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Observation and experience linking science and indigenous knowledge at Zuni, New Mexico

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Ancient agricultural societies farming the same soils for centuries offer alternative knowledge for combating desertification. The resulting agriculture is sustainable as well as culturally and environmentally appropriate. This paper describes an approach to enabling one such system at the Zuni Indian Reservation, New Mexico. The approach links agroecology and ethnoscience research to grassroots community action. Agroecology research has revealed enhanced soil quality in traditional runoff agricultural fields, while ethnoscience shows a subtle understanding of local soils and geomorphology. The research supports community action by recognizing and valuing a local agricultural system so that solutions to land degradation can build on indigenous knowledge.

Keywords: agroecology; soil conservation; participatory development; indigenous knowledge; ethnoscience; ethnopedology

'Understanding Indians is not an esoteric art. All it takes is a trip through Arizona or New Mexico, watching a documentary on TV, having known one in the service, or having read a popular book on them.

There appears to be some secret osmosis about Indian people by which they can magically and instantaneously communicate complete knowledge about themselves to those interested whites. Rarely is physical contact required. Anyone and everyone who knows an Indian or who is interested, immediately and thoroughly understands them.' (Vine Deloria, Jr. (1969) from *Custer Died for Your Sins*)

Introduction

The 1992 Convention to Combat Desertification calls for linkages between science and community action as the way to foster restoration and sustainable development of marginal or degraded lands. Reflecting many years experience by development agents working with the most disenfranchised societies, this concept brings into focus

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the connection between economic marginalization and environmental degradation. Mr Deloria's sarcastic statement underscores difficulties of linking science and community action: too often, knowledge of methods, goals, and motivations of local communities is taken for granted by scientists with little basis for real understanding of social and cultural parameters. Experiences from collaborative research with community initiatives on the Zuni Indian Reservation may provide insights into how real linkages can give local significance to research and respect to local knowledge. Civilizations like Zuni, which have developed and thrived for millennia completely outside the realm of conventional science, agriculture, and belief systems, offer truly alternative views of ecology and agriculture that stem from long-term use and conservation of natural resources (Altieri 1990; Sandor & Furbee, 1996).

Land degradation came to Zuni when belief and knowledge systems developed *in situ* were displaced by imposed agricultural, land tenure, and economic systems (Cleveland *et al*., 1995). Zuni indigenous knowledge offers a basis for solutions to social and environmental problems, but decades of disregard have created a need for renewal of awareness through valuation and education.

Indigenous knowledge may enable community action and provide appropriate technological solutions to desertification. Vast cultural differences, however, between indigenous people and governing decision-makers, possibly an underlying cause of desertification in the first place, prevent necessary recognition and valuation of indigenous perception. The significant gap between perspectives of western culture and how indigenous people know and do things hampers standard ways of communicating and understanding each other.

The purpose of this paper is to present an approach used at Zuni to connect objectives of basic agroecological and ethnoscience research with those of a community initiative to combat desertification and revitalize a traditional agricultural economy. We will discuss how collaborative ethnoscience investigation of indigenous agricultural knowledge and interdisciplinary soil science research of agroecology have connected with the Zuni Sustainable Agriculture and Zuni Conservation Projects in ways that are complementary and mutually beneficial. We present preliminary findings from the two disciplines and describe the relationship between the research and the grassroots development effort at Zuni.

Environmental setting

The Zuni Indian Reservation lies in the mesa country of western New Mexico in the south-east part of the Colorado Plateau. It is characterized by high red sandstone mesas separated by broad alluvial valleys. Elevation ranges from 1838 m (6030 feet) near the Arizona border to 2347 m (7700 feet) on eastern mesas near the continental divide. Soils grade from Mollisols and Alfisols in the higher eastern valleys to Alfisols and Aridisols in the drier western portion of the reservation (USDA, in press). Valley margins, where traditional runoff agriculture is practiced, consist of coalescing alluvial fans where tributary canyons wash mixed sandy sediments from mesa uplands.

Vegetation on the mesa uplands is dominated by pinyon–juniper (*Pinus edulis*–*Juniperus* spp.) woodlands. The semi-arid grasslands of the valleys are dominated by blue grama (*Bouteloua gracilis*) and big sagebrush (*Artemesia tridentata*).

Average annual precipitation ranges from 300 to 400 mm (12 to 16 inches) and is extremely variable. May and June are usually the driest months of the year; June has a long-term average of just 10 mm. Over half of the annual precipitation falls in July, August, and September when moist air moves over the hot and dry south-western uplands and generates convection rainstorms that can be frequent and intense. These storms are usually localized and may cause severe erosion on landscapes parched by the high temperatures, hard winds, and dry weather of spring and early summer. The

remainder of each season's precipitation comes as snow and low-intensity rain during fall, winter, and early spring (Tuan *et al.*, 1973).

Zuni agricultural heritage

Archaeological evidence shows that for more than 1500 years Zuni farmers have used runoff from summer storms to grow corn and other crops in the area of present-day Zuni Pueblo (Kintigh, 1985). As with other Native American agriculture of this region, Zuni runoff farming uses no fertilizer or irrigation in the conventional sense. Farmers attribute ephemeral storm water flows, which spread onto well-placed fields on alluvial fans, with supplying moisture and nutrients to produce crops. Farmers may also control erosion and the movement of sediment by farming and stabilizing alluvial fans.

Runoff agriculture was widespread until after the 1850's, with as much as 4050 ha (10,000 acres) of corn under cultivation on the Zuni Reservation (Ferguson & Hart, 1985). Zuni farmers and gardeners grew many other crops, including beans, squash, melons, peppers, and, after European contact, wheat and peaches. Vegetables were grown in specialized 'waffle gardens' near the Zuni River and other permanent sources of water.

Disruption and desertification

Beginning late in the 19th century south-western landscapes entered an erosional period after many centuries of stability and aggradation (Bryan, 1928; Leopold *et al.*, 1966; Cooke & Reeves, 1976). The most noticeable and well documented manifestation of the problems consists of severe incision of both ephemeral and perennial stream courses. But drastic shifts in vegetation toward woody shrubs, lowering of local water-tables, and severe wind erosion are also well documented, as is major and expansive sedimentation in many irrigation, flood control, and stock water reservoirs. All of these indicators of desertification are both obvious and well documented on the Zuni Indian Reservation (Hart, 1995).

The latter part of the 19th century was also the beginning of the United States occupation in the South-west and saw many social and economic changes that disrupted traditional agricultural methods (Hart, 1995). By 1900 repression and disease on the Zuni Indian Reservation resulted in the lowest population, around 1400 people, in recorded history (Ferguson, 1996). Twentieth century U.S. government programs to reallot reservation lands and modernize agriculture imposed foreign farming and land tenure systems on the ancient and complex indigenous systems. Resulting land disputes have disabled the use of Zuni lands for nearly 100 years and continue to be a major obstacle in revitalizing agriculture. Large-scale irrigation projects facilitated a switch to conventional agricultural methods of livestock and forage production. These methods largely displaced indigenous crop and pastoral systems. Failure of the dams from rapid sedimentation resulted in drastic shrinking of irrigable areas and contributed to a major decline in the number of Zuni people drawing a livelihood from the land.

Zuni priorities for development and conservation

Disruption at Zuni by exogenous agencies and the damage to natural resources has forced Zunis to consider and articulate some important principles for how and why Zuni will be researched in the future. The critical contention is whose perspective will

ultimately guide the investigations at Zuni and how findings will be incorporated into the realities of future Zuni land use.

The Zuni Conservation Project (ZCP) is a Zuni agency established as part of the Zuni land claims settlement with the United States Congress to oversee restoration of Zuni land and to promote sustainable use of resources, particularly through agriculture. ZCP and its component, the Zuni Sustainable Agriculture Project (ZSAP), are therefore the main actors for infusing community priorities and concerns into the research being presented in this paper. These agencies work to reverse downcutting and erosion, which represent the historical destabilization of the Zuni landscape. They also seek to develop agriculture in a way that is meaningful and feasible for the land users and growers of the Zuni community. Toward that end, a major priority in policy (Enote *et al.*, 1993) and in practice at Zuni is a serious effort to understand and incorporate the needs of small farmers and the realities they face, including extremely strong social, cultural, and religious values. Their work has been to make those concerns the basis for future development plans. They mean to promote conservation on Zuni's own terms (Enote, 1997).

In 1990 a field soil study was approved to begin evaluating the long-term effects of Zuni traditional runoff farming and systematically probing the underlying local knowledge base of soils. In the last 6 years the sampling scheme expanded to a full-scale investigation of watershed and alluvial processes used in Zuni runoff agriculture under an independent National Science Foundation grant project. The soil study became part of a bigger project to collate Zuni knowledge and views about land and land use.

This work was performed under a consultancy component of a Ford Foundation grant to the Zuni Sustainable Agriculture Project. These research initiatives were originally designed to use indigenous knowledge to make research locally relevant while generating important data on the stability of land under cultivation in semi-arid environments. The process and methods, however, became more refined through interaction and experience with the farmers of the Zuni Sustainable Agriculture Project.

Multilateral development agencies are beginning to strongly emphasize the promoting of the true exchange of information and merging of experience and knowledge of local stakeholders into project designs. The Zuni situation is an interesting example of fostering agriculture and conservation on fragile lands. The following is an outline of research methods of a two-pronged approach to research the agroecology and the indigenous knowledge system of Zuni farming in a way that links the valuable perspective of farmers at Zuni with outside science.

Agroecology of Zuni runoff farming

Ancient agricultural societies that are still harvesting crops from soils farmed for centuries offer several opportunities for sustainable agriculture research. Since most soil quality research is done on soils farmed for less than 150 years, the study of ancient agricultural soils like those of Zuni can bring a more appropriate time-scale to notions of sustainability and agriculture (Sandor & Eash, 1991). Such societies also offer opportunities to compare agroecological effects of long-term, subsistence-oriented farming systems to those of relatively recent, intensive, yield-oriented agriculture. Such research supports grassroots community action because it recognizes and values locally developed indigenous knowledge for coping with environmental constraints. Such research can help enable community conservation and development initiatives by communicating the value of local indigenous knowledge to decision-makers in terms that allow comparison to exogenous solutions.

Early accounts of the Zuni people reveal a thriving agricultural community where, as Coronado reported to the Viceroy Mendoza in 1540, '(the people) are all well nurtured and condicioned… The victuals which the people of this country have, is Maiz, whereof they have great store…' (Cushing, 1920). Grown in rain-fed, runoff agricultural fields, corn was the staple crop for survival and trade. F.H. Cushing (1920) gave the following account of a cornfield in the 1880s:

> 'The effect of the network of barriers is what the Indian prayed for, namely, that with every shower, although the stream go dry three hours afterward, water has been carried to every portion of the field, has deposited a fine loam over it all, and moistened from one end to the other the substratum. Not only this, but also, all rainfall on the actual space is retained and absorbed within the system of minor embankments.'

The runoff farming system described by Cushing apparently uses runoff and sediments to renew soil moisture and fertility. Soil and water conservation, then, is not a social responsibility separate from agricultural production but is the central component of the farming system. The unforgiving agricultural setting of the Zuni Reservation shows the importance of conservation of soil and water after summer thunderstorms as an immediate issue on which crop survival depends.

Two hypotheses have emerged from the literature on Zuni runoff agriculture — both early accounts and archaeological reports — and from preliminary investigations and discussions with farmers: (1) utilization of runoff water and sediment has maintained soil fertility in long-term runoff agricultural fields; and (2) utilization of runoff water and sediment from ephemeral storm water flows could mitigate severe erosion and sedimentation downstream. Ongoing agroecological research funded by the National Science Foundation is exploring these and other hypotheses related to Zuni runoff agriculture.

An initial study compared three long-term cultivated sites with paired uncultivated sites, one on an unincised runoff field where water spreads over the field and deposits suspended material (the Pescado field), one on the floodplain of a now deeply incised water course (lower Galestina field), and one on an erosional backslope position (upper Galestina field). Soils of the Pescado field generally have better tilth, including higher concentrations of total nitrogen and organic carbon, than adjacent uncultivated soils. Soils of both Galestina fields, however, show degradation compared to uncultivated pairs on a scale similar to conventionally cultivated semi-arid soils (Fig. 1) (Norton, 1996). A complete report of this study is in preparation for

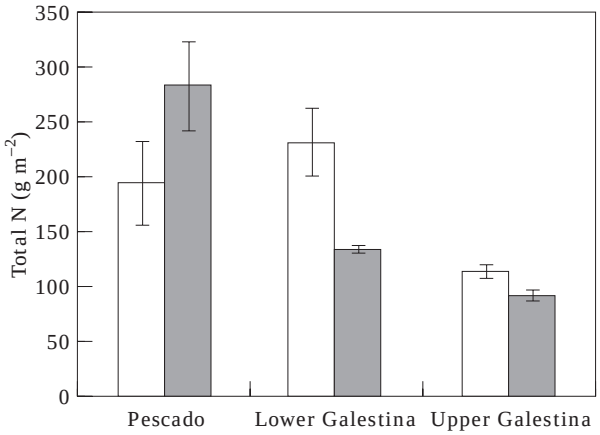

Figure 1. Total nitrogen in paired cultivated (▩) and uncultivated (□) soils. Each pair is the mean from ten 15-cm depth samples collected along paired transects. Total N was determined by Kjeldahl digestion. Error bars represent standard deviation.

publication. The results suggest that flooding of agricultural fields after summer storms maintains soil productivity under cultivation.

As has been described, most runoff fields on the reservation are abondoned, and runoff-spreading systems have not been maintained for many years, even in the runoff fields that continue to be farmed. Figure 2 shows relative soil moisture content across the Pescado field, revealing that, as would be expected, the unincised swale that carries most runoff water through the field has the highest moisture content in the upper 1·5 m of the soil. This finding is confirmed by field and aerial photograph observations of green strips of vegetation across alluvial deposits where ephemeral streams run through unincised swales after rainstorms. These swales almost invariably lead to series of head cuts that drop into the deeply incised arroyos of larger drainages.

The preliminary data presented in Fig. 2, along with the observations, suggest potential for increased storage of runoff water in the soils of alluvial fans with runoff spreading. Re-establishing runoff spreading systems could essentially widen the 'green zone' observed along the shallow water courses, enhancing crop and/or forage production and reducing concentrated flows of runoff and sediment down slope.

Ongoing research is replicating these studies and is exploring the effects of runoff materials on corn production, soil hydrology, soil fertility, and microbial activity, including mycorrhizal infection, in cornfields. The studies should provide relevant information on the value of traditional runoff agriculture practices for present-day agricultural revitalization and combating desertification on the reservation. One tangible effect of the research is an apparent reawakening of Zuni farmers themselves toward the value of knowledge about rain-fed farming learned from their grandparents.

Zuni soil knowledge

Native Americans have their own progression of beliefs, values, and knowledge developed during their unique history. That history at Zuni includes 1000 years of gardening and farming in their semi-arid environment, successfully and continuously on the same land resource. Any investigation into the process of land degradation, desertification, agriculture, or the workings of the semi-arid ecosystem — certainly any attempt to influence them — would logically attempt to understand the Zuni way of knowing about, believing about, and behaving in their natural environment. The

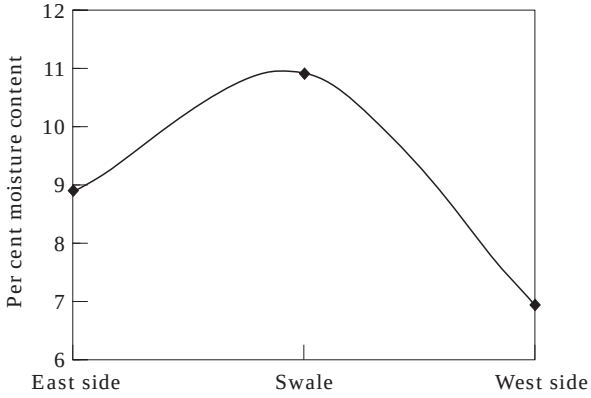

Figure 2. Mean gravimetric soil water content in 1·5-m depth auger samples across the Pescado field.

systematic investigation of the indigenous knowledge system of the Zuni can make some of these time-honed insights explicit for outside researchers to help make research relevant and, therefore, beneficial to Zuni farming.

It is precisely the uniqueness of Zuni history and knowledge that makes it valuable and at the same time difficult to grasp. Cross-cultural communication has always been an obstacle to positive interactions between people. Each side has its own filter through which people perceive and make sense of the real situation before them. Though this idea is better understood today, its extreme importance to agricultural development is not. Much of the logic and belief that makes farming behavior 'rational' is implicit even to the possessors of that knowledge. Therefore, outsiders can easily miss key elements to conclude that actions are not rational. When we bring our rationale to a new place, it becomes what rural sociologists have termed 'decontexturalized rationality' (Kloppenburg, 1991, p. 534).

Indigenous knowledge represents the internal basis for decision-making, and efforts to genuinely assist local people should begin there (Warren *et al.*, 1989). But even when this point is recognized, few people have in mind any conceivable means to explore the other view. This inadequacy is visible in development discussions today where researchers who have spent many years training in their particular natural science disciplines consider a few meetings with local farmers for 'listening to community concerns' a way of understanding the local knowledge system of farming that is perhaps centuries old. Good intention is insufficient for bridging the gap separating a different cultural history and place.

Anthropology, and particularly the subfield of ethnoscience, has developed theory and techniques to elicit components of the knowledge system and make concepts and principles clear and relevant to outsiders (Werner & Fenton, 1970; Conklin, 1972). This is a difficult process. Often knowledge exists in any number of unique forms, especially in oral cultures, and many time-refined knowledge systems exist now only in remnants. The diversity of indigenous farming has produced diverse methodologies for looking at the underlying knowledge, from describing conservation techniques to identifying indigenous soils and terms (Tabor, 1992), and elucidating the mental framework for decision-making (Furbee, 1989). Detailed procedures have been developed for thorough, effective fieldwork (Werner & Schoepfle, 1987). Interpretations of data collected include determining consistent patterns that represent the shared knowledge and organizing information in knowledge structures such as taxonomies, which are more recognizable to western scientists.

It was hypothesized that the knowledge system must contain information on soils and soils processes at Zuni because this information was needed for the elaborate techniques of water spreading and sediment harvesting. A soil science understanding of the area was combined with descriptions of past Zuni farming techniques to design an interview instrument with 107 questions probing soil terms and descriptions of landscape processes from every possible angle and through different lines of reasoning. One cross-section of the interview data was a comparison of meanings given for soil words. A matrix was used to compare farmer responses to reveal consistent concepts. Long-time elderly Zuni farmers described the following: ***he'bik'yaye***, a sticky clay area with poor infiltration; ***so:lana***, a coarse alluvial sediment that captures water and is fertile; and ***danaya so:we***, an organically enriched soil from below upland forest trees. Zuni farmers also had terms for salt or alkali crust and aeolian sediments among others (Pawluk, 1995). Overall, soil terms emphasized surface conditions for water infiltration and transport of parent material. The impact of horizonation on field moisture, development of a level fertile field surface through sedimentation, and the mixing of soil textures are among the principles that emerged from the interview dataset. In the case of Zuni the cognitive system provided a rich alternative but complementary view to the natural science study of the effects of farming practices on alluvial fan soils.

In indigenous systems, limiting environmental characteristics are often reflected by subtle distinctions in term definitions and the consolidating criteria of any ordering scheme. Clearly the processes of sedimentation and infiltration were of utmost importance to past generations of farmers at Zuni. For development efforts the concrete benefits of knowing such local priorities have been discussed elsewhere (Pawluk *et al*., 1992) but briefly include knowing where research and assistance efforts are most efficient, improving communication of information and conservation ideas (when scientists use local terminology), and the discovery of local water and soil conservation technologies that may rely on subtle principles.

The importance for participatory development, however, becomes clearer in the discussion from Koppenburg, a rural sociologist. He is interested in other ways of knowing about agroecology and how to bring farmers and their knowledge back into formal knowledge production in agriculture. He points out that the very different situation in the development of local knowledge, from what he calls the labor process, makes it fundamentally different from but complementary to 'scientific' knowledge:

> '… intimate sustained engagement with their means of production endow farmers not only with a deep knowledge of local particularities, but also with a holistic and systematic understanding of local agriculture that reductionist science cannot easily approximate' (Kloppenburg, 1991).

The relevance of what Kloppenburg is saying for development has to do with sustainability. Because local technical knowledge is 'pre-adapted to its physical and human ecology,' (McCorkle in Kloppenburg, 1991) its elaboration and improvement are more likely to be sustainable in the long-term. The local farmer's situation is strengthened not only because this type of assistance is more environmentally and socially appropriate and incorporates real constraints of farmers but because cultural views and biases are embodied in the knowledge system. Valuing local agricultural knowledge strengthens culture as well.

Though this was the theoretical approach for involvement with Zuni agriculture, the real learning came from direct interactions with farmers. Repeatedly they presented their principles and tried to understand ours until we could finally make the necessary connections to see their point.

One example will suffice. During the ethnoscience soil study the English word *sand* appeared, when used by the Zuni, to reflect more than the precise agronomy definition we knew. During one discussion about field soils a ZSAP farmer, recalling ideas from a previous presentation on enhancing soils with organic matter, summarized with the statement, '… so when you add all that forest soil and manure you change the clay into sand… right?' That comment brought together other evidence to clarify the fuller meaning of 'sand.'

To Zunis sand meant a soil with good tilth. This clarification of what appears as an illogical statement from an agronomic perspective had obvious benefits for the exchange of ideas. Our scientific ideas can also be more seriously considered by local people when these ideas are stated in terms relevant to these people.

The repercussions of respecting this local knowledge and a real interest to share ideas had a profound effect on stimulating the thoughts of community people as well as researchers. Many times Zuni sentences about some aspect of farming or natural ecology seemed inappropriate, only to be substantiated when the Zuni way of thinking and the unique landscape ecology were more fully understood. Those were important moments for all involved.

Summary

In many places in the world a concerted effort is required to halt land destabilization and desertification caused by historical forces that produced social and environmental

disruption. At Zuni, New Mexico, government reallocation of lands, promotion of dam irrigation and modern farming methods, and the shear force of cultural change have disrupted an agriculture that stretches 1000 years into prehistory. In collaboration with the Zuni Tribe, we evaluated the long-term effects of agriculture on soils and explored the significance of Zuni farming techniques in terms of local agroecology. A component of that study sought to identify Zuni principles about landscape processes and agriculture in order to formalize Zuni soil knowledge. The focus on indigenous knowledge in both components connected research efforts to a community initiative to revitalize Zuni agriculture. A serious systematic effort to understand the local rationale and incorporate Zuni-developed knowledge and world view into research designs increases respect and communication and thereby empowers the local farming community to develop agriculture and conserve resources on their own terms.

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