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# Doctoral Dissertation Improvement Grant: Early Human Settlement of the High-Altitude Pucuncho Basin, Southern Peruvian Andes

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## Preview of Award 1208748 - 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:	1208748
Project Title:	Doctoral Dissertation Improvement Grant: Early Human Settlement of the High-Altitude Pucuncho Basin, Southern Peruvian Andes
PD/PI Name:	Daniel H Sandweiss, Principal Investigator Kurt Rademaker, Co-Principal Investigator
Recipient Organization:	University of Maine
Project/Grant Period:	06/01/2012 - 05/31/2013
Reporting Period:	06/01/2012 - 05/31/2013
Submitting Official (if other than PD\PI):	Kurt Rademaker Co-Principal Investigator
Submission Date:	10/27/2013
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Kurt Rademaker

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### Accomplishments

#### \* What are the major goals of the project?

The ultimate goal of the project was to understand better the timing, environmental setting, and adaptations involved in the initial human settlement of the high Peruvian Andes. Human settlement of Earth's high-altitude mountains and

plateaus is among the most recent of our species' biogeographic expansions. Current anthropological models (Aldenderfer, 2006, 2008) emphasize the physiographic and biological challenges inherent to these extreme environments to explain a lack of pre-11 ka archaeological evidence above 4000 m elevation in the Andes (Aldenderfer, 1998, 1999; Jolie et al., 2011) and on the high Tibetan Plateau (Brantingham et al., 2013). However, few archaeological studies targeting hunter-gatherer sites have been conducted in these areas.

Prior to receiving NSF Doctoral Dissertation Improvement Grant # 1208748, the Co-Principal Investigator (PI) had discovered early archaeological sites in the Pucuncho Basin, a wetland oasis ringed by glaciated volcanoes in the Andes of southern Peru. One of these sites, Pucuncho (4350 m elevation), yielded fluted Fishtail projectile points, suggesting human exploration of this area 12.8-11.7 ka (Jackson, 2006). A second site, Cuncaicha rockshelter (4480 m elevation), had basal ages of 12.4-11.8 ka, establishing Cuncaicha as one of the oldest known directly-dated archaeological sites in the Andes Mountains.

As Pucuncho and Cuncaicha are the highest Pleistocene sites yet discovered anywhere in the world, interdisciplinary study of these sites and their landscape can yield important information on the development of human adaptations to extreme high-altitude environments, the timing and process of human colonization of the Andes, human-environment dynamics from 12 ka to present day, and the development of inter-zonal connections in South America. Construction of robust absolute archaeological and paleoecological chronologies constitute important first steps toward achieving these larger research objectives.

The PIs requested NSF funds for the final laboratory phase of this dissertation project, in order to: 1) strengthen the preliminary chronological data from Cuncaicha shelter, 2) provide information on the development of local habitats important to Andean animals and people for successful colonization of high-altitude zones, 3) facilitate analysis of material remains recovered from Pucuncho Basin open-air and rockshelter sites, and 4) prepare a final report sharing the project's findings with the Peruvian Ministry of Culture, a requirement for all archaeological research projects conducted in Peru.

## References

- Aldenderfer, M.S., 1998. *Montane Foragers: Asana and the South-Central Andean Archaic*. University of Iowa Press, Iowa City
- Aldenderfer, M.S., 1999. The Pleistocene/Holocene transition in Peru and its effects upon human use of the landscape. *Quaternary International* 53/54, 11-19.
- Aldenderfer, M.S., 2006. Modelling plateau peoples: the early human use of the world's high plateaux. *World Archaeology* 38(3), 357-370.
- Aldenderfer, M.S., 2008. High elevation foraging societies. In: Silverman, H., Isbell, W.H. (Eds.), *Handbook of South American Archaeology*. Springer, New York, pp.131-144.
- Brantingham, P.J., Xing, G., Madsen, D.B., Rhode, D., Perreault, C., van der Woerd, J., Olsen, J.W., 2013. Late occupation of the high-elevation northern Tibetan Plateau based on cosmogenic, luminescence, and radiocarbon ages. *Geoarchaeology* 28, 413-431.
- Jackson, L.J., 2006. Fluted and Fishtail points from southern coastal Chile: new evidence suggesting Clovis- and Folsom-related occupations in southernmost South America. In: Morrow, J.E., Gencco, C. (Eds.), *Paleoindian Archaeology: A Hemispheric Perspective*. University of Florida Press, Gainesville, pp. 105-122.
- Jolie, E.A., Lynch, T.F., Geib, P.R., Adovasio, J.M., 2011. Cordage, textiles, and the late Pleistocene peopling of the Andes. *Current Anthropology* 52(2), 285-296.

**\* What was accomplished under these goals (you must provide information for at least one of the 4**

**categories below)?****Major Activities:**

1. Accelerator mass spectrometry (AMS) dating of the long-term occupation sequence from the Cuncaicha rockshelter site to strengthen the preliminary site chronology
2. AMS dating of the Rio Blanco geologic section to provide information on the development of local biotic habitats important to Andean animals and people
3. Shipment of archaeological samples to colleagues to facilitate analysis of material remains
4. Final report preparation for the Peruvian Ministry of Culture

**Specific Objectives:**

1. Dating of the Cuncaicha rockshelter occupation sequence at the University of Arizona AMS Lab was designed to verify the stratigraphic integrity of the upper levels of the archaeological site and to provide precise chronological control for the sequence of recovered materials that was suspected to span ~12 ka to present day. One reviewer of the proposal requested that a subset of AMS dates be obtained via the XAD method at a second radiocarbon lab, PaleoResearch Institute, in order to verify the preliminary AMS ages obtained at the Arizona Lab.
2. Dating of the Rio Blanco geologic section at the University of Arizona AMS Lab would provide a local paleoenvironmental record that could be compared with the archaeological record from Cuncaicha rockshelter. The specific goal was to determine whether human migration into the Pucuncho Basin occurred before, during, or after the establishment of biologically productive local wetland habitats at the end of the Pleistocene.
3. Sample shipment to colleagues at various institutions initiated the analysis of materials from the Cuncaicha rockshelter occupation sequence, with the goal of characterizing patterns of technology, subsistence, mobility, and inter-zonal linkages involved in settlement of the high-altitude Pucuncho Basin.
4. Preparation of a technical report to the Ministry of Culture is a requirement of all archaeological research projects conducted in Peru.

**Significant Results:**

1. Based on preliminary excavations in 2010, funded through other sources, and absolute dating, funded partially by this NSF doctoral dissertation grant, Cuncaicha shelter was first occupied by humans up to ~12.6 ka, making Cuncaicha one of the oldest known archaeological sites in the Andes Mountains and the highest Pleistocene site yet discovered anywhere in the world.

The Cuncaicha rockshelter site chronology is based on 35 AMS ages obtained on ultrapurified bone collagen at two labs, the University of Arizona AMS Lab and PaleoResearch Institute. Most dates were obtained on faunal remains with clear anthropogenic butcher marks in association with abundant, unequivocal artifacts. To test the accuracy of the ultrapurified bone collagen ages obtained at the University of Arizona Lab, three split samples were also dated at PaleoResearch Institute using the XAD ultrapurification technique. Dates on these split samples provided by both labs are statistically indistinguishable at one-sigma.

Twenty-three (23) AMS ages constrain the initial Terminal Pleistocene component, making Cuncaicha one of the best-dated Terminal Pleistocene occupations in all of South America. The Terminal Pleistocene occupation evidence at Cuncaicha (4480

m elevation) challenges the idea that due to the physiological challenges of life at high altitude, human settlement of high-mountain environments such as the Andes significantly lagged occupation of lower ecological zones (Aldenderfer, 2006, 2008; Jolie et al., 2011), an idea proposed based on the absence of Terminal Pleistocene sites above ~4000 masl in both the Andes and the Tibetan Plateau. Based on the information provided by this doctoral dissertation research, the high-altitude “barrier” model is no longer tenable for the Andes.

The initial occupation of Cuncaicha was synchronous with that of Guitarrero Cave (2580 masl) (Lynch 1980; Jolie et al., 2011) in north-central Peru and was contemporary with, or slightly postdated, the early coastal sites Quebrada Jaguay (Sandweiss et al., 1998) and Quebrada Tacahuay (Keefer et al., 1998; deFrance et al., 2001, 2009) in southern Peru. The accuracy of the early coastal dates is uncertain, owing to unresolved old wood and old water issues. Although the uncertainty of early coastal chronologies will have to be addressed to arrive at a definitive answer, the addition of the Cuncaicha chronology to regional settlement data (Rademaker et al., 2012) suggests that life at high altitude was within the physiological capability of Terminal Pleistocene humans and that colonization of the Peruvian Andes was achieved in a synchronous biogeographic expansion to all zones currently occupied by people.

The site chronology also indicates that Cuncaicha is among the longest occupied archaeological sites in the Andes Mountains, although human presence was discontinuous. The set of AMS ages clearly shows that the Cuncaicha rockshelter sequence has stratigraphic integrity. The site contains four occupation components corresponding with distinct strata: Terminal Pleistocene (~12.6-11.3 ka, n=23), Early Holocene (~9.5-9.3 ka, n=6), Late Holocene I (~5.7-5.1 ka, n=6), and Late Holocene II (~4 ka–present, n=2). Such long-term occupation sequences are rare in Peru and almost unknown in the high Andes and will permit examination of long-term development.

2. Local glacial geologic records (Bromley et al., 2009, 2011a, 2011b) have yielded valuable paleotemperature reconstructions, but determining the paleohydrology of the Pucuncho Basin and the history of local wetlands also is important for understanding long-term Andean ecologic change. The Co-PI's previous attempts to core wetland sediments within the Pucuncho Basin were unsuccessful. Since the 10-m, Rio Blanco section was the largest sedimentary exposure in the region, we had hoped the section would yield a long paleoecologic record. Absolute AMS dating of 10 sediment samples from Rio Blanco, however, indicates that the ~10 m section was emplaced within the past ~4.1 ka, so the Rio Blanco section cannot contribute long-term paleoecologic data. Extraction of sediment cores from several lakes near Nevado Firura, located north of the Pucuncho Basin, is planned to obtain a long-term paleoecologic/paleohydrologic record.

3. Colleagues at the University of Maine, University of Pennsylvania, University of California (Santa Cruz), University of Calgary, Canada, and University of Tubingen, Germany, currently are analyzing ceramic and lithic artifacts, faunal remains, botanical remains, and sediments from the Cuncaicha occupation sequence. These analyses are aimed at understanding the process and environmental setting of initial colonization, as well as long-term patterns of seasonality, subsistence, inter-zonal connections, lithic and other technologies, camelid domestication, and human-environment dynamics.

4. A technical report was submitted to Peru's Ministry of Culture in September

2012, fulfilling legal obligations to the Peruvian government.

## References

- Aldenderfer, M.S., 2006. Modelling plateau peoples: the early human use of the world's high plateaux. *World Archaeology* 38(3), 357-370.
- Aldenderfer, M.S., 2008. High elevation foraging societies. In: Silverman, H., Isbell, W.H. (Eds.), *Handbook of South American Archaeology*. Springer, New York, pp. 131-144.
- Brantingham, P.J., Xing, G., Madsen, D.B., Rhode, D., Perreault, C., van der Woerd, J., Olsen, J.W., 2013. Late occupation of the high-elevation northern Tibetan Plateau based on cosmogenic, luminescence, and radiocarbon ages. *Geoarchaeology* 28, 413-431.
- Bromley, G.R.M., Schaefer, J.M., Winckler, G., Hall, B.L., Todd, C.E., Rademaker, K., 2009. Relative timing of last glacial maximum and late-glacial events in the central tropical Andes. *Quaternary Science Reviews* 28(23-24), [2514-2526](#).
- Bromley, G.R.M., Hall, B.L., Rademaker, K.M., Todd, C.E., Racoviteanu, A.E., 2011a. Late Pleistocene snowline fluctuations at Nevado Coropuna (15°S), southern Peruvian Andes. *Journal of Quaternary Science* 26(3), 305-317.
- Bromley, G.R.M., Hall, B.L., Schaefer, J.M., Winckler, G., Todd, C.E., Rademaker, K.M., 2011b. Glacier fluctuations in the southern Peruvian Andes during the late-glacial period, constrained with cosmogenic <sup>3</sup>He. *Journal of Quaternary Science* 26(1), 37-43.
- deFrance, S.D., Keefer, D.K., Richardson, III, J.B., Umire Alvarez, A., 2001. Late Paleo-Indian coastal foragers: specialized extractive behavior at Quebrada Tacahuay, Peru. *Latin American Antiquity* 12, 413-426.
- deFrance, S., Grayson, N., Wise, K., 2009. Documenting 12,000 years of coastal occupation on the Osmore littoral, Peru. *Journal of Field Archaeology* 34, 227-246.
- deFrance et al., 2001,
- Jolie, E.A., Lynch, T.F., Geib, P.R., Adovasio, J.M., 2011. Cordage, textiles, and the late Pleistocene peopling of the Andes. *Current Anthropology* 52(2), 285-296.
- Keefer, D.K., deFrance, S.D., Moseley, M.E., Richardson, III, J.B., Satterlee, D.R., Day-Lewis, A., 1998. Early maritime economy and El Niño events at Quebrada Tacahuay, Peru. *Science* 281, 1833-1835.
- Lynch, T.F., 1980. *Guitarrero Cave: Early Man in the Andes*. Academic Press, New York.
- Rademaker, K., Bromley, G.R.M., Sandweiss, D.H., 2013. Peru archaeological radiocarbon database, 13,000-7000 14C B.P. *Quaternary International* 30, 34-45.
- Sandweiss, D.H., McInnis, H., Burger, R.L., Cano, A., Ojeda, B., Paredes, R.,

Sandweiss, M., Glascock, M., 1998. Quebrada Jaguay: early maritime adaptations in South America. *Science* 281, 1830-1832.

Key outcomes or  
Other achievements: NSF funds were critical for the successful completion of the doctoral dissertation.  
The key contributions of the doctoral dissertation included:

Creation of a digital database of Peruvian archaeological radiocarbon dates from 13,000-7000 14C B.P. and identification of taphonomic and research biases limiting current understanding of basic patterns of settlement, population, and technology in the highlands, as well as the nature of inter-zonal connections.

Comprehensive mapping and multi-technique geochemical characterization of the Alca obsidian source, one of the largest and most geochemically complex obsidian sources in South America and one of the three most economically important sources of volcanic glass in prehistoric Peru. Six geochemically distinct Alca obsidian sub-groups were mapped and characterized, and three potential source areas for the Alca-1 obsidian artifacts at Terminal Pleistocene coastal site Quebrada Jaguay QJ-280 were identified.

Development of a predictive model for the QJ-280 – Alca-1 corridor using quantitative GIS least-cost analysis and optimal foraging theory predictions.

Region-level archaeological surveys between QJ-280 and Alca-1 obsidian deposits, resulting in the discovery of 194 new archaeological sites and 151 new non-site elements. Based on surface indications, some of these new sites and non-site elements in the coastal and puna ecozones were Early Holocene and Terminal Pleistocene age, constituted evidence of early coast-puna linkages, and suggested that the high-altitude Pucuncho Basin was inhabited in the Terminal Pleistocene.

Geophysical survey and test-excavation of seven plateau rockshelter sites and systematic surface collection of two-open air workshop sites. Two Terminal Pleistocene-age archaeological sites were identified in the high-altitude Pucuncho Basin: Pucuncho, an open-air site at 4350 masl, contains the highest-altitude Fishtail and fluted projectile points discovered to date in South America. Cuncaicha rockshelter, located 7 km east of Pucuncho at 4480 masl, was dated to ~12.4-11.8 ka, making it among the oldest sites in Peru and the highest Pleistocene archaeological site in the world. Pucuncho and Cuncaicha are probably linked to one another and to site QJ-280 on the Pacific Coast, although the nature of these early connections has yet to be determined.

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

The Co-PI received training in sample preparation, ultrapurification pretreatment, and combustion of organic microfossil and archaeological bone collagen samples at the University of Arizona AMS Lab under the direction of Dr. Gregory Hodgins. The visit to the Tucson, Arizona lab facilitated meeting other archaeologists and earth scientists with shared interests in archaeological sciences and archaeometry.

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

The Co-PI completed a doctoral dissertation (Rademaker, 2012) and a technical report written in Spanish for Peru's Ministry of Culture, which the Co-PI also distributed to the pastoralist communities of the Pucuncho Basin. So far, the Co-PI has lead-authored three peer-reviewed publications on this work (Rademaker et al., 2012; Rademaker et al., 2013a, Rademaker et al., 2013b) corresponding with three chapters in the doctoral dissertation. In addition, the PIs have co-authored a publication in Spanish in the top Peruvian archaeological journal (Sandweiss and Rademaker,

2013). The Co-PI currently is preparing a manuscript on the Cuncaicha rockshelter chronology for a top journal.

The Co-PI has given invited presentations on this project at the 2012 Society for American Archaeology meeting in Memphis, Tennessee, Center for the Study of the First Americans at Texas A&M University, Climate Change Institute at the University of Maine, Peabody Museum of Archaeology and Ethnology at Harvard University, and the Institute for Archaeological Sciences at the University of Tübingen, Germany.

## References

Rademaker, K., 2012. Early human settlement of the high-altitude Pucuncho Basin, Peruvian Andes. University of Maine. Ph.D. thesis, Orono, University of Maine, 253 p.

Rademaker, K., Reid, D.A., Bromley, G.R.M., 2012. Connecting the dots: least-cost analysis, paleogeography, and the search for Paleoindian sites in southern highland Peru. In: White, D.A., Surface-Evans, S. (Eds.), *Least Cost Analysis of Social Landscapes: Archaeological Case Studies*. Salt Lake City: University of Utah Press, pp. 32-45.

Rademaker, K., Bromley, G.R.M., Sandweiss, D.H., 2013. Peru archaeological radiocarbon database, 13,000-7000 14C B.P. *Quaternary International* 30, 34-45.

Rademaker, K., Glascock, M.D., Kasier, B., Gibson, D., Lux, D.R., Yates, M.G., 2013. Multi-technique geochemical characterization of the Alca obsidian source, Peruvian Andes. *Geology* 41(7), 779-782.

Sandweiss, D.H., Rademaker, K.M., 2013. El poblamiento del sur Peruano: costa y sierra. *Boletín de Arqueología PUCP* 15, 274-294. Lima.

## Supporting Files

Filename	Description	Uploaded By	Uploaded On
Cuncaicha_chronology.pdf	AMS ages from Cuncaicha rockshelter and Rio Blanco geologic section, partially funded by NSF Doctoral Dissertation Improvement Grant #1208748	Kurt Rademaker	08/31/2013
Rademaker et al. 2012 LCA.pdf	Rademaker, K., Reid, D.A., Bromley, G.R.M., 2012. Connecting the dots: least-cost analysis, paleogeography, and the search for Paleoindian sites in southern highland Peru. In: White, D.A., Surface-Evans, S. (Eds.), <i>Least Cost Analysis of Social Landscapes</i>	Kurt Rademaker	10/27/2013
Rademaker et al. 2013 QI Peru 14C database.pdf	Rademaker, K., Bromley, G.R.M., Sandweiss, D.H., 2013. Peru archaeological radiocarbon database, 13,000-7000 14C B.P. <i>Quaternary International</i> 30, 34-45.	Kurt Rademaker	10/27/2013
Sandweiss and Rademaker-Bol PUCP 13.pdf	Sandweiss, D.H., Rademaker, K.M., 2013. El poblamiento del sur Peruano: costa y sierra. <i>Boletín de Arqueología PUCP</i> 15, 274-294. Lima.	Kurt Rademaker	10/27/2013

## Products



## Books

### Book Chapters

#### Conference Papers and Presentations

Rademaker, K., Sandweiss, D.H. (2013). *Early Settlement in the Andes*. Yale-Maine-Harvard meeting, Peabody Museum of Archaeology and Ethnology.. Harvard University. Status = OTHER; Acknowledgement of Federal Support = Yes

Rademaker, K., Sandweiss, D.H. (2012). *Functional variability in early lithic technologies of southern Peru*. Society for American Archaeology. Memphis, TN. Status = OTHER; Acknowledgement of Federal Support = Yes

Rademaker, K., Bromley, G.R.M. (2013). *Human and environmental interactions in the high Andes of Peru: An interdisciplinary perspective*. Keynote presentation at 21st Annual Harold W. Borns Symposium/40th Anniversary of Climate Change Institute.. University of Maine. Status = OTHER; Acknowledgement of Federal Support = Yes

Rademaker, K. (2013). *Investigation of the late-glacial human settlement of the Peruvian Andes*. Center for the Study of the First Americans. Texas A&M University. Status = OTHER; Acknowledgement of Federal Support = Yes

Rademaker, K. (2013). *Investigation of the late-glacial human settlement of the Peruvian Andes*. Institute for Archaeological Sciences. University of Tübingen, Germany. Status = OTHER; Acknowledgement of Federal Support = Yes

#### Inventions

Nothing to report.

#### Journals

#### Licenses

Nothing to report.

#### Other Products

Nothing to report.

#### Other Publications

#### Patents

Nothing to report.

#### Technologies or Techniques

Nothing to report.

#### Thesis/Dissertations

Rademaker, K.. *Early human settlement of the high-altitude Pucuncho Basin, Peruvian Andes*. (2012). University of Maine. Acknowledgement of Federal Support = Yes

#### Websites

Nothing to report.

## Participants/Organizations

### What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Sandweiss, Daniel	PD/PI	12

Rademaker, Kurt

Co PD/PI

12

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**Full details of individuals who have worked on the project:**

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**Daniel H Sandweiss****Email:** dan.sandweiss@umit.maine.edu**Most Senior Project Role:** PD/PI**Nearest Person Month Worked:** 12**Contribution to the Project:** Doctoral advisor**Funding Support:** none**International Collaboration:** No**International Travel:** No

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**Kurt Rademaker****Email:** kurt.rademaker@umit.maine.edu**Most Senior Project Role:** Co PD/PI**Nearest Person Month Worked:** 12**Contribution to the Project:** Doctoral candidate**Funding Support:** none**International Collaboration:** No**International Travel:** No

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**What other organizations have been involved as partners?**

Nothing to report.

**What other collaborators or contacts have been involved?**

YES

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

The project contributed new archaeological information on the biogeography and evolution of humans, the settlement of the Americas, and the human ecology of high-mountain environments. The addition of the Cuncaicha chronology to regional settlement data suggests that life at high altitude was within the physiological capability of Terminal Pleistocene humans and that colonization of the Peruvian Andes was achieved in a synchronous biogeographic expansion to all zones currently occupied by people.

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

Archaeological knowledge of the initial settlement of extreme environments can provide the historical depth needed to determine the evolutionary history of certain traits, such as adaptation to hypoxia and other high-altitude conditions. This project provides data of potential value to physical anthropologists, human physiologists, and geneticists.

Nearly all of earth's landscapes have been modified by people, and the high Andes are no exception. A better understanding of the long-term history of human presence and activities in the Andean landscape, a major goal of this project, contributes valuable information on Andean geomorphology and ecology, as well as human prehistory, necessary for understanding the high Andes as a coupled system.

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

Nothing to report.

**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 project provided valuable educational and professional development opportunities for the Co-PI, as well as graduate and undergraduate students who participated as field and laboratory assistants. The pastoralist communities of the Pucuncho Basin also participated in the investigation of their own cultural patrimony through this project.

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## 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.