**NASA APPLIED SCIENCES INITIAL ASSESSMENT REPORT**

**Title**: Using NASA resources to inform climate and land use adaptation: Ecological

forecasting, vulnerability assessment, and evaluation of management options across

two US DOI Landscape Conservation Cooperatives

**NRA**: NNH10ZDA001N - BIOCLIM

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**SUMMARY**

The US Department of Interior created Landscape Conservation Cooperatives (LCCs) in 2009 to improve management of federal lands under climate change. The goal of this project is to refine and demonstrate the four steps of a climate adaptation planning strategy in the Great Northern and Appalachian LCCs using NASA and other data and models. We aim to enhance decision support across the LCCs by providing a framework, data products, and scientific knowledge to facilitate climate vulnerability assessment across multiple federal jurisdictions. Within individual federal units, the project provides a basis for assessing which resources are most vulnerable to climate change and selecting effective management strategies. This report assesses mid-term progress of this four-year NASA Applied Sciences Project.

Work to date has focused on: assessing the needs of collaborators, synthesizing current knowledge on climate change and ecological response, and hindcasting and forecasting ecosystem processes and biodiversity response (tree species, vegetation communities) under climate and land use change. In the remaining two years of the project, we will convene expert panels to assess ecological vulnerability to these changes, evaluate management alternatives, recommend strategies for implementation, and provide decision-support resources. Interpreting progress in terms of NASA Applied Sciences Readiness Levels (ARLs), the project started at ARL 1: Basic Research, is now at ARL 4: Initial Integration & Verification, and we anticipate reaching ARL 5: Validate in Relevant Environment. It is our hope that this work in two LCCs will lead to similar applications across the national network of LCCs.

 We assessed the state of decision support and perceived needs of our LCC and National Park Service collaborators via written survey. Six of our eight key collaborating federal units provided extensive responses to the seven-question survey. The responses revealed that their current knowledge about past and future global change is low to moderate, frameworks for climate change adaptation have not been formalized in their units, relevant data and knowledge is relatively unavailable to them, and that the data and decision-support tools to be developed in this project would be of high value.

 We conclude that managing federal lands under climate change is an extraordinary challenge and that carefully crafted approaches, data sets, and analyses are required to make progress. Our project is well on track to develop these resources through close collaboration with our LCC and NPS partners.

**INTRODUCTION**

**Purpose of the Report**

This report assesses mid-term progress of this four-year NASA Applied Sciences Project as specified in the Applied Sciences Program Project Reporting Guidelines (DRAFT: March 23, 2012). Our initial report, the Project Plan (Hansen et al. 2012), laid out in detail the scope of the project and how it is being executed and managed. This Initial Assessment Report is to be “written at a predefined milestone roughly mid-way into the project, at which point enough enhancements to the DST should be functional so that a useful, self-assessment can be made”. The goal is to help guide the work during the remainder of the project. The NASA Applied Science Program incorporated Applications Readiness Levels (ARLs) into its program tracking in 2011 after our project was in progress. ARLs provide a systematic, graduated scale for articulating the maturity of projects as they progress. The solicitation under which we were funded (NNH10ZDA001N – BIOCLIM) was written prior to the ARL system. Given that the goals and objectives of our funded proposal were written to be responsive to that solicitation, we use this report as an opportunity to interpret the project in terms of the ARL system.

**Overview of Decision-Support Tools and Enhancements**

Climate change is increasingly seen as a threat to natural resources. Consequently, the U.S. Department of Interior (DOI) launched in 2009 new programs on climate science including the creation of Landscape Conservation Cooperatives (LCCs), which are tasked with crafting practical, landscape-level strategies for managing climate-change impacts across networks of federal lands (U.S. Department of the Interior 2009). Consistent with these programs, the NPS published a climate change response strategy (National Park Service 2010) which states that the NPS “will conduct scientific research and vulnerability assessments necessary to support NPS adaptation, mitigation, and communication efforts”. In the face of global change, an NPS science advisory panel recommended in 2012 that, “The overarching goal of NPS resource management should be to steward NPS resources for continuous change that is not yet fully understood, in order to preserve ecological integrity…” (Colwell et al. 2012, pg. 11).

These DOI efforts can be enhanced through use of NASA data and products. Thus, the goal of this project is to refine and demonstrate the four steps of a climate adaptation planning strategy (Glick et al. 2011) in the Great Northern and Appalachian LCCs using NASA and other data and models. Objectives are as follows.

1. Quantify trends in ecological processes and ecological system types from past to present and under projected future climate and land use scenarios using NASA and other data and models across the LCCs.

2. Assess the vulnerability of ecological processes and ecological system types to climate and land use change by quantifying exposure, sensitivity, adaptive capacity, and uncertainty in and around focal national parks within the LCCs.

3. Evaluate management options for the more vulnerable ecosystem processes and types within these focal parks.

4. Design multi-scale management approaches for vulnerable elements to illustrate adaptation strategies under climate and land use change.

5. Facilitate technology transfer of data, methods, and models to LCCs and federal agencies to allow the decision support tools to be applied more broadly.

A key decision of the LCCs and the federal units within them is how to operationalize climate adaptation planning to provide the science needed to support management under climate change. Thus, our project is developing and demonstrating an approach for climate change adaptation that is informed by NASA data and products. The project will enhance decision support of the USDOI at two levels. At the level of LCCs, **the project is providing a framework, data products, and scientific knowledge to enhance climate vulnerability assessment across multiple local, state, and federal jurisdictions.**  At the level of individual federal management units such as national parks, **the project is providing a basis for assessing which resources are most vulnerable to climate change and selecting effective management strategies**.

**Summary of Work Performed to Date**

Details of the methods being used were summarized in the Project Plan (Hansen et al. 2012). Here we summarize the major accomplishments to date.

1. Assess needs of collaborators. We convened eight one to two day workshops and field trips with National Park Service collaborators to describe the project to them, invite detailed participation, and identify which of their climate related needs the project can best address (Table 1). These needs included general methods of vulnerability assessment and interagency collaboration, ecosystem process metrics (e.g., snowpack), and elements of biodiversity at species and community levels. We followed up these workshops with a survey to quantify the collaborator s’ decision support capabilities near the start of the project (see below).

2. Synthesize Current Knowledge. Since our proposal was written, several excellent studies have been published on climate vulnerability in the Rocky Mountains and Appalachian regions and new data sets have become available. We elected to synthesize these studies as a quick way to help inform our collaborators of the current state of knowledge. Our new science will then advance that state of knowledge. The syntheses addressed two questions:

**How have climate and land use changed in the past century and how are they projected to change in the coming century?**

**How is vegetation responding to current climate change and projected to respond to future change?**

We are representing the climate results for each focal national park as “primers”, simple documents designed to allow our collaborators to quickly see trends in key climate drivers and potential ecological consequences. For an example for Rocky Mountain National Park, see <http://www.montana.edu/lccvp/documents/amkROMOClimatePrimerandbasicplots.pdf>. Our synthesis of current knowledge on vegetation response involves analysis of existing data sets to highlight which tree species and community types are projected to contract, expand, or remain stable within the LCCs and the source areas for potential new species. An example for the Appalachian LCC is at <http://www.montana.edu/lccvp/documents/LCCVP_ALCCtreespecies.pdf>. Upon completion, the climate primers and vegetation summaries will be distributed to collaborators in the form of NPS Resource Briefs Briefs – short (few page) summaries that have a common look and feel that is familiar to most land managing agencies.

 We have additionally assessed past and potential future change in climate, land use, invasives, and vegetation for 57 national park units across the U.S. (Hansen et al. In Press) as a context for the analyses within the two LCCs.

Table 1. Workshops convened with collaborators to establish information needs.

|  |  |  |  |
| --- | --- | --- | --- |
| Organization | Key Collaborators | Date | Needs We Can Address |
| Greater Yellowstone Coord Comm Whitebark Pine Subcomm. | Virginia Kelly, Karl Buermeyer, Dan Reinhart, Nancy Bokino, Kristin Legg | April 2012 | Effectiveness of “GYCC WBP Strategy” under future climate |
| Rocky Mountain NP | Ben Bobowski, Judy Visty, Jeff Connor, John Mack, Larry Gamble, Jim Cheatham, Mary-Kay Watry, Nate Williamson | Nov 2012 | Climate, land use, ecosystem interactionsLimber pineCollaborative management among agencies |
| Yellowstone NP | Dave Hallac, Ann Rodman, P.J. White, Roy Renkin,  | Nov 2012Jan 2013 | Whitebark pine Grassland phenologyYNP climate change program direction:Monitoring, Vulnerable resources,Management options |
| Great Smoky Mt NPShenandoah NPApp. Highlands I&M | Jim Renfro, Jeff Troutman, Tom Remaley, Jim Schaberl, Paul Super, Jeb Wofford | Nov 2012 | Vegetation comm (6 across elevation range)PACE methodsLand use legacy in parks |
| Delaware Watergap | Rich Evans, Mathew Marshall, Leslie Moorlock | Nov 2012 | Hemlock vegetation communityLand use / hydrology |
| Grant Teton NP | Sue Consolo Murphy, Kelly McClosky, Cathy Melander | May 2013 | Snow packWhitebark Pine |

3. Perform new science to assess vulnerability. The bulk of our activities have been aimed at the science development that is the underpinning of climate vulnerability assessment.

- Framework for climate change adaptation planning. We expanded on the core approach of Glick et al. (2011) to provide an approach highly relevant to federal land managers, particularly the National Park Service (Olliff et al. 2013). Co-Investigator Tom Olliff is climate change coordinator for the NPS Intermountain Region. He has led this effort and is working towards implementing the approach in the national parks of the intermountain region.

-Ecological forecasting of climate and ecosystem processes. We have downscaled CMIP5 climate models to 30 arc-seconds (~800m). A publication on this data set (Thrasher et al. In Review) was submitted to EOS. Our historical and projected land use change maps were updated. The climate and land use data were used as inputs to the Terrestrial Observation and Prediction System, the ecosystem process outputs are now finalized, summary statistics were completed for each national park, and are being reviewed by the team. Examples of results are at: <http://www.montana.edu/lccvp/documents/amkTOPS_Update_21May2013_v2.pptx>.

-Ecological forecasting of vegetation response. The team is actively developing habitat distribution models for ecological system types (community types) and tree species within the two LCCs. We have compiled predictor data from the 30 arc-second PRISM climate data set, constructed water balance models, and geomorphic data sets. Response data have been compiled from the USFS Forest Inventory and Monitoring Program and several other sources. Pilot models have been constructed for limber pine (Monahan et al. In Review), whitebark pine, and spruce-fir forests, and cove forests and used to project shifts in habitat suitability under future climate. Models are under development for other vegetation types.

-Assessment of vulnerable elements. Expert workshops are planned for the coming year to use the results above as the basis for assessments to determine most vulnerable elements.

4. Management strategies. The project will work with collaborators to develop, evaluate, and possibly implement management strategies aimed at maintaining vulnerable resources across multiple federal jurisdictions. Thus far we have developed a detailed set of methods for achieving this in the form of a proposal on whitebark pine management in Greater Yellowstone. The proposal was funded by the North Central Climate Sciences Center and will be conducted synergistically with this project.

5. Inform decision support and policy. We will do so in the form of agency resource briefs, scientific publications, policy documents, methods as Standard Operating Procedures, data sets, and software. These are in various stages of development at this time.

**APPLICATION READINESS LEVEL**

The core decisions the project is designed to inform and the means of achieving them are presented in Table 2. Below, we cross-walk the main activities of the project to the ARL system.

**Project Starting ARL**

ARL 1: Basic Research

Scientific questions of high priority to LCC management agencies identified. NASA data resources and models identified that could be applied to address the priority science questions.

**ARL’s Achieved**

ARL 2: Application Concept

Project concept and framework developed. Framework for addressing climate change impacts using NASA data resources presented to protected area managers within LCC agencies.

ARL 3: Proof of Application Concept

Survey of scientific questions of high priority to managers completed. Initial modeling analyses complete and presented to LCC managers. Project has established feasibility of completing high resolution analyses for LCC priority science questions.

**Current ARL**

ARL 4: Initial Integration & Verification

Downscaled climate projections, ecological process model output, and biodiversity models are integrated to allow ecological hindcasting and forecasting of biodiversity response to climate change. Results are reported to managers for verification and refinement. Organization challenges of enacting landscape-wide climate change adaptation strategies across multiple agency jurisdictions identified.

**Anticipated ARLs**

ARL: 5 Validate in Relevant Environment

During the remaining two years of the project, we will simulate the outcomes of alternative landscape adaptation scenarios, convene expert panels to develop and evaluate management options, demonstrate steps in climate vulnerability across the network of US national parks, and deliver key data sets, publish methods as standard operating procedures, include stakeholder representatives in the project team, demonstrate the methods and utility of them through workshops and scientific publications.  This will validate the proposed approach in a relevant environment.

**Discussion**

Federal natural resource agencies typically require multi-year periods to operationalize and implement changes in decision making procedures, particularly those that require NEPA compliance. Thus the enhancements produced by this project are likely to come to full fruition after the completion of the four-year project. We represent our ARL within this reality and have high confidence we can achieve ARL 5. If, however, our results are used to make specific collaborator decisions before the completion date, the project may reach ARL 6. One example is if our prototype system is integrated into the Intermountain Region of the National Park Service. The NPS IMR has set as a high priority implementing climate change adaptation procedures across the national parks within its domain. Co-Investigator Tom Olliff is using this project to inform the development of those procedures and may be able to implement the procedures within the Intermountain Region before the completion of this project. Similarly, if our data sets and methods are added to and maintained in LCC, NPS, and/or USGS data stores by completion, the project may achieve ARL 7. Also, we are working with NPS to incorporate our data and analyses into the NPS State of the Parks reports, which are a high priority for NPS and would result in wide dissemination and use of NASA products.

Table 2. Vehicles by which the LCCVP project enables decision support across a hierarchy of stakeholders.

|  |  |  |
| --- | --- | --- |
| Decision to be made | Stakeholder | Vehicles |
| What procedures can best be used to operationalize climate change adaptation planning and management across LCCs and networks of NPS units? | LCCs and NPS regions | ) Develop, demonstrate, and describe in policy documents an effective approach) Identify scientific questions of high priority to LCC management agencies.) Use NASA data resources and models to hindcast and forecast climate change and ecological response.) Review forecast results with collaborators to refine and establish feasibility.) Synthesize the results across LCCs to provide the science to support climate vulnerability assessments) Document methods and data sets to allow the LCCs and NPS regions to incorporate these into their decision support systems |
| In what ways should current management in individual federal units and among neighboring units be modified to be effective under climate change. | Individual federal unitsInteragency cooperatives within PACEs\* | ) Quantify past and projected future exposure and potential impacts based on synthesis of existing knowledge and ecological hindcasting and forecasting) Convene expert panels to interpret hindcasts and forecasts to identity most vulnerable elements) Convene expert panels to develop and evaluate management options) Simulate the outcomes of alternative landscape adaptation scenarios) Evaluate results with collaborators to identify desired scenarios for implementation) Document methods, data sets, and synthesis of results to support the implementation of the scenario. |

\*PACEs – Protected-area Centered Ecosystems

**PROJECT ASSESSMENT**

**Introduction**

 The initiation of our project largely coincided with the new DOI focus on climate change and the creation of the LCCs. Thus, it was necessary to focus the first year of our project on informing our LCC and NPS collaborators on climate vulnerability planning and the potential for NASA data and products to enhance decision support. We thus did our initial benchmark survey of cooperator climate decision support in the beginning of year two and report results here. A follow-up survey near the end of the project will assess the extent to which this project enhanced data use and accessibility, as well as use of decision support systems.

**Methods**

 We sent a pre-project survey to each of the eight NPS units that have agreed to be formal collaborators to the project. Each unit was asked to complete one survey that reflected the overall responses of their participating staff. To date, we have received six responses. The eight units are identified below.

1. Yellowstone National Park

2. Rocky Mountain National Park

3. Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee

4. Great Smoky Mountains National Park

5. Appalachian Highlands Inventory & Monitoring Program

6. Delaware Water Gap National Recreational Area

7. Shenandoah National Park

8. Grand Teton National Park

**Results and Interpretation**

*Q1: Describe your level of knowledge about past change in climate and land use from 1900 to present and about projected change in climate and land use to 2100 within and surrounding your management unit.*

Among the six respondents, three characterized themselves as having Moderate levels of knowledge and three as has having Limited levels of knowledge of *past* and *potential future* climate (Figs. 1 and 2). None of the units believed they had extensive knowledge of change. Of the three respondents that felt they had limited knowledge of past and future change around their units, one respondent said “We have very little knowledge of past climate change and land use surrounding our unit.” Another respondent said “Significant opportunities exist to have explicit examples of the interactions between climate change and land use change as we look towards the future.”

Of the three respondents that felt that had moderate knowledge of past and future change around their units, one pointed to our previous NASA Applied Sciences project (PALMS) as a useful data source. Another cited the tool Climate Wizard as a decision-support system that is useful to inform management. Overall, the level of knowledge surrounding past and future change in our collaborators units is relatively low to moderate, meaning the LCCVP project has opportunity to help fill this knowledge gap considerably with our data products and tools.

*Q2: What is your current approach to managing natural resources under existing and projected climate and land use change? List 3-5 of the key steps you use to go from identifying potential conservation concerns to implementing management to alleviate concerns for high priority issues?*

We analyzed the answers to identify if collaborators had an established approach to management under climate and land use change and if they were currently altering management approaches and decisions given knowledge of change. Of the five respondents for this question, three indicated they are still managing for “business as usual”, and have not altered their management approach to deal with climate or land use change (Fig. 3). One respondent stated “We are currently managing the same as in the past.” Another said “Managers are cognizant of potential impacts [of change], but not ready to commit to altering management practices given uncertainties, and the logistical implications of large-scale alterations in a cumbersome bureaucracy.”

Of the two respondents that acknowledged some effort to alter management approaches to deal with change, one said they are focused on “managing for resilience” by using sound science and practicing adaptive management. The other respondent said their primary means of managing for change was to assess potential impacts of climate change as part of NEPA analyses.

Overall, the collective responses demonstrate that there is not yet a systematic approach to managing for change that has gained wide acceptance among the public lands managers we surveyed. Of those who are trying to actively address change, the approaches so far are not inconsistent with managing under business as usual, and show much room for more explicit and systematic consideration of management options under change. The respondents who clearly stated they had not changed their management approach cited uncertainty in the data, uncertainty about potential adverse effects of active management (over no action), and the difficulty of ‘turning the ship’ or steering a bureaucracy away from current norms toward new and untested approaches, as factors that hinder managing for climate change.

*Q3: What types of management actions do you currently use to manage your resources considering existing and projected climate and land use change? How do you prioritize among different management options? Are there specific management actions that you are unable to implement because of regulatory restrictions, lack of public will, or other barriers? If so, what are they and what barriers are prohibiting their use?*

This question was intended to explore the types of adaptation management actions managers are currently using, how they prioritize among those actions, and if they face challenges or barriers to using such adaptation options. Five of six respondents stated that they have undergone analyses to determine what resources are priorities for management, and they believe these will be the same resources that will be prioritized under change. However, four of six have not identified adaptation options, or management actions that will help priority resources cope with change.

Of the respondents who currently have not identified clear adaptation management actions, one respondent said that currently they are concentrating on “Encouraging and supporting new research”, although they identified a paucity of funding as a barrier to this approach. Another respondent was quite bleak, and noted “Besides documenting current conditions and conserving genetic material, I don’t know that there’s much we can do but watch as these communities disappear.”

Of the respondents who had identified some adaptation management actions, one indicated that they had identified connectivity corridors between their unit and other protected lands, but cited a lack of funding for conservation easements as a barrier to implementation. Another respondent stated that currently they “likely will use limited to no intervention in Park wilderness areas (95% of the unit), but will consider active intervention and cooperative planning for border areas.” This suggests that this unit believes current park policy requires a “hands off” approach to adaptation, which may or may not be perceived as a barrier. This unit cited land use outside the park as being the major barrier to cooperative planning in their border areas.

*Q4 & 5: Do you currently have the data and decision support tools necessary to execute these steps? If not, what data and decision support tools do you think would be most useful? What are the major conceptual challenges you face in executing these steps? Do you have adequate access to how-to guides or hands-on training? If not, what would be most useful?*

Question 4 sought to assess what types of data and decision support tools collaborators currently have access to, and what they think would be most useful in supporting management decisions under change. Six of six respondents said they needed downscaled climate data at a scale that is useful and relevant for their management unit, and that such information was not currently available, or not accessible to staff (Fig. 4). One of these units is seeking data on the rates and direction of change at localized (rather than regional) scales. Another unit has access to models that will downscale climate impacts at a local scale, but the models require localized temperature and precipitation data, which the park currently does not have access to, and which would be greatly welcomed. A third unit is looking specifically for data that helps them to understand which species are most vulnerable to climate change. Overall, most collaborators sought localized data that takes into account topographical and elevational gradients as well as seasonal variability (especially regarding changing precipitation patterns and related changes in hydrology).

Five of six respondents stated that user-friendly tools and how-to guides were necessary for decision support. For example, one unit felt that relatively good field data are available, but in their case, good tools that help support decision-making are lacking. Another unit stated “we do not have access to hands-on guides or adequate training” for translating climate data into information that can support adaptation options. Another unit stated that the uncertainty of change (rate, magnitude, direction) and the uncertainty about biological responses to change was a major knowledge gap, and more localized data and support tools that can help address managing under such uncertainty would be useful. A fourth unit stated that “the ever-evolving ‘frameworks’ for addressing climate change need clarity, synthesis and regular updating. It seems like there is a new framework to consider, every few weeks.” Finally, a unit stated “There are no data support tools available that are push button/user friendly. That’s a problem. Data needs to be manually acquired and data products are cumbersome. We need a better way/user friendly/push button tool for remote sensing capability. Tools are difficult to work with and hard to understand how to compile.” Essentially, guides that make data more accessible and easier to work with, as well as training and guides that help translate data into information that can support management decisions are needed in all collaborator units.

*Q6: What additional resources (concepts, data, and/or tools) would improve your ability to manage under climate and land use change?*

This open-ended question was meant to identify any additional challenges, needs or barriers that collaborators experienced when attempting to manage under change.

Two of the three unit respondents stated that increased policy direction is necessary: “it is unclear what would be appropriate actions within the NPS framework. Should we manage for refugia and corridors or allow processes to continue hands-off?” Likewise, a unit stated “Perhaps the most difficult decision managers will face is whether to intervene with active management”. Given that many park units operate under the “natural regulation hypothesis”, managers will need to wrestle with the types of adaptation actions they believe are consistent with their unit’s mandate and mission. Thus, it will be critical for our team to identify a range of alternatives of adaptation options that are cognizant of constraints either placed upon or perceived by Park unit managers.

The respondents highlighted the need for help in prioritizing which species to manage under change, and specifically which species are “lost causes” and perhaps should not be made a priority for investment. One unit stated this succinctly: “We don’t know what resources or species we can likely maintain, and which are very likely be “lost causes”. We don’t have species and/or habitat distribution models for the area. We need a climate vulnerability assessment and adaptation plan. There are too many unknowns to help give us a place to start.” Another unit echoed this sentiment, and said “realistic approaches to begin and enhance scenario planning efforts that lead to true adaptive management approaches that can be continually evaluated over time, and which are realistic and can be funded” are most needed.

*Q7: Which of the landscape metrics listed in Table 1 do you currently have access to? What time periods and spatial extents do your data sets cover? How relevant is each metric to management of natural resources in your unit under climate and land use change?*

This question sought to ensure that the data sets this project will generate will indeed be relevant and useful to our collaborators. We listed the data sets and associated spatial resolution for each data set and asked collaborators to identify which data sets they currently had access to, and to tell us how relevant each metric was to decision-making. Five of six respondents stated that the data sets we intend to generate are highly relevant for management, although one unit stated that annual versus decadal variability was desired (Fig. 5). Additionally, five of six respondents stated that they currently did not have access to the data sets that our project will generate (Fig. 6). There was a lone exception, who stated: “According to our GIS specialist, we have access to all of them. These just take so much time to access, understand, utilize for the park.” Hence, while this unit may have access, they are not currently utilizing the data. It is our goal to not only develop the data sets, but to make such information accessible, useful and meaningful for our collaborators.

Of note from this question, five of six respondents stated that the spatial resolution we are able to downscale to (1 km) may still be too coarse to inform on-the-ground management decisions. For example, one unit stated: “In general, the metrics appear to be conceptually in alignment with management issues; however, our experience suggests that the data sets are at a scale not commensurate with protected area-level management issues, as it relates to actionable items. They seem more relevant to landscape level decisions that are rarely under one jurisdiction. That said, we value this opportunity to reevaluate this perception with the principal investigators and to seek strategic landscape-level partnerships to address issues at km scale data.” We believe that indeed our data sets are at a scale useful for decision-makers, and we look forward to designing guides that help our collaborators understand the opportunities associated with our data, and not focus exclusively on the limitations associated with the scale of resolution.

 Despite the concern from collaborators about the scale of the datasets, collaborators were very optimistic about working with our project team. Here are a sample of comments from collaborators:

* “This assessment is a first of its kind for our unit. It will be important and help us into the future understand changes to the vegetation communities from possible climate change.”
* “We value this opportunity.”
* “An assessment of this nature will provide important information at a scale we hope will help answer what’s happened, what’s happening, and what future changes in vegetation communities can be expected.”

**Discussion**

The pre-project collaborator survey proved to be exceptionally informative. The questions helped us to better understand the struggles our collaborators have with both accessing meaningful data on climate and land use change, as well as translating that data into information that can support decision making. Of note, we have a better understanding of the constraints that managers face, namely that challenges exist not only in translating data for use in decision-making (a challenge that we anticipated), but also that policy-related constraints exist that may likely influence which adaptation options are considered feasible (a challenge that we had not anticipated). Such insights will help our team work closely with our collaborators to identify adaptation options that are feasible for our partners. Overall, we feel very optimistic that the project will provide novel and useful information to our collaborators at a time when such information is lacking and collaborators are challenged to find such support.

 Our follow-up survey will be designed to assess the utility of our decision-support products to the collaborators. We had identified three assessment metrics in our Project Plan:

* the number and usefulness of indicators of ecosystem condition that we provide;
* the value of the results of the vulnerability assessments; and
* the extent to which the evaluation and implement of management options were enhanced by the products from objectives 1-4 of the project.

In the report on our follow-up survey, we will evaluate these metrics in terms of: were expectations met?; where did the system fall short and why?: what worked well and why?; and what is our plan for addressing shortcomings?

**CONCLUSIONS AND NEXT STEPS**

 Climate adaptation planning is very complex and implementation across federal lands is an extraordinary challenge. Within federal units, local managers are generally overwhelmed with immediate management issues. In nearly all of our first workshops with collaborators, they indicated that climate change was not a high priority for them because of more near-term issues, because they did not have a good sense of the rates and potential consequences of climate change, and especially because they did not have access to the conceptual framework, data sets, and scientific knowledge required to assess climate vulnerability and manage accordingly. By our second or third interactions, however, there was a dramatic increase in interest and optimism that this project can help them make progress on these issues. Now at the end of the second year, we regularly get inquiries from the cooperators on the most recent findings and activities. These observations and the responses to the survey described above are evidence that the project has great potential to help advance climate adaptation planning for these cooperators and serve as high profile case studies for LCCs and federal land units nationally. We conclude that the project is highly relevant, on task, and can achieve considerable success by executing the project plan.

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Hansen et al. Informing implementation of the Greater Yellowstone Coordinating Committee’s Whitebark Pine Strategy. North Central Climate Sciences Center. $447,000. Approved for 2013-2015.

Avery, Gross, et al. Advancing National Park Service scenario planning: Developing integrated climate and impacts scenarios and evaluating their use in workshops. NOAA Regional Research Partnership $178,738. In Review.

Outreach

Gross. Mountain Climate Research Conference (MtnClim). Oct 2012.

Gross. NPS Colorado River Steering Committee. March 2013.

Gross. NPS Intermountain Region Climate Workshop. Feb 2012.

Gross. NPS Isle Royale Scenario Workshop. Jan 2013.

Gross. North Central Climate Science Center, Adaptation Working Group. Apr 2013.

Hansen. North Central Climate Sciences Workshop. Nov 2012

Hansen. Ecological Society of America meeting. Aug 2012.

Hansen. Zool Soc of London & Wildlife Cons Soc Symposium on protected areas, Nov 2012.

Hansen. Montana EPSCoR meeting. Feb 2012.

Hansen. Conservation Biology Annual Meeting. July 2013.

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Monahan. US Regional Association of the IALE. Apr 2012.

Monahan. Rocky Mountain NP limber pine long-term management strategy. Jan. 2013.

Monahan, Gross. NPScape – USGS Resource for Advanced Modeling Center. May 2013.

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Nelson. Natural Resources Defense Council, Invited Presentation. July 2013.

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