elements of ecosystem and biodiversity are likely to be most vulnerable to which forms of drought across the ecoregions of the CSC.
- We will work with Resources for Advanced Modeling (RAM) to incorporate appropriate drought metrics into it data bases and prepare guidelines for RAM users on application of these metrics for ecosystem process and species distribution modeling.

Integrate with and help support the three case-study projects and inform the ReVAMP concept

Each of the three case studies will be modeling ecological response to climate change. We will work with each group to help identify potential sensitivities to drought in their study areas and ways that these sensitivities may influence management options. We will additionally invite the case studies to conduct simulation experiments similar to the design use by the Impacts Team to test hypotheses on ecological response to drought.

Conduct additional collaboration and activities to help meet the two objectives listed above.

The sagebrush ecosystem represents an important component of the western NCCSC domain and is the study ecosystem for one of the three case study projects that deals with sage grouse. Current understanding of how drought impacts sage grouse via effects on sagebrush regeneration is underdeveloped. Thus, the Impact Team continue the modeling work on sagebrush steppe ecosystem modeling by the Lauenroth lab at the University of Wyoming to assess sagebrush seedling response to drought. Additionally, the Lauenroth lab will examine forb dynamics. There is widespread agreement that forbs are key components of sage grouse habits. Despite considerable uncertainty about the relative importance of particular forb species, the contribution of forb presence and abundance to hen and chick nutrition is well recognized. These contributions include both direct effects, e.g. forb consumption by sage grouse, as well as indirect effects, e.g. sage grouse consumption of insects that are associated with the forbs. The Lauenroth group will evaluate the composition and dynamics of forb species in sage grouse habitats as the first step in a range-wide analysis of the distribution and abundance of forbs in sagebrush plant communities. Once a literature evaluation is completed, the team will investigate the potential to categorize the forb species into functional plant types as a precursor to incorporating them into ongoing sagebrush plant community modeling work. This research will be accomplished by a graduate student.

4. Characterizing Adaptive Capacity of Stakeholder Communities and Informing Management Options

Drought is part of the normal climate variability and livelihoods in the Great Plains and Intermountain Western United States, so human-ecological communities are highly adaptive and adapted to drought conditions. However, recent severe droughts of the 2000s and 2010s along with climate change projections have increased the interest and need for better understanding of drought science and decision making. The purpose of the Drought Risk and Adaptation in the Interior (DRAI) study is to understand how the U.S. Department of Interior's federal land and resource managers and their stakeholders (i.e., NPS, BLM, FWS, BOR, BIA and tribes, among others) are experiencing and dealing with drought in their landscapes. The DRAI project is a fundamental part of the North Central Climate Science Center (NC CSC) the cross-cutting drought science initiative as it will play a large role in connecting the science outcomes of the other two foundational science areas with "on the ground" management and decision making of DOI managers and tribes. The overarching goal is to learn more about drought within the DOI public lands and resource management in order to contribute to both the NC CSC regional science as well as providing managers and other decision makers with the most salient, credible, and legitimate research to support land and resource management decisions. As such, the DRAI project will

Conduct additional collaboration and activities to help meet the two objectives listed above.

Drought Risk and Adaptation in the Interior (DRAI, pronounced "dry") that would select several sites in the region to conduct in-depth analysis on drought in the DOI context.

Research questions include:

1. How are the DOI managers experiencing and dealing with drought (e.g., is it something they already respond to/plan for, what drought impacts are they seeing, do they have drought plans, etc.)?
2. How do DOI managers frame drought risk for the land and resources they manage?
3. How do the federal agencies work with state, local, tribal entities on preparing for and responding to drought?
4. What are policy or management innovations that federal agencies have utilized to cope with drought in their systems?

Goals and Objectives:

We hope to learn how drought manifests differently across various types of landscapes and ecosystems (e.g., riparian, terrestrial, rangelands, forests), how federal land managers perceive the risk of drought in their landscape (including impacts on ecosystems, ecosystem services, and their stakeholders' livelihoods and tourism/recreation experiences), what decisions they have to make related to drought, if they use drought indicators for decisions, how much they know and understand the science of drought, including the understanding of drought in the context of both historical and future climate variability and change. We also hope to learn what capacity and barriers federal land managers and their stakeholders have to cope with and adapt to drought and the related climatic, social and ecosystem changes in their landscapes.

Methodology

This project will use an integrated Social-ecological Systems (SES) approach to understanding the

interactions between bio-physical and human systems. The study will utilize the following methods:

- Literature and document review on drought and drought-related federal land management issues, decisions
- Directed and/or semi-directed interviews with federal land managers and other key stakeholders
- Observation of relevant meetings/workshops related to the topic
- Qualitative data analysis of interview data using Atlas.ti
- Additional stakeholder engagement as needed: e.g., possible focus groups and/or additional interviews or surveying as determined by the evolution and refinement of the project
- Participation in the development of a NIDIS (National Integrated Drought Information System) pilot in the Missouri River Basin

Initial exploratory research will focus on the Yampa-White Basins region DOI land managers and their stakeholders. Ideally this will include an initial round of 10-20 interviews with federal land managers and other key stakeholders who partner with federal land managers on drought-related resource management (e.g., water commissioners and division engineers or reservoir mangers). After this initial research, additional interviews will be conducted in other locations within the north central region, such as in other parts of Colorado and the Upper Colorado Basin as well as managers in the Missouri Basin (e.g., Colorado, Wyoming, Montana, South Dakota, and Nebraska). Since the focus is on public lands and federal land managers, we will need to determine with our federal and university partners the best target group(s) for additional participants. This will include close collaboration with our partners at the National Drought Mitigation Center, NIDIS, Western Water Assessment, and others. At this point, it is difficult to determine the full number of interviews, but a best guess is on the order of 50-100 over the upcoming one to two years.

In addition to the DRAI project, the adaptation foundational science area will **build on the existing work of the other two foundational science areas, the National Climate Assessment (NCA), and the NCPP pilot projects through the following additional activities:**

- Develop research strategy and approaches for the Adaptation and Decision Making Working Group (ADMWG)
- NC CSC (McNeeley's) Yampa-White Basins region vulnerability and adaptation research, focus on water/drought
- Develop data management protocol for social ecological system analytical system
- Ojima/McNeeley will lead national cross-CSC working group on social-ecological systems climate response network

Integrate with and help support the three case-study projects and inform the ReVAMP concept

- Identify team member from each funded study to join and participate with ADMWG.
- Identify social ecological system approaches and management linkages relevant to climate impacts, response options, and adaptive capacity
- Facilitate the development of social ecological climate response options

5. Integration and Synthesis Activities

The research activities associated with this proposed effort builds on the ReVAMP framework and will develop a working set of case study protocols which will inform further science delivery and information exchange among researchers and managers of our region. This effort will be developed through a set of workshops, webinars, and periodic conference calls between members of the NC CSC research staff, the foundation science teams, and research and managers involved in our funded research projects.

The efforts with the funded activities will be coordinated between the foundational area leads and with PI's from each of the 3 funded projects. Initial efforts will be aimed to identify key information and research activities which align with the climate, impacts, and adaptation foundational areas. The coordination between the foundational research areas and the funded projects will identify climate information needed to support research questions for these funded projects. Issues related impacts and biodiversity changes associated with the funded projects will be further developed and analysis support where possible will be provided. Adaptation planning and enhanced social-ecological considerations will be developed with these funded projects.

These collaborative and supportive efforts will be conducted through conference calls, webinar, team member exchanges, and through the use of the Resource for Advanced Modeling (RAM). We plan to have regular team discussions and coordinated efforts on various topics which the foundational teams will facilitate integration and synthesis across scales and topics of the research activities.

The drought focus will also serve to integrate and provide a mechanism to organize research tools and information across disciplines in a more structured fashion. The RAM will be integral for this effort to capture and to maintain data-model interactions between research foci and decision maker's needs.

The NC CSC will use the RAM to integrate research activities associated with ReVAMP to help the NC CSC develop data exchange and development of information useful to researchers and managers in our region. The funded projects will provide real-world examples to improve the information content for interface between research tools and management tools. These activities and the RAM collaboratory will enhance our science delivery and the development of the foundational science areas. These funded projects and the drought analysis will enhance our understanding of how to incorporate science information into the decision processes and serve as a catalyst for interaction across the NC CSC foundational research areas to meet the information needs of that decision process.

The objective of ReVAMP is to develop a regional resource for managers to access and utilize the best available climate science and synthesis to inform their strategic planning and management decision. The NC CSC staff will take the lead on defining and operationalizing the ReVAMP. The funded research projects used as initial users of ReVAMP and the RAM resources.

Each of the funded projects and the foundational team members will participate in one or more

sessions in the USGS Resource for Advanced Modeling (RAM).[1] The specific timing and ecological response modeling activities will be determined individually for each project. However, each session will have expertise and participation from members of the three foundation science teams as well as computational, geospatial, and biostatistical support from the NC CSC.

Each RAM session will include:

- A team approach (including land managers and scientists from the pilot project, representatives from the foundation science areas, and NC CSC staff)
- Easy access to a full suite of climate data
- Transparency on input data and modeling procedure
- Visual output to reveal climate contribution to ecological model and/or management simulation results and
- The ability to quickly explore "what if" scenarios

These RAM sessions with the funded projects, using the expertise from the three foundational science areas, will be used to configure the operational structure for ReVAMP. After utilizing the RAM for the three year duration of the funded projects, the NC CSC will have a better idea of how many clients the ReVAMP could serve in an operational capacity, the range of consulting and follow-up services that could/should be offered through ReVAMP, and the resources (human, computation, data) required to provide those services.

[1] http://www.fort.usgs.gov/ram/