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Preview of Award 1010516 - Annual Project Report

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Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1010516
Project Title:	CNH: Acequia Water Systems Linking Culture and Nature: Integrated Analysis of Community Resilience to Climate and Land-Use Changes
PD/PI Name:	Alexander G Fernald, Principal Investigator Jose A Rivera, Co-Principal Investigator Vincent Tidwell, Co-Principal Investigator John L Wilson, Co-Principal Investigator
Recipient Organization:	New Mexico State University
Project/Grant Period:	09/15/2010 - 02/29/2016
Reporting Period:	09/01/2014 - 08/31/2015
Submitting Official (if other than PD\PI):	Alexander G Fernald Principal Investigator
Submission Date:	06/09/2015
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Alexander G Fernald

Accomplishments

* What are the major goals of the project?

The goals of this project are to understand acequia-moderated linkages between culture and nature and to quantify community survival tipping points. The objective is to quantify the role of acequias in hydrologic buffering, community resilience, and ecosystem health. The **central hypothesis** is that traditional acequias create and sustain intrinsic linkages between human and natural systems that increase community and ecosystem resilience to climatic and socioeconomic stresses. Two sets of linkages are explored: 1) socioeconomic and cultural acequia linkages within and between communities and uplands; and 2) hydrologic acequia linkages between surface water and groundwater in river valleys and contributing watersheds. The working null hypothesis is that stresses from climate change and population growth will have no appreciable effect on the function, performance resilience, and longevity of agro-enviro-social systems of acequia communities.

The following list highlights major anticipated outcomes of the project. The cited years represent the expected initiation and completion dates. The ambitious proposed outcomes are realistically obtainable due to ongoing successful team cooperation and infrastructure foundations established by NM EPSCoR. The NM EPSCoR project that ended in 2013 treated the topic of NM sources of mountain runoff. The physical infrastructure developed under NM EPSCoR allows this proposed project to address complex questions at multiple spatial scales without a large investment in equipment and materials. This leveraging of a complementary project enables budget allocation for participants with all expertise needed to complete the major outcomes listed below and described in more detail in the proposal text. The NM EPSCoR project that began in 2013, titled *Energize New Mexico*, treats the topic of regional water budgets and continues to complement this study.

a) A system dynamics decision support system, the Rio Grande Water and Society Simulation Model (RGWSSIM), will allow simulations of changes in human and natural systems linked by acequia communities. RGWSSIM will operate on a computer and be accessible to community users. Scenarios will consider climate and economic changes as well as stakeholder-defined impacts such as climate and land use on river/riparian function, trade-offs among competing agricultural practices, and associated economic/environmental consequences of alternative resource management strategies. Years 1-5. **Ongoing**

b) A model of acequia community economic adaptability and resilience that will provide cutting-edge analysis of community economics and resource use. The project will yield entirely new analyses of sociocultural and economic relationships in acequia communities. It will characterize dynamics of changing natural resource use in a multi-cultural setting across multiple temporal and spatial scales. The analysis will address significant recent pressures on acequia communities and provide quantified estimates of community resilience tipping points. The model and analysis will inform the RGWSSIM with functions developed to describe equitable resource sharing and sustainable land use. Years 1-5. **Ongoing**

c) An integrated multi-model and multi-scale approach to studying hydrologic connections between managed agricultural valleys and associated unmanaged forested watersheds. Applied to this unique setting, the suite of models will provide state-of-the-art advances in two areas of hydrologic research: 1) multiple flow path and residence time analysis of surface-subsurface exchange over small to large spatial scales, and 2) ecohydrologic connectivity analysis of managed and unmanaged human and natural landscapes. Water budget and flow-path analyses will also be used to parameterize and inform the RGWSSIM. Years 1-5. **Ongoing**

d) Educational programs for K-12, undergraduates, graduate students, teachers, stakeholders, and the general public. K-12 student efforts will tap into NM EPSCoR programs. This project will support undergraduate and graduate college students, importantly at multiple minority-serving institutions. Extension service-directed programs and local community group programming will reach community members as will the New Mexico Acequia Association. The general public had access to a museum exhibit about multiple human and natural aspects of acequia communities. Currently, the ARTS Lab of UNM is documenting the exhibit, as a permanent virtual exhibit for posting on a website accessible by the public, The Virtual New Mexico Project. The website will be used as a deliverable in 2016. Years 1-5. **Ongoing/Completed museum exhibit is open to the public until Saturday, June 6, 2015**

e) Integrated online atlas with maps of human and natural interactions in the upland to irrigated valley continuum and at multiple scales, including the local, valley, and regional scales. These maps will identify communities,

water works, wildlife habitat, biodiversity, wildlife corridors, upland vegetation, grazing areas, hydrology source and sink areas. For policy development, the maps will also show resource scenarios with different impacts as mentioned above based on the system dynamics model outputs and the mapping spatial analysis. Years 3-5. **Ongoing**

f) Peer reviewed articles (at least 14 total with two per senior personnel) addressing the different topics investigated in this research effort and participation in local, national, and international meetings for project results dissemination. Years 2-5. **Ongoing**

Study the Rio Chama basin region in Rio Arriba County to test ideas about the coupling of natural and human systems dynamics.

The major goal of this specific component of the CNH Acequia project is to understand the role that small-scale raising of livestock plays in conferring resilience to acequia communities of Northern New Mexico. We seek to assess the conditions and characteristics of small-scale livestock operations and identify livestock-related factors that could trigger future community tipping points.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: The modeling effort has followed standard SD modeling procedures. During the first three months of Ben Turner's PostDoc, he read previous literature (developed by team members but also other literature relevant to acequias, water resources management, and modeling in general, etc.) as well as communicated with several key team members to develop the Dynamic Hypothesis to guide quantitative model construction. Ben then developed various components in the model and organized data that would be used for reference modes or model inputs. Once the model was in an early working order, calibration to existing data was done for the Alcalde study community. The other two communities will be calibrated once the model interface and timing issues are determined for the existing Alcalde model. During this time, Ben Turner has documented the model development process in two conference papers (*System Dynamics Society International Conference*). The papers will be packaged together, along with results from the first objective (see below) for the first journal article submission. The second journal article submission will focus on scenario testing. Although the model is not ready for this yet, Ben has been working with the team to develop 7 or 8 key focusing questions that will be tested using the model.

Specific Objectives: The first objective is to conduct robust sensitivity analysis of the model to changes in qualitative and unknown variables in order to identify 'tipping points' of sustainability (i.e., at what point do changes in certain variables create undesirable changes in the make-up of the acequia community). This is currently in process.

The second objective is to test specific economic and policy scenarios that threaten the sustainability of acequias. This differs from objective 1 (which used endogenous variables of unknown certainty of parameter values) by using policy and economic forcings to the model.

Significant Results: Significant results to date primarily include having built the model. By September, the tipping points analysis and scenario tests will be completed with at least one journal article submitted (in *Sustainability*).

Key outcomes or Other achievements: The core group met in Mescalero, New Mexico on December 12 and 13, 2014 to begin writing a High Impact Paper. The core group will attend another meeting July 15 and 16 in Santa Ana Pueblo, NM to complete the High Impact Paper and prepare it for submission. The goal is to submit this paper Fall of 2015.

*** What opportunities for training and professional development has the project provided?**

The project has trained undergraduate, masters, and PhD students. It has provided professional development for field hydrologists, museum curators, and community hydrologists.

*** How have the results been disseminated to communities of interest?**

Steve Guldán representing the Agricultural Science Center at Alcalde, has completed numerous presentations to various audience types including: international visitors, the Institution of American Indian Arts, Ghost Ranch Conference Center class, NMSU Ag Development class, USDA/Western SARE administrators, Western State Department of Agriculture Directors, and to international conference participants at the Congresos de la Universitat Politecnica de Valencia, Irrigation, Society and Landscape in Valencia, Spain. The presentations included walking tours of the Alcalde Research Station, oral presentations, and slideshows. The audience size varied from 5 to 150 people.

*** What do you plan to do during the next reporting period to accomplish the goals?**

The project will produce a book that will make research results available and understandable to a wide range of stakeholders in NM as well as community irrigation leaders and water managers from other regions.

The project will also produce a High Impact Paper that will enlarge impacts to a global scale. The paper will include principles we are learning that can be used elsewhere.

The High Impact Paper and book will provide on research efforts usable for integrated modeling that will contribute to enhancing science and get that information to researchers and practitioners.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
CNH retreat.pdf	The core group met in Mescalero, NM on December 12 and 13, 2014 to begin work on the "High Impact Paper" and attached are the notes from the meeting as well as graphics that were drawn during the meeting while discussing ideas. The "High Impact Paper" wi	Alexander Fernald	06/09/2015

Products

Books

Book Chapters

Conference Papers and Presentations

Gonzales, M., J. Rivera, and S. Thompson (2014). *Agricultural adaptations and land use change in acequia irrigation settlements at the Rio Chama and Rio Grande confluence of New Mexico*. 2014 JCOWR Conference. Tufts University, Medford, MA. Status = UNDER_REVIEW; Acknowledgement of Federal Support = Yes

Gonzales, M. (2013). *Climate connections, resurfacing cities of the American Southwest*. Climate Change Town Hall Meeting, New Mexico Sierra Club. Albuquerque, New Mexico. Status = OTHER; Acknowledgement of Federal Support = Yes

Fernald, A., J. Rivera, S. Rodriguez, V. Tidwell, C. Ochoa, Q. Ortiz, and S. Guldan (2015). *Connectivity of coupled hydrologic and human systems as the basis of resilience in traditional irrigation communities in New Mexico*. Congresos de la Universitat Politecnica de Valencia, Irrigation, Society and Landscape. Tribute to Tom F. Glick. Valencia, Spain. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Turner, B., and V. Tidwell (2015). *Developing a System Dynamics Model to Investigate Sustainability of Traditional Acequia Communities of New Mexico*. The 33rd International Conference of the System Dynamics Society. Cambridge, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Guldan, S., A. Fernald, and C. Ochoa (2015). *Documenting hydrological benefits of traditional acequia irrigation systems: collaborative research in New Mexico, USA*. Congresos de la Universitat Politecnica de Valencia, Irrigation, Society and Landscape. Tribute to Tom F. Glick. Valencia, Spain. Status = SUBMITTED; Acknowledgement of Federal Support = Yes

Stewart-Maddox, N., V. Ward, K. Coker, E. Tysor, J. Wilson, M. Frisbee and T. Schlossnagle (2013). *Groundwater/surface-water interaction in a losing reach of the El Rito Watershed*. Geological Society of America Ann. Mtg.. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tolley, D., M.D. Frisbee, J.J. Harding and J.L. Wilson (2013). *High elevation streamflow generation*. Geological Society of America Ann. Mtg. Denver, CO. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Rivera, J., J.E. Arellano, E.R. Lamadrid, and T.M. Saldana (2015). *Irrigation and society in the Upper Rio Grande Basin, USA: A heritage of mutualism*. Congresos de la Universitat Politecnica de Valencia, Irrigation, Society and Landscape. Tribute to Tom F. Glick. Valencia, Spain. Status = SUBMITTED; Acknowledgement of Federal Support = Yes

Cruz, J.J., A.G. Fernald, K.J. Gutierrez, C.O. Ochoa, and S.J. Guldan (2014). *Irrigation water balance of agricultural corridors in Northern New Mexico*. 59th Annual New Mexico Water Conference. Santa Fe, NM. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Turner, B., and V. Tidwell (2015). *Model Evaluation and Sensitivity Analyses of an Acequia Community Irrigation System Dynamics Model*. International Conference of the System Dynamics Society. Cambridge, MA. Status = OTHER; Acknowledgement of Federal Support = Yes

Arumi, J.L., O. Melo, J. Nunez, and M. Billib (2015). *Riego y Usuarios del Agua en Chile. Desde la Revolucion a la Evolucion*. Congresos de la Universitat Politecnica de Valencia, Irrigation, Society and Landscape. Tribute to Tom F. Glick. Valencia, Spain. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Steele, C., E. Elias, A. Rango, J. Mejia, and A. Fernald (2014). *Simulating streamflow under a warming climate: implications for acequia communities in the Upper Rio Grande*. Western Snow Conference 2014. Durango, Colorado. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tysor, Elizabeth H., J. Howard, N.S. Maddox, J. Swanson, A. Degon, M.D. Frisbee, J.L. Wilson, and B. Newman (2014). *Springs and the role of stratigraphy and structure on streamflow generation in El Rito Watershed*. Geological Society of America, Annual Meeting. Vancouver, British Columbia. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Ochoa, C., S. Guldan, A. Fernald, V. Tidwell, E. Elias, K. Gutierrez, and M. Borman (2014). *Surface water and shallow groundwater interactions in semiarid agro-ecosystems of the western USA*. European Geosciences Union, General Assembly. Vienna, Austria. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

J. Swanson, N. Stewart-Maddox, A. Degon, J. Howard, L. Tsinnajinnie, M.D. Frisbee, J.L. Wilson, and B.D. Newman (2014). *Testing a community water supply well located near a stream for susceptibility to stream contamination and low-flows*. American Geophysical Union, Fall Annual Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Tsinnajinnie, L., M. Frisbee and J.L. Wilson (2013). *The Relationship between streamflow in the El Rito watershed, New Mexico, and recharge variability, residence times, and springflow*. American Geophysical Union, Fall Ann. Mtg.. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Stewart-Maddox, Noah, A. Degon, E.H. Tysor, J. Swanson, J. Howard, M.D. Frisbee, J.L. Wilson, and B. Newman (2014). *The role of structure and stratigraphy on groundwater/surface-water interactions in a gaining reach of the El Rito Watershed*. Geological Society of America Annual Meeting. Vancouver, British Columbia. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Degon, A., E.H. Tysor, J. Swanson, J. Howard, L. Tsinnajinnie, M.D. Frisbee, J.L. Wilson, and B.D. Newman (2014). *The role of structure and stratigraphy on groundwater/surface-water interactions in a gaining reach of the El Rito Watershed*. American Geophysical Union, Fall Annual Meeting. San Francisco, CA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Inventions

Journals

Fernald, A., S. Guldán, K. Boykin, A. Cibils, M. Gonzales, B. H. Hurd, S. Lopez, C.G. Ochoa, M. Ortiz, J. Rivera, S. Rodriguez, and C.M. Steele (2015). Linked hydrologic and social systems that support resilience of traditional irrigation communities. *Hydrology and Earth System Sciences*. 19 . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5194/hess

Fleming, W.M., J.A. Rivera, A. Miller, and M. Piccarello (2014). Ecosystem services of traditional irrigation systems in northern New Mexico, USA. *International Journal of Biodiversity Science, Ecosystem Services & Management*. 10 (4), 343-350. Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1080/21513732.2014.977953

Raheem, N., S. Archambault, E. Arellano, M. Gonzalez, D. Kopp, J. Rivera, S. Guldán, K. Boykin, C. Oldham, A. Valdez, S. Colt, E. Lamadrid, J. Wang, J. Prince, J. Goldstein, P. Arnold, S. and Martin, E. Dingwell (). A framework for assessing ecosystem services in acequia irrigation communities of the Upper Rio Grande Watershed. *WIREs Water*. . Status = ACCEPTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Steele C.M., E. Elias, and A. Rango (). Simulating historical runoff from Upper Rio Grande sub-basins with the Snowmelt Runoff Model. *Journal of Hydrology Regional Studies*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Tolley, D., M. Frisbee and J.L. Wilson (2015). Deep groundwater contributions to streamflow in the high-elevation Crystalline Bedrock Rio Hondo Watershed, Northern New Mexico, USA. *Water Resources Research*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Tysor, E., N. Stewart-Maddox, M.D Frisbee and J.L. Wilson. (2015). The role of groundwater in the generation of streamflow in a sedimentary mountain catchment. *Water Resources Research*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes

Licenses

Other Products

Physical Collections.

Acequia Museum Exhibit:

Description and Purpose: The exhibit at UNM's Maxwell Museum of Anthropology opened on May 3, 2014, and featured study description and results, artifacts, instruments, photographs, video, farm tools, and other products based on the NSF CNH research in New Mexico. It will close in June of 2015. Currently the ARTS Lab of UNM is documenting the exhibit as a permanent virtual exhibit for posting on a website accessible by the public. The virtual exhibit is entitled, Virtual New Mexico Project.

How shared: The opening celebration, of "El Agua es Vida: Acequias in New Mexico," was free to the university community, acequia organizations in New Mexico, general public and media.

Funding was provided to the Maxwell Museum in an NSF CNH/NMSU subaward, plus supplemental funding from the UNM Center for Regional Studies, with co-sponsorship by the Friends of the Maxwell Museum and the Alfonso Ortiz Center for Intercultural Studies.

NSF Acknowledged: YES

A few donated parts of the exhibit will eventually be housed at the New Mexico Water Resources Research Institute at New Mexico State University.

CNH Acequia DropBox.

A secure web-based external repository that allows invited project participants efficient access to all data and information relevant to the CNH project

Invited talk to the general public.

Dr. Brian Hurd performed a presentation: "A Global View on Climate Change and Water and Food Security Challenges" to 51-100 general public participants in April 2015.

Other Publications

Lopez, S.C., A.F. Cibils, U. Smedly, S. Guldán, S. Fernald, C. Ochoa. (2014). *Linkages between livestock -raising and Acequia irrigation farming in traditional agropastoral communities of northern New Mexico*. Submitted summer of 2014. Status = OTHER; Acknowledgement of Federal Support = Yes

Patents**Technologies or Techniques****Thesis/Dissertations**

Lopez, SC. S. Guldán, S. Fernald, and C. Ochoa. *The role of livestock in suppressing rangeland weeds and sustaining traditional agropastoral communities in northern New Mexico*. MS Thesis. 124 p. Las Cruces, NM. (2014). New Mexico State University. Acknowledgement of Federal Support = Yes

Websites

New Exhibit on Acequias at the Maxwell Museum

http://newmexicomercury.com/blog/comments/new_exhibit_on_acequias_at_the_maxwell_museum

A review of the Acequia Exhibit, "El Agua Es Vida" by Michael Agar, an anthropologist, for VB Price's blog, NM Mercury.

The National Science Foundation is recognized within the

review. Supporting Files

Filename	Description	Uploaded By	Uploaded On
Documenting Hydrological Benefits of Traditional Acequia Irrigation Systems Collaborative Research in New Mexico, USA.pdf	A paper presented by Steve Guldán and Alexander Fernald in Valencia, Spain as a part of the Irrigation, Society, Landscape, Tribute to Thomas F. Glick at Valencia, Universitat Politècnica de Valencia 2014	Alexander Fernald	06/04/2015
Connectivity of Coupled Hydrologic and Human Systems as the Basis of Resilience in Traditional Irrigation Communities in New Mexico.pdf	A paper presented by Alexander Fernald, Jose Rivera, Sylvia Rodríguez, and Steve Guldán in Valencia, Spain as a part of the Irrigation, Society, Landscape, Tribute to Thomas F. Glick at Valencia, Universitat Politècnica de Valencia 2014	Alexander Fernald	06/04/2015
Irrigation and Society in the Upper Rio Grande Basin, USA A Heritage of Mutualism.pdf	A paper presented by Jose Rivera in Valencia, Spain as a part of the Irrigation, Society, Landscape, Tribute to Thomas F. Glick at Valencia, Universitat Politècnica de Valencia 2014	Alexander Fernald	06/04/2015
Riego y Usuarios del Agua en Chile. Desde la Revolución a la Evolución.pdf	A paper presented by Jose Luis Arumi in Valencia, Spain as a part of the Irrigation, Society, Landscape, Tribute to Thomas F. Glick at Valencia, Universitat Politècnica de Valencia 2014	Alexander Fernald	06/04/2015

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Fernald, Alexander	PD/PI	2
Rivera, Jose	Co PD/PI	1
Tidwell, Vincent	Co PD/PI	1
Wilson, John	Co PD/PI	4
Guldán, Steve	Co-Investigator	2
Arumi, Jose	Faculty	1

Name	Most Senior Project Role	Nearest Person Month Worked
Boykin, Kenneth	Faculty	1
Cibils, Andres	Faculty	1
Frisbee, Marty	Faculty	2
Gomez-Velez, Jesus	Faculty	0
Gonzales, Moises	Faculty	1
Hurd, Brian	Faculty	2
Ochoa, Carlos	Faculty	1
Phillips, Fred	Faculty	1
Rodriguez, Sylvia	Faculty	1
Steele, Caitriana	Faculty	1
Gunda, Thushara	Postdoctoral (scholar, fellow or other postdoctoral position)	0
Turner, Benjamin	Postdoctoral (scholar, fellow or other postdoctoral position)	2
Garcia, Paula	Other Professional	0
Newman, Brent	Other Professional	1
Ortiz, Marquita	Other Professional	1
Romanek, Devorah	Other Professional	1
Herrera, Fernando	Technician	1
Cruz, Jose Juan	Graduate Student (research assistant)	8
Gutierrez, Karina	Graduate Student (research assistant)	4
Lopez, Alejandro	Graduate Student (research assistant)	7
Sabie, Robert	Graduate Student (research assistant)	5
Tolley, Douglas	Graduate Student (research assistant)	1

Name	Most Senior Project Role	Nearest Person Month Worked
Tsinnajinnie, Lani	Graduate Student (research assistant)	1
Wang, Chao	Graduate Student (research assistant)	1
Ratliff, Jesslyn	Non-Student Research Assistant	4
Degon, Amber	Undergraduate Student	0
Stewart-Maddox, Noah	Undergraduate Student	3
Swanson, Jake	Undergraduate Student	0
Tysor, Elizabeth	Undergraduate Student	3

Full details of individuals who have worked on the project:

Alexander G Fernald

Email: fernald@nmsu.edu

Most Senior Project Role: PD/PI

Nearest Person Month Worked: 2

Contribution to the Project: Alexander Fernald is the PI and overseer of the CNH Acequia Project and Team Members.

Funding Support: NM EPSCoR

International Collaboration: Yes, Chile

International Travel: Yes, Spain - 0 years, 0 months, 3 days

Jose A Rivera

Email: jrivera@unm.edu

Most Senior Project Role: Co PD/PI

Nearest Person Month Worked: 1

Contribution to the Project: Jose Rivera serves as Co-PI of NSF grant to NMSU and as the PI of a subaward from NMSU to UNM. Compiled research reports submitted by four CNH supported graduate students from 2011 to 2014: socio-ecological history of the Rio Chama Basin; Cultural Mapping Inventory of Land and Water Resources; Agricultural Small Farm Land Use Study; Homesteads and Place Names Database of Santa Fe National Forest.

Funding Support: None

International Collaboration: Yes, Spain

International Travel: Yes, Spain - 0 years, 0 months, 3 days

Vincent Tidwell**Email:** vctidwe@sandia.gov**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 1

Contribution to the Project: Vince Tidwell guides the systems modeling component of the project and also assisted in general project planning.

Funding Support: NM EPSCoR

International Collaboration: No

International Travel: No

John L Wilson**Email:** jwilson@nmt.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 4

Contribution to the Project: John Wilson led hydrologic studies of mountain watersheds.

Funding Support: NM Tech GRC; Other NSF grant (GW Age)

International Collaboration: No

International Travel: No

Steve Guldán**Email:** sguldán@nmsu.edu**Most Senior Project Role:** Co-Investigator**Nearest Person Month Worked:** 2

Contribution to the Project: Steve Guldán is assisting with data collection and publications. Coordinates assistance of Alcalde staff on some aspects of field work. Steve also presents project objectives and results as needed at meetings and when giving tours at the Alcalde Science Center.

Funding Support: none

International Collaboration: No

International Travel: Yes, Spain - 0 years, 0 months, 3 days

Jose Arumi**Email:** jarumi@udec.cl**Most Senior Project Role:** Faculty**Nearest Person Month Worked:** 1

Contribution to the Project: Dr. Jose Luis Arumi is currently working on the project 'Water availability in a stressed Andean watershed in Central Chile: Vulnerability under climate variability', funded by the Chilean Sciences Council (Fondecyt) that can be used as a parallel Chilean research project. The creation of a new Water Center will provide the basis of future collaboration between the Acequia Team, the Chilean partners, and the Chilean canal users.

Funding Support: Support from his home university

International Collaboration: Yes, Chile
International Travel: Yes, Spain - 0 years, 0 months, 3 days

Kenneth Boykin

Email: kboykin@nmsu.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: Kenneth Boykin oversees a graduate student and participating in collaborative research that includes developing the project scope and modeling.

Funding Support: none

International Collaboration: No
International Travel: No

Andres Cibils

Email: aciblis@nmsu.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 1

Contribution to the Project: Andres Cibils studies the role of livestock in acequia community resilience and is involved in manuscript development.

Funding Support: New Mexico Agricultural Experiment Station

International Collaboration: No
International Travel: No

Marty Frisbee

Email: mdfrisbee@purdue.edu
Most Senior Project Role: Faculty
Nearest Person Month Worked: 2

Contribution to the Project: Marty Frisbee worked closely with the team on field work, modeling and interpretation and wrote papers.

Funding Support: none

International Collaboration: No
International Travel: No

Jesus Gomez-Velez

Email: jdgomez7127@gmail.com
Most Senior Project Role: Faculty
Nearest Person Month Worked: 0

Contribution to the Project: Jesus Gomez-Velez is a new professor and contributed to modeling and results synthesis.

Funding Support: USGS

International Collaboration: No
International Travel: No

Moises R Gonzales

Email: mgonzo1@unm.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 1

Contribution to the Project: Moises Gonzales developed a proposal to the McCune Foundation to conduct capacity building in rural economic development at Rio Arriba and Santa Fe County Indo-Hispano Villages that will extend and complement the work of the NSF CNH project. The proposal was funded at \$20,000 and the project commenced in May 2015 and will be followed by a summer field school in June and July of 2015.

Funding Support: Tri-State EPSCoR, NM EPSCoR, McCune Foundation

International Collaboration: No
International Travel: No

Brian Hurd

Email: bhurd@nmsu.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 2

Contribution to the Project: Brian Hurd contributed to collaborative research and Brian is the lead investigator on Socio-Economic Assessment and Analysis.

Funding Support: none

International Collaboration: No
International Travel: No

Carlos Ochoa

Email: carlos.ochoa@oregonstate.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 1

Contribution to the Project: Carlos Ochoa has participated in several meetings to discuss project findings and publication of results. He contributes to project outreach. Aspects of this project were incorporated into a case study analysis for undergrad and graduate level classes in Watershed Management and Riparian Ecology Management that were taught in the winter term, (Jan-Mar), 2015 at OSU.

Funding Support: Oregon Agricultural Experiment Station

International Collaboration: No
International Travel: No

Fred M Phillips

Email: phillips@nmt.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 1

Contribution to the Project: Fred Phillips advised on field methods and results synthesis.

Funding Support: New Mexico Tech GRC

International Collaboration: No

International Travel: No

Sylvia Rodriguez

Email: sylrodri@unm.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 1

Contribution to the Project: Sylvia Rodriguez is the project consultant from UNM. She participated in the development and acted as guest curator of an exhibit, entitled "El Agua es Vida: Acequias in New Mexico," at the Maxwell Museum of Anthropology at UNM (Albuquerque campus). The exhibit was showcased on May 3, 2014 and was taken down on June 6, 2015.

Funding Support: none

International Collaboration: No

International Travel: Yes, Spain - 0 years, 0 months, 3 days

Caitriana Steele

Email: caiti@nmsu.edu

Most Senior Project Role: Faculty

Nearest Person Month Worked: 1

Contribution to the Project: Caitriana Steele worked with data from the snow runoff simulations.

Funding Support: NMSU/Jornada

International Collaboration: No

International Travel: No

Thushara Gunda

Email: tgunda@gmail.com

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 0

Contribution to the Project: Thushara Gunda will perform watershed modeling summer of 2015.

Funding Support: none

International Collaboration: No

International Travel: No

Benjamin Turner

Email: bturner@nmsu.edu

Most Senior Project Role: Postdoctoral (scholar, fellow or other postdoctoral position)

Nearest Person Month Worked: 2

Contribution to the Project: Benjamin Turner is a collaborative researcher who is assisting with the integrated modeling effort.

Funding Support: none

International Collaboration: No

International Travel: No

Paula Garcia

Email: lamorena@lasacequias.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 0

Contribution to the Project: Paula Garcia contributed to the project through the New Mexico Acequia Association.

Funding Support: NMAA

International Collaboration: No

International Travel: No

Brent Newman

Email: bnewman@lanl.gov

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: Brent Newman provided field studies and assisted with radon surveys of streams.

Funding Support: none

International Collaboration: No

International Travel: No

Marquita Ortiz

Email: quita@lasacequias.org

Most Senior Project Role: Other Professional

Nearest Person Month Worked: 1

Contribution to the Project: Marquita Ortiz provided acequia expert input and survey involvement with Dr. Hurd and Dr. Rivera. She worked with Dr. Rivera on socio-cultural data collection and analysis and she collaborated on the "El Agua es Vida: Acequias in New Mexico" exhibit housed at the Maxwell Museum in Albuquerque, NM. Conducted outreach for the exhibit.

Funding Support: NMAA

International Collaboration: No

International Travel: Yes, Spain - 0 years, 0 months, 3 days

Devorah Romanek

Email: dromanek@unm.edu

Most Senior Project Role: Other Professional
Nearest Person Month Worked: 1

Contribution to the Project: Devorah Romanek is the ethnology curator for the Maxwell Museum at UNM in Albuquerque, NM and prepared the museum exhibit that was showcased on May 3, 2014 and helped to close the exhibit on June 6, 2015.

Funding Support: UNM

International Collaboration: No
International Travel: No

Fernando Herrera

Email: fah@nmsu.edu

Most Senior Project Role: Technician
Nearest Person Month Worked: 1

Contribution to the Project: Fernando Herrera tests, calibrates, deploys, and implements hardware designed to collect data at remote sites and provides routine maintenance as well as gathers and delivers raw data to researchers.

Funding Support: none

International Collaboration: No
International Travel: No

Jose Juan Cruz

Email: cruzjuan@nmsu.edu

Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 8

Contribution to the Project: Jose Juan Cruz collaborates on research involving agricultural water distribution in acequia irrigated valleys in Northern New Mexico.

Funding Support: CONACYT (Consejo Nacional de Ciencia Y Tecnologia) INIFAP (Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias)

International Collaboration: No
International Travel: No

Karina Gutierrez

Email: kgutier@nmsu.edu

Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 4

Contribution to the Project: Karina Gutierrez assisted Dr. Fernald with data research in Northern New Mexico for the CNH project and for her graduate work. Karina graduated December 2014.

Funding Support: none

International Collaboration: No
International Travel: No

Alejandro Lopez**Email:** arlopez@nmsu.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 7**Contribution to the Project:** Alejandro Lopez is Assisting Dr. Fernald and Dr. Guldán with data research in Northern New Mexico.**Funding Support:** Some funding provided by the NMSU Alcalde Research Station-Alcalde, NM. Plant and Environmental Sciences**International Collaboration:** No**International Travel:** No

Robert P Sabie**Email:** rpsabie@nmsu.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 5**Contribution to the Project:** Robert Sabie is involved with collaborative research.**Funding Support:** none**International Collaboration:** No**International Travel:** No

Douglas Tolley**Email:** gustolley@ucdavis.edu**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1**Contribution to the Project:** Douglas Tolley is a research assistant who conducted field measurements; results synthesis and contributed to prepared papers.**Funding Support:** EPSCoR**International Collaboration:** No**International Travel:** No

Lani Tsinnajinnie**Email:** lani.tsinnajinnie@gmail.com**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1**Contribution to the Project:** Lani Tsinnajinnie assisted with field work. She provided research assistance by conducting field measurements and results synthesis.**Funding Support:** EPA**International Collaboration:** No**International Travel:** No

Chao Wang**Email:** chao.wang.1001@outlook.com**Most Senior Project Role:** Graduate Student (research assistant)**Nearest Person Month Worked:** 1**Contribution to the Project:** Chao Wang is a new student who has begun modeling work.**Funding Support:** NM Tech Hantush Fellowship**International Collaboration:** No**International Travel:** No

Jesslyn Ratliff**Email:** jesslynr@nmsu.edu**Most Senior Project Role:** Non-Student Research Assistant**Nearest Person Month Worked:** 4**Contribution to the Project:** Jesslyn Ratliff is the Program Coordinator and provides project support for all of the CNH Acequia Team Members.**Funding Support:** none**International Collaboration:** No**International Travel:** No

Amber Degon**Email:** ad03613@georgiasouthern.edu**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 0**Contribution to the Project:** Amber Degon assisted with field work. Amber was a REU student that conducted field measurements in El Rito.**Funding Support:** none**International Collaboration:** No**International Travel:** No

Noah Stewart-Maddox**Email:** noah.fencer@gmail.com**Most Senior Project Role:** Undergraduate Student**Nearest Person Month Worked:** 3**Contribution to the Project:** Noah Stewart-Maddox conducted field measurements and related laboratory analyses.**Funding Support:** Noah will continue to study Northern NM at Purdue University.**International Collaboration:** No**International Travel:** No

Jake Swanson

Email: jpsalfa11@yahoo.com

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 0

Contribution to the Project: Jake Swanson assisted with field work. He is a REU student who conducted field measurements in El Rito.

Funding Support: none

International Collaboration: No

International Travel: No

Elizabeth Tysor

Email: etysor@gmail.com

Most Senior Project Role: Undergraduate Student

Nearest Person Month Worked: 3

Contribution to the Project: Elizabeth Tysor conducted field measurements and related laboratory analyses.

Funding Support: none

International Collaboration: No

International Travel: No

What other organizations have been involved as partners?

Name	Type of Partner Organization	Location
Acequias of El Rito	Other Nonprofits	El Rito area of Northern New Mexico
Acequias of the Rio Hondo	Other Nonprofits	Rio Hondo area of Northern New Mexico
NMSU Alcalde Science Center	Academic Institution	Alcalde, NM
Natural Resources Conservation Service	Other Organizations (foreign or domestic)	United States
New Mexico Acequia Association	Other Nonprofits	Santa Fe, NM
New Mexico EPSCoR	State or Local Government	Albuquerque, NM
New Mexico Institute of Mining and Technology	Academic Institution	Socorro, NM
Northern New Mexico Stockman's Association	Other Nonprofits	Taos, NM

Name	Type of Partner Organization	Location
Rio Hondo Valley Acequia Association	Other Nonprofits	Taos, NM
Sandia National Laboratories	Other Organizations (foreign or domestic)	Albuquerque, NM
Taos Valley Acequia Association	Other Nonprofits	Taos, NM
UNM Center for Regional Studies	Academic Institution	Albuquerque, NM
Alcalde Acequia Association	Other Nonprofits	Alcalde, NM
UNM Community & Regional Planning Program	Academic Institution	Albuquerque, NM
UNM Maxwell Museum	Academic Institution	Albuquerque, NM
UNM Resource Center for Raza Planning	Academic Institution	Albuquerque, NM
US Geological Survey	Other Organizations (foreign or domestic)	United States
USDA Forest Service; Carson National Forest	Other Organizations (foreign or domestic)	Carson, NM
USDI BLM Taos Field Office	Other Organizations (foreign or domestic)	Taos, NM
Universidad de Concepcion	Academic Institution	Chile, South America
University of New Mexico	Academic Institution	Albuquerque, NM
County Assessor's Office	State or Local Government	Rio Arriba County
El Rito Acequia Association	Other Nonprofits	El Rito, NM
El Rito Regional Water and Wastewater Association	Other Nonprofits	El Rito, NM
Environmental Protection Agency	Other Organizations (foreign or domestic)	United States
La Nueve Acequias en el Rio Grande	Other Nonprofits	Northern New Mexico
Long Term Ecological Research Network	Other Organizations (foreign or domestic)	North America

Name	Type of Partner Organization	Location
Los Alamos National Laboratory	Other Organizations (foreign or domestic)	Los Alamos, NM

Full details of organizations that have been involved as partners:
Acequias of El Rito

Organization Type: Other Nonprofits

Organization Location: El Rito area of Northern New Mexico

Partner's Contribution to the Project:

Facilities

Collaborative Research

More Detail on Partner and Contribution: A. de la Otra Vanda, A. Madre, A. Alire, A. del Monte, and A. del Jaral

Acequias of the Rio Hondo

Organization Type: Other Nonprofits

Organization Location: Rio Hondo area of Northern New Mexico

Partner's Contribution to the Project:

Facilities

Collaborative Research

More Detail on Partner and Contribution: La Cuchilla ditch, A. de Los Prando, A. de San Antonio, Canoncitos ditch north, Canonictos ditch south, A. de Atalaya, A. Madre del Llano, A. de La Plaza

Alcalde Acequia Association

Organization Type: Other Nonprofits

Organization Location: Alcalde, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

County Assessor's Office

Organization Type: State or Local Government

Organization Location: Rio Arriba County

Partner's Contribution to the Project:

In-Kind Support

More Detail on Partner and Contribution: Levi Valdez provided land parcel data to Graduate Student for use in the study of Rio Arriba County land use change 1935-2012

El Rito Acequia Association**Organization Type:** Other Nonprofits**Organization Location:** El Rito, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution:

El Rito Regional Water and Wastewater Association**Organization Type:** Other Nonprofits**Organization Location:** El Rito, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution: Juan Garcia provided interview to Graduate Student regarding El Rito farm and ranch economy.

Environmental Protection Agency**Organization Type:** Other Organizations (foreign or domestic)**Organization Location:** United States**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution: William Kepner and Anne Neale helped to develop biodiversity metrics.

La Nueve Acequias en el Rio Grande**Organization Type:** Other Nonprofits**Organization Location:** Northern New Mexico**Partner's Contribution to the Project:**

Facilities

Collaborative Research

More Detail on Partner and Contribution: A. de Alcalde, A. de la Canova, A. Ancon, A. San Rafael del Guique, A. Madre del Bosque, A. de Los Chicos, A. Garcia, A. del Medio, A. Rinconada Isla

Long Term Ecological Research Network**Organization Type:** Other Organizations (foreign or domestic)**Organization Location:** North America**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution:

Los Alamos National Laboratory**Organization Type:** Other Organizations (foreign or domestic)**Organization Location:** Los Alamos, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution: Field studies

NMSU Alcalde Science Center**Organization Type:** Academic Institution**Organization Location:** Alcalde, NM**Partner's Contribution to the Project:**

In-Kind Support

Facilities

Collaborative Research

More Detail on Partner and Contribution:

Natural Resources Conservation Service**Organization Type:** Other Organizations (foreign or domestic)**Organization Location:** United States**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution: Rewa Charles serves as an end user for biodiversity metrics.

New Mexico Acequia Association**Organization Type:** Other Nonprofits**Organization Location:** Santa Fe, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution:

New Mexico EPSCoR**Organization Type:** State or Local Government**Organization Location:** Albuquerque, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

New Mexico Institute of Mining and Technology**Organization Type:** Academic Institution**Organization Location:** Socorro, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution:

Northern New Mexico Stockman's Association**Organization Type:** Other Nonprofits**Organization Location:** Taos, NM**Partner's Contribution to the Project:**

Facilities

More Detail on Partner and Contribution:

Rio Hondo Valley Acequia Association**Organization Type:** Other Nonprofits**Organization Location:** Taos, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution:

Sandia National Laboratories**Organization Type:** Other Organizations (foreign or domestic)**Organization Location:** Albuquerque, NM**Partner's Contribution to the Project:**

Collaborative Research

More Detail on Partner and Contribution:

Taos Valley Acequia Association**Organization Type:** Other Nonprofits**Organization Location:** Taos, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

UNM Center for Regional Studies

Organization Type: Academic Institution

Organization Location: Albuquerque, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

UNM Community & Regional Planning Program

Organization Type: Academic Institution

Organization Location: Albuquerque, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

UNM Maxwell Museum

Organization Type: Academic Institution

Organization Location: Albuquerque, NM

Partner's Contribution to the Project:

Facilities

Collaborative Research

More Detail on Partner and Contribution: UNM Maxwell Museum Staff curated the Acequia Exhibit, utilizing materials such as museum historical photographs.

UNM Resource Center for Raza Planning

Organization Type: Academic Institution

Organization Location: Albuquerque, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution: RCRP (Moises Gonzales) helped graduate students to develop a companion project in economic development for the communities of the lower Rio Chama, the Santa Cruz Basin, and Alcalde on the Rio Grande. RCRP also designed and built two physical terrain models for installation at the Maxwell Museum of Anthropology for display as part of the Acequia Exhibit.

US Geological Survey

Organization Type: Other Organizations (foreign or domestic)

Organization Location: United States

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

USDA Forest Service; Carson National Forest

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Carson, NM

Partner's Contribution to the Project:

Facilities

Collaborative Research

More Detail on Partner and Contribution: Allowed access to grazing allotment livestock records.

USDI BLM Taos Field Office

Organization Type: Other Organizations (foreign or domestic)

Organization Location: Taos, NM

Partner's Contribution to the Project:

Facilities

More Detail on Partner and Contribution: Allowed access to grazing allotment livestock records.

Universidad de Concepcion

Organization Type: Academic Institution

Organization Location: Chile, South America

Partner's Contribution to the Project:

Collaborative Research

Personnel Exchanges

More Detail on Partner and Contribution:

University of New Mexico

Organization Type: Academic Institution

Organization Location: Albuquerque, NM

Partner's Contribution to the Project:

Collaborative Research

More Detail on Partner and Contribution:

What other collaborators or contacts have been involved?

Nothing to report

Impacts**What is the impact on the development of the principal discipline(s) of the project?**

Connected coupled systems are making great strides with linking a common language of a system dynamics model.

An important theoretical development has been the demonstration that hydrologic connectivity and community connectivity are interlinked and each supports the resilience and health of the other. These relationships were presented in peer reviewed papers at an international conference in Valencia, Spain.

What is the impact on other disciplines?

Other disciplines impacted are hydrology, ecology, and community economics in terms of utilizing a multidisciplinary framework for modeling natural and human system dynamics of resilience. This approach is potentially transformative to other world regions with high desert environments.

In addition, this study will provide insights on the interactions between two common pool resources (CPRs), surface irrigation water and grazing land. Both CPRs are critical to acequia communities yet have contrasting regulation and insight. The first CPR, which is perhaps the most crucial, is almost entirely under irrigator control, while the second is subject to fairly stringent governmental regulation and control. Livestock raising appears to be an agricultural activity that links both these CPRs.

What is the impact on the development of human resources?

The museum exhibit titled "El agua es Vida" provided information about the reasearch to a wide audience including: young people, underrepresented groups, professionals, academics, and members of the general public.

Graduate and undergraduate opportunities are being taken advantage of by underrepresented groups. Graduate students have received graduate research training at three research universities in New Mexico in six different disciplines.

What is the impact on physical resources that form infrastructure?

Nothing to report

What is the impact on institutional resources that form infrastructure?

Nothing to report

What is the impact on information resources that form infrastructure?

Nothing to report

What is the impact on technology transfer?

Nothing to report

What is the impact on society beyond science and technology?

Beyond science and technology, policy makers may also be impacted when study results are more widely disseminated. Dissemination of results has been and will continue to be accomplished through publications, including the High Impact Paper, and the book.

This component will provide important contributions to modeling the resilience of acequia farming communities in Northern NM and how they enhance hydro-ecosystem sustainability.

Changes/Problems

Changes in approach and reason for change

Nothing to report

Actual or Anticipated problems or delays and actions or plans to resolve them

The project will need extra time to finish the modeling component. Data collection was done early in the project and there were delays in hiring a post doc who could work on the modeling effort. The ongoing modeling will require a twelve month extension.

Additionally, the planned trip to Chile as contained in the budget was delayed because of collaborator changes in a governmental approach to community irrigation. The collaborator is now back on track and the CNH group plans to visit Chile in December 2015 or January 2016. Following the Chile visit, model testing will be conducted and a final report prepared. This will necessitate an end date beyond the current end date of February 2016.

Changes that have a significant impact on expenditures

Nothing to report

Significant changes in use or care of human subjects

Nothing to report

Significant changes in use or care of vertebrate animals

Nothing to report

Significant changes in use or care of biohazards

Nothing to report