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Meshing American Indian Concerns with Goals of EarthScope's USArray

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American Indian nations comprise a significant portion of the lands in the western United States, so as researchers deploy the USArray seismographic component of EarthScope across the Southwest and progress into the Rocky Mountains and Great Plains, they have crossed into Indian country (Figure 1). Informed relations among researchers and tribal officials are prerequisite to the timely permitting and deployment of scientific instruments.

Conducting Research on Sacred Land

American Indian nations are not monolithic in their response to outsiders seeking access to their lands for scientific research, but certain factors can be expected to apply in all cases. First, homelands are considered to be sacred. Sacredness of land, frequently cited although not often defined simply, implies a kinship among people, landforms, biota, and natural phenomena, manifested as a complex system of beliefs linked directly to places [*Kelley and Francis,* 1994].

In particular, geoscientific research in these places may be regarded by many American Indians as inappropriate, disrespectful, or even sacrilegious—much as anyone might feel about intrusive medical or psychological research conducted on a loved one. An ongoing federal court battle over the use of reclaimed wastewater for snowmaking on the San Francisco Peaks near Flagstaff, Ariz., an extinct stratovolcano sacred to a number of tribes but outside of any official tribal jurisdiction, demonstrates that American Indian people will defend lands they hold sacred on the basis of religious freedom.

As a consequence, tribal land-use regulations are culturally defined. Establishing scientific instruments on a tract of land may require clearances not only for environmental and wildlife impact, but also for preservation of archaeological and ethnographic resources. While such requirements also apply to federal lands, detailed knowledge of potential sites on American Indian homelands may be deemed culturally sensitive and unavailable to outsiders. In this case, researchers may only be able to request a station site somewhere within a general area, subject to confidential review and selection by elders or other traditional cultural experts.

Geoscientists and indigenous people may have very different philosophical positions on unfettered scientific inquiry [*Cajete,* 2000] and global access to local data, so it should not be assumed that purely academic-type research, such as that exemplified by EarthScope, will be immediately welcomed. Instead, American Indian landholders, not unlike many non-Indians, may be skeptical about the purpose of the research, and they may suspect hidden economic motives. History justifies their wariness: Well-remembered episodes such as the Cold War pursuit of uranium on the Colorado Plateau, a recent form of geophysical exploration on American Indian homelands, led to resource exploitation with lasting damage to environmental quality and public health [e.g., *Eichstaedt,* 1994].

Building a Partnership in Arizona

In concert with EarthScope-related research, the EarthScope education and outreach (E&O) implementation plan [*EarthScope Education and Outreach Steering Committee*, 2007] calls for partnerships with American Indians that will impart in them a sense of ownership in the project and calls for using the EarthScope facility and data to enhance interest and learning among a minority student population that has been chronically underrepresented in geoscience studies

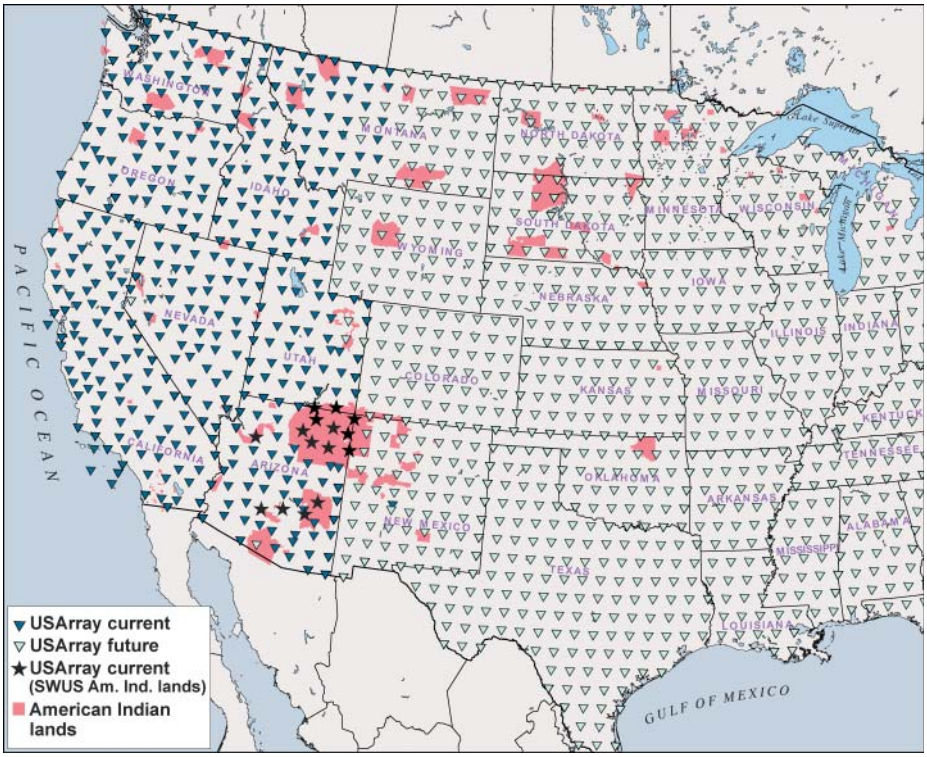

Fig. 1. Current (solid triangles and stars) and future (grey triangles) USArray Transportable Array deployments in the western contiguous United States, including American Indian lands (in salmon). Transportable Array stations sited on American Indian lands in the southwestern United States are denoted by stars.

By S. Semken, M. Fouch, E. Garnero, P. Zah, and D. Lippert

and careers [*Riggs and Semken, 2001*; U.S. National Science Foundation, unpublished data, 2006].

In Arizona, one of the first eight states to host EarthScope instrumentation, plans called for the deployment of USArray Transportable Array (TA) stations on or near the lands of as many as seven different American Indian nations. No protocols for working with these nations had been established, although useful experience accrued from the Colorado Plateau–Río Grande Rift Seismic Transect (La RISTRA) experiment on the Navajo nation [*Wilson et al.,* 2005]. EarthScope's success depends on the USArray staying on schedule and on healthy relationships with the communities it passes through. Toward this end, we have collaborated with decision-makers in American Indian communities in Arizona for the past 18 months to facilitate USArray station siting and E&O activities in a culturally appropriate manner. As the USArray progresses eastward, EarthScope scheduling—and hence research activities—will significantly benefit from similarly productive interactions with American Indian stakeholders in the Rocky Mountains and Great Plains.

Opportunities for Education and Outreach

Isolation and poverty limit educational opportunities for American Indian students in science and mathematics. EarthScope has the potential to bring cutting-edge geoscience research literally to their backyards. It is incumbent upon researchers to develop effective E&O partnerships with schools and citizen groups in tandem with siting and deployment, and these relationships must remain viable even after the instruments have been removed. Researchers should also be aware that lack of access to up-to-date instructional technologies and the Internet—the so-called "digital divide"—may remain a problem in some reservation schools and community centers. E&O projects should be designed to provide or help provide equipment and resources where they are needed.

Many American Indians are concerned about the environmental and cultural sustainability of their ways of life in small traditional communities on finite land bases. Toward this objective, indigenous educators advocate "place-based" teaching [*Cajete,* 2000], which emphasizes active inquiry by students in the local environment, the synthesis of traditional and scientific knowledge of places, and service projects to benefit communities [*Semken,* 2005]. Earth science is an important component of an authentically place-based curriculum, but the opportunity to actively investigate local geologic structure and history typically ends at the land surface. EarthScope researchers and educators can address this, in the short term by involving American Indian teachers and students in instrument deployment and data analysis, and in the long term by working with local curriculum developers to integrate findings about regional structure, dynamics, and evolution into place-based science curricula.

Perspectives and Preferences

Our direct collaboration with Arizona tribes began with a 2-day workshop, "Native American Perspectives and Preferences Bearing on EarthScope Deployments in the Southwest (NAPP-ES)," held at Arizona State University (ASU) in November 2005 and funded by the EarthScope Science program of the U.S. National Science Foundation (NSF). Workshop participants represented a broad cross section of stakeholders: the Gila River, Hopi, Hualapai, and Navajo nations; tribal schools; the national E&O programs of EarthScope, Incorporated Research Institutions for Seismology (IRIS), and University NAVSTAR Consortium (UNAVCO); siting specialists from IRIS PASSCAL (Program for Array Seismic Studies of the Continental Lithosphere); and ASU researchers and American Indian liaisons. The NAPP-ES workshop embodied a successful intercultural exchange: EarthScope researchers provided tribal decision-makers with an introduction to the scientific and E&O components of the project, while the American Indian participants shared valuable information about relevant cultural and jurisdictional issues.

The principal findings from this workshop are summarized here and offered as recommendations for subsequent siting and E&O activities:

1. Contact tribal decision-makers well in advance of instrument deployment activities. An informal, brief, expenses-paid workshop like NAPP-ES is an appropriate and effective way to introduce a critical mass of tribal officials and educators to the EarthScope program and ask for their collaboration. Goodwill earned here could be indispensable when reconnaissance and permitting activities begin.

2. Recognize that each tribal government has unique policies and protocols and that jurisdiction over land access and use may be community-based or centralized. Ask workshop participants for guidance.

3. Be aware that a suite of ethnographic, archaeological, environmental, and biological clearances may be necessary to obtain siting permits, and be prepared for unanticipated requirements (e.g., permits for the use of telemetry to relay USArray data).

4. Note that some proposed sites, although they are outside of legally designated reservations, may be located on lands recognized as ancestral or sacred by one or more American Indian nations. The status of these lands can be determined with assistance from tribal historic preservation offices.

5. Obtain permission to visit landholders and communities near each proposed station site to promote E&O partnerships. Begin all community encounters with a clear and adequate explanation of the methods and benefits of the research.

6. As USArray station construction involves digging into the Earth, it may be necessary to consult traditional healers or other cultural practitioners in the local community for their approval.

7. Volunteer to return to communities and schools to promote EarthScope and to distribute educational materials during public gatherings such as fairs, powwows, and rodeos.

8. Provide commemorative materials for schools and community centers, such as plaques, photos, and displays.

9. Help schools and community centers to enhance their technological capabilities.

10. Collaborate with indigenous educators to develop bilingual and culturally sensitive E&O materials, and encourage the use and expansion of Native scientific knowledge, terms, and pedagogy. Note that many American Indian languages are predominantly oral, so audiovisual recordings are most appropriate for Elders.

11. Make place-specific E&O materials; be sure those aimed at youth are child-friendly, presented from a student's or teacher's point of view.

12. Hold meetings and workshops in communities after USArray has passed through; keep stakeholders in the loop when research findings are presented.

The critical outcome of the NAPP-ES workshop was the opportunity to establish direct connections with most of the American Indian nations in the Arizona TA footprint. Many of the Native participants continued to provide advice and assistance to the researchers and to USArray personnel as site reconnaissance and permitting activities began. During the year following the workshop, the NAPP-ES principal investigators met separately with officials and educators at tribal offices and schools. These connections facilitated the siting and permitting of TA stations across Arizona in 2006 and early 2007 (see Figure 1).

Station Siting and Permitting

Permitting TA stations on wholly undisturbed American Indian lands in Arizona proved too laborious for timely deployment, due to a host of obligatory archaeological, ethnographic, environmental, and biological clearances. On the advice of, and frequently with direct assistance from, the NAPP-ES tribal partners, permits instead were secured for "disturbed" sites on developed land, which had already received most of the necessary clearances. This was an approach similar to that used for many TA sites on federal lands. While these sites likely possess somewhat more seismic noise on average than more pristine places, the trade-off was necessary to ensure permitting in a timely (i.e., less than 1 year) manner. Wherever possible, we sought to place TA stations on or near school

grounds, for the obvious E&O opportunities. An American Indian cultural resources consultant was retained to research the status of clearances on each site and to prepare permit applications.

Most TA stations on American Indian land were sited on one of three types of "disturbed" sites: rural homesites; the grounds of a tribal college or K-12 school; and secured uranium-mill tailings repositories, which are located near former mining communities and now are jointly managed in perpetuity by the U.S. Department of Energy and the Navajo nation. At the latter sites, the instrument is buried in an uncontaminated buffer zone between a boundary fence and a fully encapsulated tailings pile.

Education and Outreach Partnerships

Concurrently with the siting and permitting activities, we have established E&O partnerships with K-12 schools on or near the Navajo, Hopi, San Carlos Apache, White Mountain Apache, and Gila River Pima-Maricopa nations; and we have reinvigorated EarthScope's affiliation with Diné College, the tribal college of the Navajo nation. Recent or anticipated outcomes for each of the schools include enrollment in the IRIS Seismographs in Schools program (with schools receiving an AS-1 seismograph); scheduled visits from EarthScope researchers; facilitated access to educational materials from EarthScope, IRIS, UNAVCO, and other research consortia; collaboration between EarthScope researchers and schools in the development of bilingual and cross-cultural curriculum materials; and participation in the EarthScope community. As an example of the latter outcome, a geoscience instructor from Diné College and two science teachers from San Carlos High School participated in the 2007 EarthScope National Meeting in California.

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Author Information

Steven Semken, Matthew Fouch, and Edward Garnero, School of Earth and Space Exploration, Arizona State University, Tempe; E-mail: semken@asu.edu; Peterson Zah, Special Advisor to the President on American Indian Affairs, ASU; Donald Lippert, USArray Operations, Auburn, Calif.