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# Preview of Award 1010516 - Final 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<br>Jose A Rivera, Co-Principal Investigator<br>Vincent Tidwell, Co-Principal Investigator<br>John L Wilson, Co-Principal Investigator |
| Recipient Organization: | New Mexico State University |
| Project/Grant Period: | 09/15/2010 - 09/30/2016 |
| Reporting Period: | 09/01/2016 - 09/30/2016 |
| Submitting Official (if other than PD\PI): | Alexander G Fernald<br>Principal Investigator |
| Submission Date: | 12/12/2016 |
| 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 goal of this project is 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 will be 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 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 outcomes of the project. The cited years represent the initiation and completion dates. The ambitious 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, entitled *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 for simulations of changes in human and natural systems linked by acequia communities. RGWSSIM will operate on a computer to incorporate economic, social, ecological and hydrological dynamics. The model builidng blocks will include acequia mutualism, acequia community, land use, economics and time mangagement, farm and ranch activities, acequia hydrology, and ecosystem health. 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 1-6. **Complete**

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 1-6. **Complete**

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 1-6. **Complete**

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 will have access to a museum exhibit about multiple human and natural aspects of acequia communities. The ARTS Lab of UNM will document the exhibit as a permanent virtual exhibit for posting on the project website accessible by the public, The Virtual New Mexico Project. Years 1-6. **Complete/Museum exhibit website ongoing**

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 3-6.**Complete**

f) Provide 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 2-6 **Complete**

g) Create land cover maps for three acequia-irrigated valleys for eight points in time and complete a technical completion report. **Complete**

h) Create a website to house all CNH related publications, results, outcomes, workshop outcomes, and related projects. Year 6 **Complete and ongoing**

i) Study the Rio Chama basin region in Rio Arriba County to test ideas about the coupling of natural and human systems dynamics. Years 1-6 **Complete**

j) To publish a book that disseminates project results. Year 6 **Ongoing**

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. Years 1-6 **Complete**

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

Major Activities:

The System Dynamics (SD) model was developed and provided significant results (mentioned below).

Two graduate students completed the creation of land cover maps for three acequia-irrigated valleys for eight points in time and prepared a technical completion report.

Significant progress was made on the project website. The website is live and houses project details and results, project photos, project publications by topic, presentations from a 2013 Global Perspective Workshop, and project posters. The website will continue to be updated regularly with related project publications.

The project team is collaborating with other scientists to submit a paper to a special section on "Socio-hydrology: Spatial and Temporal Dynamics of Coupled Human-Water Systems." The results from this project are being used to write the paper for this submission as the project results are relevant.

Finally, the CNH project group along with other researchers submitted a pre-proposal to the National Science Foundation entitled: *PIRE-CONECT: Social and hydrologic CONnections to promote Ecosystem and Community Thrivability along irrigated river systems.* If awarded, the project team will use the award to build upon existing knowledge as a result of this project. The goal of the project would be to better understand and characterize through interntional research and education the interplay between surface water-groundwater connected hydrologic systems and water dependent communities and ecosystems.

Specific Objectives:

The final objective is to complete the book associated with this project. Project participants are working with an editor to publish the book by fall 2017. The chapters within the book correspond with CNH project results. During the final month of the project (reporting period), the book editor worked with contributing chapter authors on the second and third drafts of their chapters.

Significant Results:

The project succeeded in the development of a multidisciplinary model of acequia community function. This effort was unique in that it integrated social, economic, hydrologic, and ecologic dynamics to study natural and social stressors on acequia systems. System Dynamics (SD) was adopted for the modeling platform as it is particularly designed for multidisciplinary systems that express organized complexity and evolve over time. The model showed that physical, social, and economic indicators were strongly linked to acequia mutualism and the community participation variables. Model development relied heavily on stakeholder input and interactions with subject matter experts from a range of disciplines. A unique challenge was quantifying key social dynamics for which sensitivity analyses were conducted to quantify their role in overall system behavior and to quantify related uncertainties. Ultimately the SD model provides a platform to engage stakeholders to explore alternative adaptive measures for acequia communities in northern New Mexico.

Land cover maps for three acequia-irrigated valleys for eight point in time between 1935 and 2014 were created. The maps are consistent with documentation in agricultural extension literature and provide quantitative assessments of the changes in land cover over time. The maps aided in the process of modeling both hydrologic and socio-economic processes at a local scale and provides researchers with a dataset that picks up the subtle changes in these valleys.

Key outcomes or Other achievements:

The major achievements completed during this reporting period are the SD model, project website, and land cover maps for three acequia-irrigated valleys.

*** 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 and community hydrologists.

Two students gained considerable experience in the geographic techniques of aerial image interpretation, land cover assessment, and map accuracy assessment.

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

1. The project allowed for 20 plus co-authored publications on topics such as integrated water and human systems, hydrology, social, economic, ecosystems, climate change, and modeling.

2. The project website entitled "Water and Community Research Group" contains project publications, photos, posters, reports, event details, outcomes, and participants. The website is live to the public. In the future, the site will host CNH-related projects and their results. http://wcrg.nmsu.edu/

3. An article related to the focus of the "CNH" project was featured in the September/October 2016 issue of *AramcoWorld.* The article, written by Gerald Zarr, discusses how acequias came to exist in the American Southwest, specifically the acequia history in northern New Mexico including present day governing challenges. In the article, Zarr described the *El Agua es Vida* museum exhibit that was held at UNM's Maxwell Museum of Anthropology May 2014 thru June 2015 and referred to the "El Agua es Vida: Acequias in New Mexico" painting now housed at the New Mexico Water Resources Research Institute thanks to the artist, George Chacón. The museum exhibit has proven to be a highlight of the CNH project.

Dr. Sam Fernald was cited in the article discussing the hydrologic data that are a direct result of the "CNH" initiative. The article also includes quotes from one of the co-principal investigators of the project, Jose Rivera (UNM). Project consultant Sylvia Rodriguez (UNM) was also interviewed for the article.

The article entitled: *How the Middle Eastern Irrigation Ditch Called Acequia Changed the American Southwest* can be found here: http://www.aramcoworld.com/en-US/Articles/September-2016/How-The-Middle-Eastern-Irrigation-Ditch-Called-Ace

4. In fall of 2017, a book will be published. The book chapters will include: discussion of concerning relationships between acequia farming and rangeland grazing; how to integrate methods and tools within interdisciplinary research; an explanation of the historical and anthropological significance of the acequias; hydrological aspects of the project; acequia ecosystems; connections and integration; mutualism, cultural endurance, and resilience; and perceptions of vulnerability, preparedness, and adaptation possbilities. This book 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.

5. Land cover maps will be made available through a web-mapping application that allows users to zoom in and explore data. The information will also be available in a technical completion report.

**Supporting Files**

| Filename | Description | Uploaded By | Uploaded On |
|---|---|---|---|
| Building blocks of SD model.pdf | Conceptual diagram showing each system building block of the acequia model and the linkages between them, similar to other socio-hydrology models. | Alexander Fernald | 12/01/2016 |
| Sabie et al. El Rito Land Cover 2014.pdf | El Rito (one of the three project study sites) land cover map of 2014. This is one of eight El Rito land cover maps. The others are from 1935, 1947, 1954, 1963, 1975, 1997, and 2005. These maps aided in the SD model development. | Alexander Fernald | 12/05/2016 |
| Sabie et al. Hondo Land Cover 2014.pdf | Hondo (one of the three project study sites) land cover map of 2014. This is one of eight Hondo land cover maps. The others are from 1935, 1953, 1958, 1965, 1975, 1997, and 2005. These maps aided in SD model development. | Alexander Fernald | 12/05/2016 |
| Sabie et al. Alcalde Land | Alcalde (one of the three project study sites) land cover map of 2014. This is one of eight Alcalde land cover maps. The others are from | Alexander Fernald | 12/12/2016 |

| Filename | Description | Uploaded By | Uploaded On |
|---|---|---|---|
| Cover 2014.pdf | 1935, 1949, 1954, 1962, 1975, 1997, and 2005. These maps aided in SD model development. | | |

## Products

### Books

### Book Chapters

### Inventions

### Journals or Juried Conference Papers

Frisbee, M., D. Tolley, and J.L. Wilson (2015). How deep is 'deep groundwater' in watersheds? Field estimates of groundwater circulation depths in mountainous watersheds and their effect on spatial trends in solute concentrations in streamflow. *Water Resources Research*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Gunda, T., B. Turner, and V. Tidwell (2016). Modeling climate change impacts on a traditional agricultural community in the Southwestern United States. *Water Resources Research*. . Status = UNDER_REVIEW; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Turner, B., V. Tidwell, A. Fernald, J. Rivera, S. Rodriguez, S. Guldan, C. Ochoa, B. Hurd, K. Boykin, and A. Cibils. (2016). Modeling Acequia Irrigation Systems Using System Dynamics: Model Development, Evaluation, and Sensitivity Analyses to Investigate Effects of Socio-Economic and Biophysical Feedbacks. *Sustainability*. 8 (10), . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.3390/su8101019

### Licenses

### Other Conference Presentations / Papers

Tsinnajinnie, L.M., M.D. Frisbee, and J. L. Wilson (2016). *Hydrostratigraphic and Structural Controls on Streamflow Generation in Semiarid, Snow-Dominated, Mountainous Watersheds in the Chuska Mountains of the Navajo Nation, Northern NM/AZ.* Geological Society of America annual meeting. Denver, CO. Status = OTHER; Acknowledgement of Federal Support = Yes

### Other Products

### Other Publications

Sabie, R., A. Fernald, and M. Gay (2016). *Estimating Landcover for Three Acequia-Irrigated Valleys Using Historical Aerial Imagery*. The result of the work presented in this technical report highlight the dramatic shift of agricultural lands to non-agricultural lands and detect land fragmentation caused by new roads and structures.. Status = OTHER; Acknowledgement of Federal Support = Yes

### Patents

### Technologies or Techniques

### Thesis/Dissertations

Lopez-Moreno, A.R.. *Analysis of Soil Moisture Condition Under Different Land Uses and of Three Acequia Irrigated Valleys in Northern New Mexico (student to defend on December 14, 2016).* (2016). New Mexico State University. Acknowledgement of Federal Support = Yes

Lopez, S., A. Cibils, U. Smedly, S. Guldan, A. Fernald, C. Ochoa, and K. Boykin. *Linkages Between Acequia Farming and Rangeland Grazing in Traditional Agropastoral Communities of the Southwestern USA.* (2016). New Mexico State University. Acknowledgement of Federal Support = Yes

### Websites

*Water and Community Research Group*
http://wcrg.nmsu.edu/

The website was created to disseminate project results and details to a broad audience. The site provides research findings, deliverables, products, and events that are a direct result of the six year CNH Acequia project.

**Supporting Files**

| Filename | Description | Uploaded By | Uploaded On |
|---|---|---|---|
| Sabie et al 2016 - Estimating land cover for three acequia-irrigated valleys using historical aerial imagery.pdf | This miscellaneous report will become a technical completion report of the New Mexico Water Resources Research Institute spring 2017. The purpose of this work was to produce comparable land cover datasets for three acequia-irrigated valleys in northern New Mexico. | Alexander Fernald | 12/12/2016 |

## Participants/Organizations

**What individuals have worked on the project?**

| Name | Most Senior Project Role | Nearest Person Month Worked |
|---|---|---|
| Fernald, Alexander | PD/PI | 0 |
| Rivera, Jose | Co PD/PI | 0 |
| Tidwell, Vincent | Co PD/PI | 0 |
| Wilson, John | Co PD/PI | 0 |
| Guldan, Steve | Co-Investigator | 0 |
| Boykin, Kenneth | Faculty | 0 |
| Cibils, Andres | Faculty | 0 |
| Gomez-Velez, Jesus | Faculty | 0 |
| Hurd, Brian | Faculty | 0 |
| Ochoa, Carlos | Faculty | 0 |
| Turner, Benjamin | Faculty | 0 |
| Rosenberg, Adrienne | Other Professional | 0 |
| Herrera, Fernando | Technician | 0 |
| Cruz, Jose Juan | Graduate Student (research assistant) | 0 |
| Gay, Marcus | Graduate Student (research assistant) | 0 |
| Lopez, Alejandro | Graduate Student (research assistant) | 0 |
| Sabie, Robert | Graduate Student (research assistant) | 0 |
| Tsinnajinnie, Lani | Graduate Student (research assistant) | 0 |

| Name | Most Senior Project Role | Nearest Person Month Worked |
|---|---|---|
| Wang, Chao | Graduate Student (research assistant) | 0 |
| Ratliff, Jesslyn | Non-Student Research Assistant | 0 |
| Rodriguez, Sylvia | Consultant | 0 |

**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:** 0

**Contribution to the Project:** Alexander Fernald was the PI and oversaw the CNH Acequia Project and team members. Fernald also contributed to publications.

**Funding Support:** NM EPSCoR

**International Collaboration:** Yes, Chile
**International Travel:** No

**Jose A Rivera**
**Email:** jrivera@unm.edu
**Most Senior Project Role:** Co PD/PI
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Jose Rivera is contributing a chapter to the project book entitled: "The Roots of Community in the Northern Rio Grande: Mutualism, Cultural Endurance, and Resilience."

**Funding Support:** None

**International Collaboration:** No
**International Travel:** No

**Vincent Tidwell**
**Email:** vctidwe@sandia.gov
**Most Senior Project Role:** Co PD/PI
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Vince Tidwell is contributing a chapter to the project book entitled: "Connection and Integration: Using System Dynamics Modeling to Explore Acequia System Resiliency."

**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:** 0

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

**Funding Support:** Other NSF grant

**International Collaboration:** No
**International Travel:** No

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**Steve Guldan**
**Email:** sguldan@nmsu.edu
**Most Senior Project Role:** Co-Investigator
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Steve Guldan is contributing to a chapter on the hydrological aspects of the project to the project book. Steve also participated as a panel discussion member during a presentation to community leaders from northern New Mexico. Steve discussed the CNH research and his role at the Alcalde Science Center.

**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**Kenneth Boykin**
**Email:** kboykin@nmsu.edu
**Most Senior Project Role:** Faculty
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Kenneth Boykin is contributing to the project book by writing a chapter entitled: "Acequia Ecosystems."

**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**Andres Cibils**
**Email:** aciblis@nmsu.edu
**Most Senior Project Role:** Faculty
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Andres Cibils studied the role of livestock in acequia community resilience and was involved in manuscript development. Andres is also contributing to the project book by writing a chapter concerning relationships between acequia farming and rangeland grazing.

**Funding Support:** USDA-NIFA-Hatch #1000985

**International Collaboration:** No
**International Travel:** No

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**Jesus Gomez-Velez**
**Email:** jdgomez7127@gmail.com
**Most Senior Project Role:** Faculty
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Jesus Gomez-Velez led the Rio Hondo modeling effort.

**Funding Support:** New Mexico Tech Geophysical Research Center

**International Collaboration:** No
**International Travel:** No

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**Brian Hurd**
**Email:** bhurd@nmsu.edu
**Most Senior Project Role:** Faculty
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Brian Hurd is contributing to the project book by writing a chapter entitled: "Acequia Perceptions of Vulnerability, Preparedness, and Adaptation Possibilities."

**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**Carlos Ochoa**
**Email:** carlos.ochoa@oregonstate.edu
**Most Senior Project Role:** Faculty
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Carlos Ochoa is contributing to the project book by co-authoring a chapter on the hydrological aspects of the project.

**Funding Support:** Oregon Agricultural Experiment Station

**International Collaboration:** No
**International Travel:** No

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**Benjamin Turner**
**Email:** benjamin.turner@tamuk.edu
**Most Senior Project Role:** Faculty
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Benjamin Turner is a collaborative researcher who contributed to publications. Ben is contributing to a chapter for the project book. The chapter is entitled: "Connection and Integration: Using System Dynamics Modeling to Explore Acequia System Resiliency."

**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**Adrienne Rosenberg**
**Email:** arosen@nmsu.edu
**Most Senior Project Role:** Other Professional
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Adrienne Rosenberg is editing the project 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.

**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**Fernando Herrera**
**Email:** fah@nmsu.edu
**Most Senior Project Role:** Technician

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**Nearest Person Month Worked:** 0

**Contribution to the Project:** Fernando Herrera assisted graduate students with equipment inventory and helped them with flow and slope measurements. Fernando also helped produce the "Water and Community Research Group" website to disseminate project results as well as future related project results.

**Funding Support:** NM EPSCoR

**International Collaboration:** No
**International Travel:** No

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**Jose Juan Cruz**
**Email:** cruzjuan@nmsu.edu
**Most Senior Project Role:** Graduate Student (research assistant)
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Jose Juan Cruz collaborated 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

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**Marcus Gay**
**Email:** marcusgay71@gmail.com
**Most Senior Project Role:** Graduate Student (research assistant)
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Marcus Gay completed the digitization of land cover for the three acequia-irrigated valleys.

**Funding Support:** EPSCoR

**International Collaboration:** No
**International Travel:** No

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**Alejandro Lopez**
**Email:** arlopez@nmsu.edu
**Most Senior Project Role:** Graduate Student (research assistant)
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Alejandro Lopez assisted with data research in Northern New Mexico.

**Funding Support:** Some funding provided by the NMSU Alcalde Research Station-Alcalde, NM and the NMSU Plant and Environmental Sciences department.

**International Collaboration:** No
**International Travel:** No

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**Robert P Sabie**
**Email:** rpsabie@nmsu.edu
**Most Senior Project Role:** Graduate Student (research assistant)
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Robert Sabie completed a draft report entitled, "Estimating Landcover for Three Acequia-Irrigated Valleys Using Historical Aerial Imagery" which included compiled maps and results from the project.

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**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**Lani Tsinnajinnie**
**Email:** lani.tsinnajinnie@gmail.com
**Most Senior Project Role:** Graduate Student (research assistant)
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Lani Tsinnajinnie assisted with field work.

**Funding Support:** Other NSF grant

**International Collaboration:** No
**International Travel:** No

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**Chao Wang**
**Email:** cwang00@nmt.edu
**Most Senior Project Role:** Graduate Student (research assistant)
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Chao Wang participated in Rio Hondo modeling.

**Funding Support:** Other NSF grant

**International Collaboration:** No
**International Travel:** No

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**Jesslyn Ratliff**
**Email:** jesslynr@nmsu.edu
**Most Senior Project Role:** Non-Student Research Assistant
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Jesslyn Ratliff is the Program Coordinator and provided project support for all of the CNH Acequia team members. Jesslyn also helped to create the project website.

**Funding Support:** NM EPSCoR

**International Collaboration:** No
**International Travel:** No

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**Sylvia Rodriguez**
**Email:** sylrodri@unm.edu
**Most Senior Project Role:** Consultant
**Nearest Person Month Worked:** 0

**Contribution to the Project:** Sylvia Rodriguez was the project consultant from the University of New Mexico (UNM). Sylvia contributed to the project book by providing a chapter about the historical and anthropological significance of the acequias.

**Funding Support:** none

**International Collaboration:** No
**International Travel:** No

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**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 |
| New Mexico EPSCoR | Other Nonprofits | Albuquerque, NM |
| New Mexico Institute of Mining and Technology | Academic Institution | Socorro, NM |
| Purdue University | Academic Institution | Lafayette, Indiana |
| 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 |
| UNM Community & Regional Planning Program | Academic Institution | Albuquerque,NM |
| UNM Resource Center for Raza Planning | Academic Institution | Albuquerque,NM |
| USDA Forest Service; Carson National Forest | Other Organizations (foreign or domestic) | Carson, NM |
| Alcalde Acequia Association | Other Nonprofits | Alcalde, 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 |
| Vanderbilt University | Academic Institution | Nashville, TN |
| Water for Agriculture and Mining Resource Center (CRHIAM) | Other Organizations (foreign or domestic) | Concepcion, Chile |
| 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 |

| Name | Type of Partner Organization | Location |
|---|---|---|
| Los Alamos National Laboratory | Other Organizations (foreign or domestic) | Los Alamos, NM |
| NMSU Alcalde Science Center | Academic Institution | Alcalde, NM |
| New Mexico Acequia Association | Other Nonprofits | Santa Fe, 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, Canoncitos 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:**

**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:**

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**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:**

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**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

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**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:** Brent Newman assisted in El Rito studies.

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**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:** Steve Guldan allowed graduate students to use facilities for project activities.

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**New Mexico Acequia Association**

**Organization Type:** Other Nonprofits
**Organization Location:** Santa Fe, NM

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**Partner's Contribution to the Project:**
Collaborative Research

**More Detail on Partner and Contribution:**

**New Mexico EPSCoR**

**Organization Type:** Other Nonprofits
**Organization Location:** Albuquerque, NM

**Partner's Contribution to the Project:**
Collaborative Research

**More Detail on Partner and Contribution:** 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.

**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:**

**Purdue University**

**Organization Type:** Academic Institution
**Organization Location:** Lafayette, Indiana

**Partner's Contribution to the Project:**
Collaborative Research

**More Detail on Partner and Contribution:** Marty Frisbee worked closely with the team on field work, modeling and interpretation.

**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:**

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**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:**

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**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:**

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**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:**

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**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:**

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**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.

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**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:**

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**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:**

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**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:**

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**Vanderbilt University**

**Organization Type:** Academic Institution
**Organization Location:** Nashville, TN

**Partner's Contribution to the Project:**
Collaborative Research

**More Detail on Partner and Contribution:** Thushara Gunda performed watershed modeling.

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**Water for Agriculture and Mining Resource Center (CRHIAM)**

**Organization Type:** Other Organizations (foreign or domestic)
**Organization Location:** Concepcion, Chile

**Partner's Contribution to the Project:**
Collaborative Research

**More Detail on Partner and Contribution:**

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**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?**

The System Dynamics (SD) model that was developed during this project will provide a platform to engage stakeholders and enhance communication to explore alternative adaptive measures for acequia communities in northern New Mexico.This effort links social, economic, hydrologic, and ecologic dynamics to study natural and social stressors on CNH systems.

**What is the impact on other disciplines?**

Impact on other disciplines include surface groundwater connections, connectivity, hydrology, groundwater, and mountain front recharge, as well as sociology of irrigation community governance.

The SD model succeeds in coupling diverse disciplines such as community, economics, ecology, and hydrology.

The development of the land cover dataset provided useful information that was integrated into system dynamics modeling efforts and used for calibration of the models.

**What is the impact on the development of human resources?**

Graduate and undergraduate students took advantage of the training and educational opportunities provided by this project. Graduate students have received research training at three research universities in New Mexico.

**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?**

The CNH book that is sceduled to be published fall 2017 will make CNH project 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 availablilty of the CNH project results may serve as policy guidance as project publications provide new insights into the relationships among traditional water management systems, communities, and ladscapes; and explore hydrologic linkages between surface water and groundwater in irrigated river valleys and contributing watersheds. Also, project research shows that acequias are able to survive political-administrative changes.

This CNH project also contributed to integrating spirituality and sense of place into presentation of community resource governance and connected art with a research endeavor. This was done by the *El Agua es Vida: Acequias in New Mexico* exhibit at the Maxwell Museum of Anthropology in Albuquerque, NM (2014-2015). The exhibit included modern and archival photographs, artwork, traditional and modern objects of artifacts, texts, and audiovisual materials to tell the story of acequias. Magazine articles such as *AramcoWorld* (September/October Issue) continue to deliver the meaning and importance of the exhibit by describing some of the featured artworks along with their background and relation to this CNH project.

## 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**
Nothing to report.

**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.