Reverse Site Visit (RSV) Report
(September 2015)

NSF EPSCoR Jurisdiction:	Utah
RII Award Number:	OIA-1208732
Principal Investigator:	Michelle Baker
RII Program Solicitation:	NSF-11-565
Reverse Site Visit Date:	September 10-11, 2015

Overview

iUTAH has demonstrated substantial progress in meeting many of its goals, but still faces some noteworthy challenges. Panelists commend the team for its aggressive implementation of a range of data-collection activities as well as accomplishment of a range of activities resulting in many positive broader impacts. Among major issues that warrant special attention by the iUTAH team as it enters its final two years of funding with this award are: clearer articulation of theoretical foundations and contributions of the team's work; the need for a strategy and timeline to enable the most significant lines of inquiry to be completed; consideration of what hydrologic expertise is needed for effective groundwater research and modeling; and the completion of major projects focusing on the coupling of natural and human systems that will result in the publication of results in high-impact journals.

Research Program

Summary of Strengths

The Utah team has done an impressive job of starting with relatively few established collaborations to establishing a solid infrastructure and research plan to address a fundamentally significant problem. The development of integrated sensor networks and a social and urban observation network are especially noteworthy because of the effort made to gather a broad range of related data in a coherent way across a range of different systems and sites. The establishment of a diverse set of new interpersonal collaborative networks, many expanding beyond the original core group of researchers, also warrants special commendation.

Panelists thought that the Utah team had done an especially impressive job of involving students in iUTAH’s work, thereby enhancing the effective integration of research and education.

Research Focus Area 1:
The goals of this research focus area are to improve Utah's capacity to monitor and understand the ecohydrologic system of the Wasatch Range metropolitan area by improving watershed-scale measurement capacities and by conducting research aimed

at enhancing understanding of the biophysical processes that influence Utah's water resources.

iUTAH has scored a remarkable achievement in the instrumentation of key water quantity, quality and other hydro-meteorological variables along the transects from montane to urban settings. This is the strongest contribution shown by the project along with their cyber infrastructure set up for data management and sharing. GAMUT is operational in all three study watersheds. This is an impressive accomplishment which represents a tremendous amount of work by the iUTAH team. Real-time monitoring will now provide the spatial and temporal data necessary for the team to address their key research questions.

Panelists were intrigued by prospects for research that would incorporate dynamics regarding how dust, fires, beetle-induced tree loss, and other factors impact water quality and availability in the study region.

With respect to Research Focus Area 1.3, the team has conducted very solid research in order to refine downscaled atmospheric science models in order to more effectively and accurately account for distinctive features of local landscapes. This kind of work already warrants dissemination through appropriate atmospheric science journals, and future work may well result in publications in a broader range of journals as well as potential funding from NSF programs like Climate and Large-Scale Dynamics and Geography and Spatial Sciences either individually or collectively through co-review.

Panelists were impressed that all milestones had been met by the end of Year 3.

Research Focus Area 2:
The goals of this research focus area are to improve capacity of Utah's science community to gather and analyze social and engineering system data on coupled water systems; to understand the interactions among urban form, environmental change, built water infrastructure, and decision making in terms of water use; and to model the impact of alternative infrastructure designs and policy options on water-use behaviors, the water cycle, the water quality, and interconnected social and environmental systems.

The core questions of this research area that focus on the factors influencing water and land-use management at regional scales and the impact of urban form on water use as well as the quantity and quality of return flows are valuable. The team has made impressive progress in pursuing innovative methods for gathering data to help answer these questions. The development of new methods for eliciting large numbers of responses to perception surveys is especially noteworthy. Plans for activities in Years 4 and 5 offer promise for helping further advance insights into factors that affect human use of water at a range of organizational scales. Utah team members should explore potential sources of funding within and across the NSF directorates for engineering (ENG) and social, behavioral, and economic sciences (SBE), including a nascent urban

science initiative alluded to in the NSF FY 2016 budget request for those and the computer science and engineering (CISE) directorates.

The team's apparent success in the development of inexpensive methods for conducting surveys should be shared with the broader community as a methodological advance, because the approach could very well have utility for addressing a diverse range of inquiries. Research on social vulnerability of flooding and other water-related issues offers promise for helping accomplish the goals of this project.

Panelists noted progress has been made on the typology of urban neighborhoods and urban growth models. This work will facilitate future research across this research area. They also noted that key informant interviews, media analysis, and other key facets of data collection had been accomplished.

Panelists were pleased to see that the team has engaged an economist to pursue relevant work on groundwater markets and felt that the research emphasis on green infrastructure offers promise.

Research Focus Area 3:

One goal of this research focus area is to describe the water system as a whole by exploring linkages between biophysical and social dynamics using results from the other two research focus areas in order to facilitate interactions with stakeholders. This research focus area also seeks to improve capacity to study the complexity of local water issues by facilitating the integrated analysis of disparate datasets and models.

The Utah team has positioned itself to be able to engage in highly significant research related to complex interactions between human actors (both individuals and organizations) and biophysical systems. The potential for focused studies at a range of spatial, temporal, and organizational scales is considerable, as is the potential practical value of research findings. If developed effectively, the kinds of studies that team members envision could prove to be very competitive in NSF competitions like the Dynamics of Coupled Natural and Human Systems, and if attention also is given to relevant agriculture and/or other food-related factors, one or more evolving food-energy-water nexus competitions may also be possible sources of funding.

Panelists were impressed with the software development that the team has accomplished, and they were pleased to see the code provided via open-access outlets to facilitate the work by others.

Panelists recognized the potential for future work on visualization, and they viewed the interactive kiosk for the redesign of a climate exhibit in collaboration with the Natural History Museum of Utah as evidence of this kind of work by the team.

Summary of Weaknesses

Although the Utah team has done an excellent job of outlining a research plan that directly addresses critical Utah problems in innovative ways that likely will be of enormous benefit to the state, the fundamental, generalizable value of their research is understated. The character of the research plan indicates that team members are knowledgeable about broader theoretical and conceptual perspectives that should enable their research to have much broader intellectual merit, and the conceptual framework they have developed is appropriate for a far greater range of locales than just those in Utah. Establishing the broader conceptual foundations of the research and demonstrating how project findings will have intellectual merit far beyond specific study sites will be essential as members of the Utah team turn to other NSF competitions for funding to replace dollars previously provided by EPSCoR. The Utah team should make the basic research facets of their work more explicit and seek ways to ensure that future Utah-based research will be viewed as valuable by other scholars addressing other geographic locations. An additional factor for iUTAH researchers to consider is how to ensure that their research will make novel and distinctive contributions to broader knowledge.

The first three years of the project were occupied mostly in successfully deploying the network and launching an ambitious research project. The second part of the project faces the challenge of building a solid body of knowledge that will represent the legacy of the project. The publication outcome of the project has been, up to this point, biased towards ecohydrology. Panelists expect to see high-impact publications coming out of the project in the next couple of years. These new publications should represent the interdisciplinary nature of the project and involve researchers from the different disciplines and universities represented in the project. Panelists suggest that the iUTAH team explicitly develop a strategy to enable the most significant lines of inquiry to be completed during the time period when EPSCoR resources are available.

Research Focus Area 1:

Panelists expressed concern that the lack of groundwater data may hinder the team's ability to address some research questions. They recognize that funding constraints limited the team's ability to invest in groundwater monitoring and that some additional efforts, including a small number of wells and staffing focused on groundwater have been added. As hydrology is central to the research questions posed by iUTAH, panelists remain concerned about the paucity of hydrologic expertise on the project team. The hydrologic modeling necessary to assess the impact of land-use change on climate and streamflow would benefit from more active collaboration by hydrologists. It's unclear to the panel how spatial scaling and hydrologic modeling will be accomplished. The synthetic benchmarks to come in Years 4 and 5 are critical to the success of this research focus area, including the coupling between biophysical and social factors. How can the biophysical data collected in GAMUT inform research in social-ecohydrology? This integration is critical to the team's ability to make fundamental advances in knowledge.

Panelists suggest that iUTAH incorporate spatial data, including GIS layers related to soils, land cover, geology, and other relevant variables, as well as remotely sensed data for their study sites in the data repository as part of the project's cyberinfrastructure.

With respect to Research Focus Area 1.3, the focus area title of "Climate and Land Use Change" is not really appropriate at this stage, because the work so far seems to have emphasized a limited number of land-surface features, but not really land use. Plans for Years 4 and 5 indicate that there may be more attention given to land use as normally conceived, and one of the latter-year objectives is to develop ways to use such refined climate models in land-use change scenarios. This may be more a nitpicky point regarding a general title, because the current broader land-surface-climate interaction work has been and likely will continue to be critical and effective. But Utah team members may want to consider more carefully how they are characterizing sets of variables to be addressed in order to provide others with better understanding of the nature of the projects they have completed, are engaged in now, and will undertake in the future.

Research Focus Area 2:

The social science theoretical contributions regarding landscape transition and transformation need to be more fully articulated. Researchers working in each subarea should ensure that research questions they pursue are based both on broader conceptual framing of projects as well as local circumstances. This will help their research findings to have significant theoretical merit as well as practical societal value.

The social science component of the study conducted a water survey and generated very useful sets of data. This endeavor could have a significant contribution if the analysis were to be extended to generate information on perception of end users on water resources and adaptation strategies in the face of water shortage. Results of this study could also be used to generate valuable information useful for policy makers to make informed decisions. Team members should consider the development of a policy brief outlining science-policy linkage and the role of outputs of this study in managing water resources.

Panelists thought that the conceptualization of the ways that governance influences water supply and demand and the characterization of different institutional contexts are underdeveloped.

Panelists suggest that the team more explicitly consider how agriculture is incorporated into their research activities given the very large share of Utah's water that is used for agriculture.

Panelists were intrigued by the potential for research on green infrastructure, including its social acceptability, but it was difficult to determine exactly what would be done and how it related to the broader goals for this research area.

Panelists observed that few publications had yet appeared regarding work for this research focus area and encourage team members to disseminate their findings in leading social science journals.

Research Focus Area 3:
While continuing to build on successes with respect to both acquisition of data and development of integrative modeling approaches, the Utah team should focus more on the conceptual framing of a set of research projects. This framing will enable the team to more effectively develop intellectually compelling projects that demonstrate the value of their data-collection and data-assimilation work. Panelists suggest that the team specify what theoretically motivated questions this coupled collection of data will answer.

Panelists were concerned that it may be difficult for the team to complete its work on integrating models and data in ways that will permit completion of significant research projects that explicitly address the coupled interactions between human and natural systems and that yield major publications in leading interdisciplinary journals.

Project Elements

Summary of Strengths

Diversity:
The diversity plan is inclusive and what has been achieved so far is excellent involving various groups in the research and training programs. The panel viewed the iFellows program, Water Girls program, USU-Blanding Native American mentorships, research catalyst grants, innovation awards, and near-peer mentoring as exemplary. The panel was impressed with the range of educational opportunities provided by iUTAH that encourage broad participation in iUTAH and more broadly in pursuing STEM fields.

Workforce Development:
The traineeship program and an understanding that young people need to acquire practical workforce skills was a clear strength of the educational efforts provided by iUTAH. Training opportunities for students in programming and geo-visualization are well aligned with workforce demands in these fields.

Cyberinfrastructure:
The data acquisition and sharing plan under the cyberinfrastructure component of the project is one of the strongest contributions of iUTAH. The open data sharing policy will ensure the data exchange and collaborative work not only within iUTAH and EPSCoR but also outside EPSCoR projects. The iUTAH CloudShare collaborative file sharing system and the Modeling and Data Federation (MDF) website that is operational along with a capability of visualization of both raw and value added hydro-climatic information are commendable efforts. Enabling accessibility of GAMUT data via the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) Hydrologic Information System (HIS) HydroDesktop software is another strength.

External Engagement:
The Utah team has done an impressive job of building links among colleges and universities in Utah as well as with selected primary and secondary schools. One senses that the web of educational interactions will continue as more iUTAH programs provide opportunities for students and teachers and the value of those interactions become more widely known. The team also has developed solid working relations with a number of relevant government units and nonprofit organizations. Although comparable interactions with private-sector firms have been more limited, the Utah team appears open to pursuing interactions that may be appropriate to advance research, education, application of findings, and/or workforce development.

Evaluation and Assessment:
Although the Utah team apparently was somewhat stymied in its evaluation and assessment efforts in its early years, its plans are now solid, with reliance on a special expert, engagement of the AAAS, and an external advisory board. The team also appears to be engaging in effective self-assessment.

Sustainability:
This project has made progress that is likely to be sustained because of the institutional links that have been forged. For example, vice presidents for research of the three major research universities in Utah have signed a memorandum of understanding that commits each unit to sustain collaboration initiated through iUTAH. In addition, PIs of the project are working towards securing permanent funding sources in the state that will support the network of sensors beyond 2017. Utah State University and the University of Utah are having cluster faculty hires on the topics pioneered by iUTAH.

Panelists were encouraged to learn that iUTAH researchers are developing proposals for a range of competitions at NSF and elsewhere.

Management:
The panelists were impressed with the progress that the Utah team has made in adjusting to the departure of three key members of the team's initial leadership, and they commend the current team for keeping this project going in meaningful and effective ways. They noted the hiring of an administrative officer as a valuable addition to the team, and they were pleased with the way that the team developed plans for a visualization effort to replace the initial plans to develop environmental situation rooms.

Summary of Weaknesses

Diversity:
While panelists recognize the real challenges to enhancing diversity in the iUTAH team, they encourage the leadership to pursue additional avenues to enhance diversity in both faculty and student groups. As recognized by the leadership team, role models are essential to creating cultural change. The diversity program efforts would also benefit from including farmers (4H, FFA) and other end users who are critical players in using

and managing water resources. On-farm demos on effective farm water management, workshops, and environmental education on water resources could be beneficial.

Workforce Development:
Panelists questioned how the iUTAH team assesses workforce demands in Utah and if jobs will be available to students in appropriate areas following project participation. Panelists encourage iUTAH to raise this issue with policy-makers to consider future job needs and how iUTAH is helping to prepare a scientifically literate workforce.

Cyberinfrastructure:
The CI effort could further capitalize on existing achievements by expanding options for data presentation and outputs beyond the raw data. This will be helpful for non-technical users. Panelists also suggested that the iUTAH website make it easier to identify and access publications and other products resulting from the team's work.

Management:
Panelists strongly encouraged the team to continue efforts to broaden the diversity of its membership, including the key leadership positions.

The panel encourages the iUTAH leadership to explicitly articulate a timeline for completion of the most critical tasks, including completion of major projects focusing on the coupling of natural and human systems and publication of results in high-impact journals.

Jurisdiction-Specific Award Conditions

The award-specific conditions related to education plans have previously been satisfied. Panelists thought that educational activities were a continuing strength of the project.

Prior RSV Recommendations

1. "Demonstrate progress on social science research by designing social science research protocols and instruments before the end of Year 2":

> The Utah team has done an excellent job of responding to this recommendation, with research protocols now being implemented in a number of different ways.

2. "Show evidence of a tight coupling between social and biophysical sciences through specific initiatives in joint research problems, questions, methodological procedures, and survey instruments":

> The Utah team has made commendable progress in advancing its capabilities to bridge the biophysical sciences and the social and engineering sciences through coordinated data-collection and methodological advances. As noted above, more attention needs to be given to grounding research that will explicitly address human and natural system interactions in a broader conceptual framework, and

the fundamental questions to be pursued with initial studies should be driven by a desire to speak to broader scholarly discussions as well as to the focused needs in Utah. In sum, trends are positive, but the next few years will be critical as researchers start to demonstrate the value of their integrated approach.

3. "Create a plan to address the lack of groundwater expertise":

Recommendations for including expertise in groundwater modeling in the team are addressed as shown in Year 3 report. Recommendations to add groundwater monitoring wells and include a groundwater component in Research Focus Area 1 were partially addressed. Existing monitoring programs by the US Geological Survey (USGS) and those shallow groundwater monitoring wells installed by Brigham Young University (BYU) along with groundwater modeling efforts by other researchers will address the concern. Panelists remain uncertain as to whether appropriate hydrologic expertise has been added to the team and as to how relevant work will be conducted.

4. "Develop a precise set of requirements for contributing data and models to the iUTAH web portal":

This recommendation was addressed in the Year 3 report. The project is now using uniform requirements for contributing data and models to the iUTAH web portal.

Summary Statement

The iUTAH team is addressing a significant issue that is relevant in Utah and elsewhere. Substantial progress has been made in accomplishing project goals. Significant improvements have been made in transforming the research capacity and culture within the state of Utah. The team is poised to make significant intellectual contributions to theory associated with coupled natural and human systems, but it needs to more explicitly ground its work in theory so that project findings will have high intellectual merit and strong positive impacts. The team also needs to ensure it is well positioned to make the strongest possible case for support from other sources as it transitions out of EPSCoR.

Panelists were impressed with the broad range of education and outreach activities that the team has accomplished, and they thought that the broader impacts of this project were very positive.

Panelists suggest that the following issues be given special attention:

- The theoretical foundations and contributions of the team's work need to be made more explicit in order for their work to have intellectual significance well beyond Utah. Panelists believe that the team should make clear what

theoretically motivated questions their data-collection and data-analyses efforts will answer.

- iUTAH would benefit from developing a strategy and timeline to enable the most significant lines of interdisciplinary inquiry to be completed during the time period when EPSCoR resources are available.

- Given the central role that hydrology plays in iUTAH's work, the team would benefit from additional hydrologic expertise, especially with respect to groundwater research, data, and modeling.

- The social science theoretical contributions regarding landscape transition and transformation need to be more fully articulated. Panelists observed that few publications have appeared yet regarding the team's social science research, and they encourage team members to disseminate their findings in leading social science journals.

- iUTAH will benefit from the development of a timeline for completion of major projects focusing on the coupling of natural and human systems that will result in the publication of results in high-impact journals.

Recommendations

1. iUTAH would benefit from explicitly stating how the theoretical foundations and contributions of the team's work will have intellectual significance beyond Utah
    a) Explain how future endeavors and work to date on theoretical foundations and frameworks will be applicable regionally, nationally, or globally. Describe what theoretically motivated questions the iUTAH data-collection and data-analyses efforts will answer.
    b) Submit a plan for ensuring that the theoretical social science contributions regarding landscape transition and transformation build on progress to date and that research findings will be disseminated, especially to the scientific community through peer-reviewed publications.

2. Develop a project-wide plan for ensuring the most significant lines of interdisciplinary inquiry are completed during the remaining project period. This plan should:
    a) ensure that projects focusing on the coupling of natural and human systems are completed;
    b) establish mechanisms for effectively disseminating research results and key findings from across the research focus areas (especially from interdisciplinary investigations) and ensure that they are identified for publication in peer-reviewed journals; and,
    c) identify candidate high-impact high-visibility journals for submitting high-impact research results.

3. While hydrological processes are central to the iUTAH project goals and objectives, it is not apparent that the necessary data, modeling, or expertise have or will take place to address these questions. This issue was raised by the first RSV panel and has not been adequately addressed. Develop a strategy for expanding research capacity in groundwater hydrology, either through team members or collaborations, to ensure that iUTAH has appropriate expertise to address the major research goals that involve hydrological processes.

4. Submit a plan for sustaining project activities and infrastructure beyond the period of the RII Track-1 funding. Address in particular the strategies for:
    a) securing funding to sustain key infrastructure such as observations in GAMUT and cyberinfrastructure facilities; and,
    b) submitting proposals to secure funding for research; the plan should specifically address future calls for multidisciplinary and complex collaborative research efforts that would both build on and sustain elements of iUTAH accomplishments.

Plans and strategies requested above must:

- include timelines and metrics or milestones;
- name responsible parties for carrying out specified tasks or following up on actions items; and,
- Describe the anticipated outputs or deliverables.