A Study of a Pre-Columbian Irrigation System at Newcomb, New Mexico

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ESRI 380 New York St., Redlands, CA 92373-8100, USA • TEL 909-793-2853 • FAX 909-793-5953 • E-MAIL info@esri.com • WEB www.esri.com

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Richard A. Friedman, John R. Stein, and Taft Blackhorse, Jr.

Introduction

The Newcomb Pre-Columbian Irrigation System Project was funded by the Southwest Native Peoples/Native Homelands Initiative; a grant from the National Aeronautic and Space Administration (NASA) to the Earth Data Analysis Center (EDAC) at the University of New Mexico. The purpose of the initiative was to demonstrate the application of NASA technologies and remote sensing to the problem of documenting global climate change and adaptive strategies to climate change over time. The primary goal of the Newcomb Irrigation Project was to use remote sensing, global positioning system (GPS), and geographic information system (GIS) technologies to identify and map agricultural fields in the vicinity of Newcomb, New Mexico. A second goal was to apply NASA technologies to the problem of identifying other areas in the San Juan Basin where agriculture could have been practiced successfully in the past or might be practiced successfully in the future. The results described herein were first presented at the Second Quarterly Progress Meeting, held on September 8, 1999, at the Institute for the Study of the Planet Earth, University of Arizona, Tucson.

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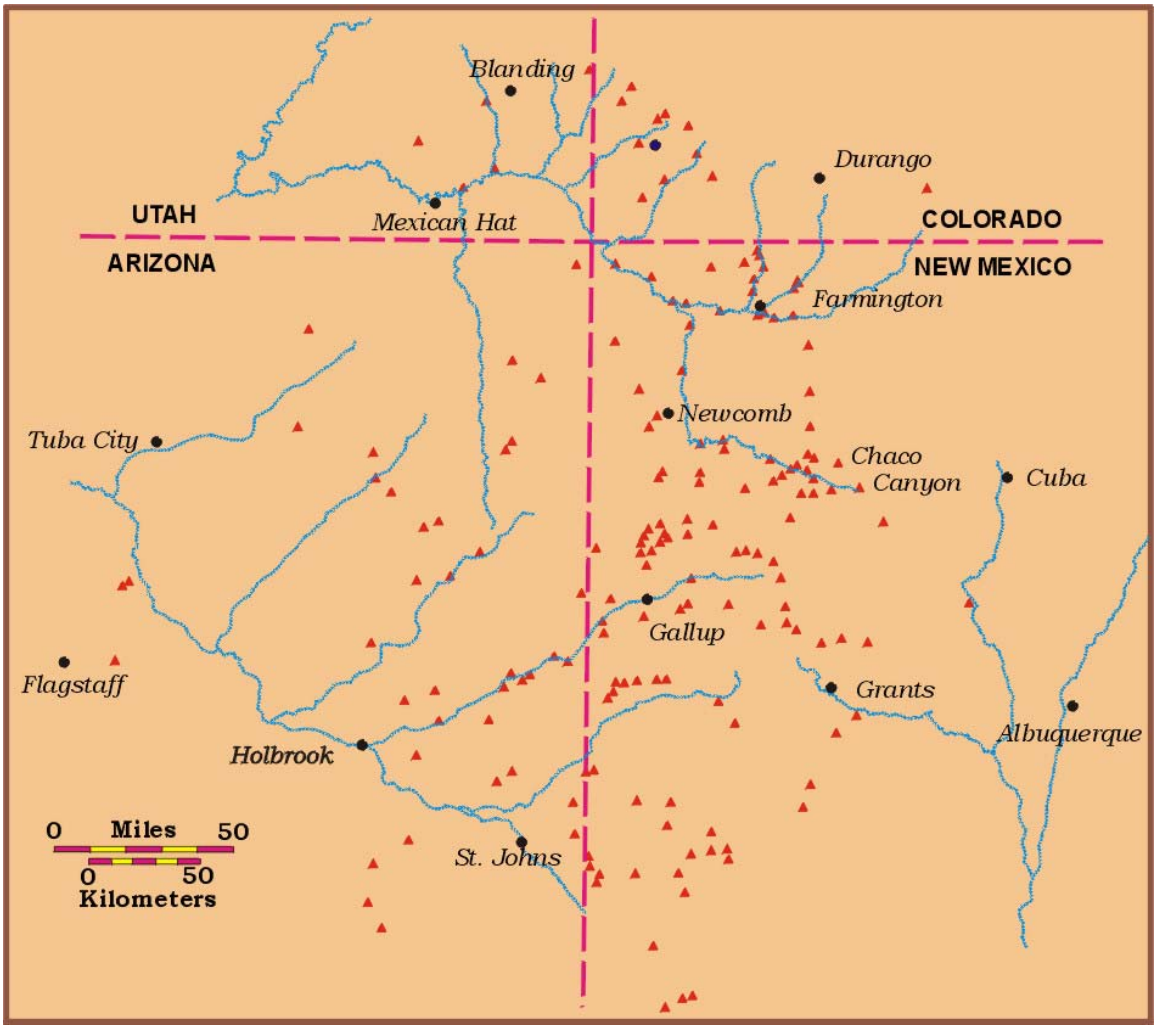
Figure 1
Great Houses in the Chaco Anasari Area of Influence



The Newcomb Irrigation Project is one component of a larger effort to document an extensive (approximately 400 square miles) pre-Columbian landscape in the vicinity of Two Grey Hills, New Mexico. This larger project is being conducted by the Navajo Nation Historic Preservation Department–Chaco Protection Sites Program, which is focused on the Chaco Protection Sites (special management areas) at Newcomb, Skunk Springs, and Crumbled House. The Two Grey Hills landscape is the western terminus of the pre-Columbian "West Road" from Chaco Canyon and, like Chaco, was extensively developed between A.D. 500 to A.D. 1300. The area is the scene of much action in Navajo oral history, and it remains a stronghold of traditional Navajo culture today.

The Two Grey Hills Study presents a unique opportunity to document a pre-Columbian landscape where the physical manifestations of the past and the oral histories that

describe them are both in a very complete state of preservation. Although accessing traditional knowledge is difficult and time-consuming, the results are well worth the effort. Embedded in the Navajo oral history is the cosmology that shaped the pre-Columbian landscape. The knowledge and values derived from oral history provide a sound basis for understanding (and ultimately for managing) the pre-Columbian remains.

During the course of mapping and interviewing it became increasingly apparent that what had long been assumed to be contemporary agricultural fields "fit" into a template of a complex landscape geometry that is demonstrably pre-Columbian in age. The accurate mapping of such an extensive system was an ideal application for GIS, GPS, and remote sensing technologies. Appropriately, the critical resource for this effort is the 1934 Soil Erosion Service (SES) aerial photography, the first aerial management archive, acquired close to 70 years ago.

Four Methods

Four pairs of aerial photographs acquired by Fairchild from the SES in 1934 were used as the base images for the field system documentation process. The 1934 aerial photographs were georeferenced to 1975 USGS orthophoto quadrangles. Features were then captured off of the 1934 photography. First, the main ditch was identified and captured in the GIS. This system feeds several groups of fields with smaller internal ditch systems. Once the main system was identified from the aerial photography, the ditch vectors were converted to three-dimensional vectors using USGS 7.5-minute digital elevation models (DEM). The three-dimensional vectors were then used to validate the aerial photointerpretation of the ditches in conjunction with spot field verification. The validation process was based on the assumption that all the ditches would have a continuous downhill slope. These vectors were also used to determine direction of flow where it was not obvious from the aerial photointerpretation. Ultimately, additional images will be used to identify modifications of the field system over the past 65 years.

The project also investigated the possibility of using large-scale satellite imagery to identify areas that may have existing pre-Columbian agricultural systems, contemporary agriculture systems, or locations that could be candidates for future agricultural development. For this phase of the project, a 1994 Thematic Mapper (TM) scene (acquired through an earlier project with NASA, Stennis Space Center), USGS DEMs, and data acquired through the Newcomb field system analysis were used. The study area was defined by the boundaries of the Tis Nas Kid, Two Grey Hills, Newcomb, and Sheep Springs 7.5-minute USGS quadrangles.

A triangulated irregular network (TIN) was created from the Tis Nas Kid, Two Grey Hills, Newcomb, and Sheep Springs 7.5-minute DEMs. The TIN was used to derive the general slope range for the Newcomb field system. Bands 2, 3, and 4 of the TM scene were used to define the spectral characteristics of the active fields within the Newcomb field system. A supervised classification of the TM image was run to create a separate image showing areas with similar spectral characteristics. This second image was used to create a GIS vegetation data layer.

Two analyses were preformed on the classified vegetation data. One analysis was to query the vegetation data and TIN to determine all locations within the four-quadrangle region that had less than a 4.5-degree slope to create a GIS data layer indicating potential areas of interest. The second analysis was simply to buffer the vegetation data from the original classification coverage. The resulting coverage was used with the original TM image and visually inspected to determine areas of interest. Selected areas from the final GIS data layers were then field checked for contemporary field systems, abandoned pre-Columbian field systems, or locations for possible new development.

The Newcomb Field System

The agricultural field system at Newcomb was established by the pre-Columbian Chaco Anasazi culture and is still in use today. The actual dating of the establishment, or first use of the field system is not known. The research required to establish this date goes well beyond the scope of the Native Peoples/Native Homelands Initiative. However, the oldest archaeological features that appear to be closely associated with the field system date to approximately 500 A.D. The evidence from the archaeological record, Navajo oral tradition, and historic records suggests that portions of this field system may have been in continuous use for approximately 1,500 years. Use of the field system was interrupted for a short time in the 1800s when the U.S. Army forcibly removed the Navajo people from the area.

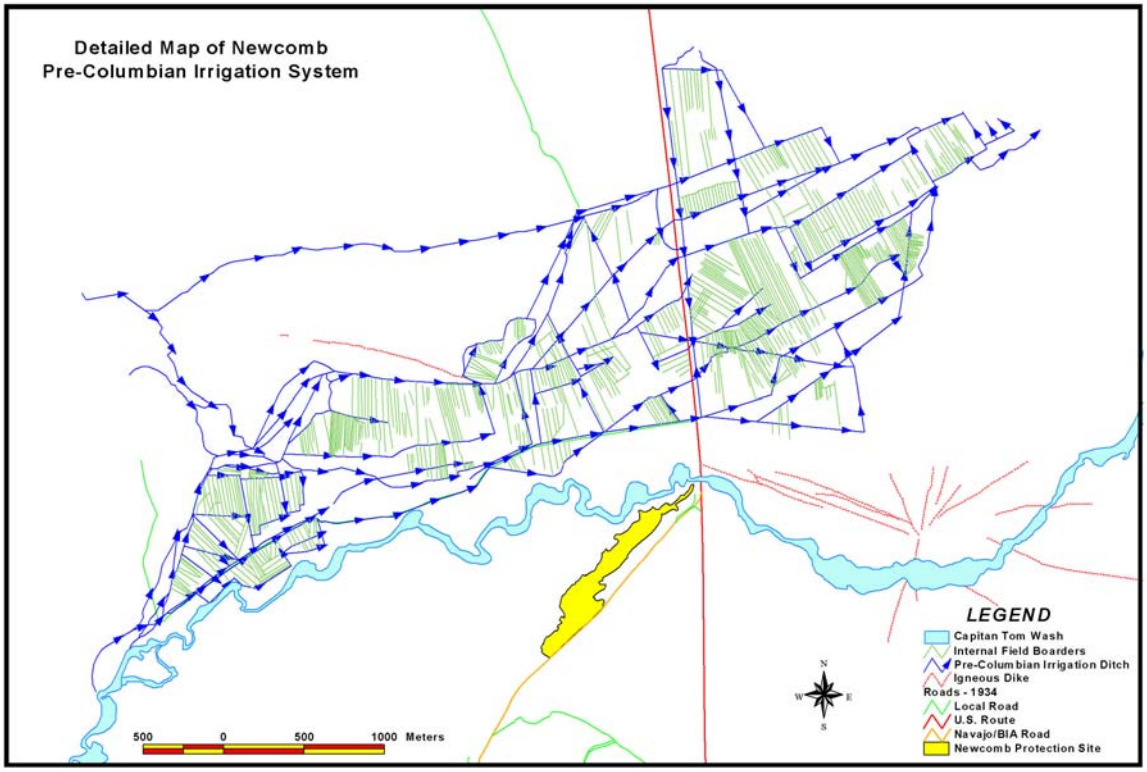
This field system exemplifies the abilities of the residents of this region to modify the physical environment to maximize the use of limited water resources. Even by today's standards, this irrigation system is an engineering marvel. Once water is introduced at the upper end of the irrigation system, its flow can be controlled throughout the system until it exits almost 6.9 kilometers later.

The field system is composed of several groups, or clusters, of fields. These fields are fed by water captured in Captain Tom Wash, To-dil-hil Wash, and an unnamed wash. There are two large water catchment features that have been greatly modified historically but are likely to be of pre-Columbian origin. One is a large reservoir (Captain Tom Reservoir), and the other is a large dike/canal that dams and re-routes the flow of Captain Tom Wash to the southwestern apex of the field system. The water can be directed to any or all of the fields within the cluster. Any excess water from the irrigation of a field is captured by another ditch, which feeds the excess water back into the system to flow on to the next cluster of fields. The individual fields have been leveled and are bordered by earthen berms. The fields are similar in design to "waffle gardens," but are much larger in size. The entire development of the Newcomb field system is approximately 6.9 kilometers in length, 2.8 kilometers wide, and has 74 kilometers of main ditches. The Newcomb field system encompasses an area of 794 hectares (1,960 acres or 3.1 square miles). It is important to note that the Newcomb field system is only one of three known systems in the study area.

The Four Corners region has been subjected to many environmental fluctuations over the past 1,500 years. Inhabitants of the area have experienced several extended periods of less than average rainfall during this time. The influences of these droughts are reflected in the efficient use of water within the field system. Water resources in this area are limited to runoff from spring snowmelt in the Chuska Mountains to the west and rainfall from the monsoon season in July and August. The system was also designed to allow

maximum use of water resources even during the periods of above average rainfall. This is important, any farmer will tell you, as too much water is just as bad as not enough water. In any irrigation system, proper flow and drainage is crucial to success. The Newcomb field system was built by expert farmers—tail water from one field is collected and moved to the next. The irrigation ditch flow patterns exhibited in Figure 2 demonstrate the complexity of the field system and the emphasis placed on maximizing water use.

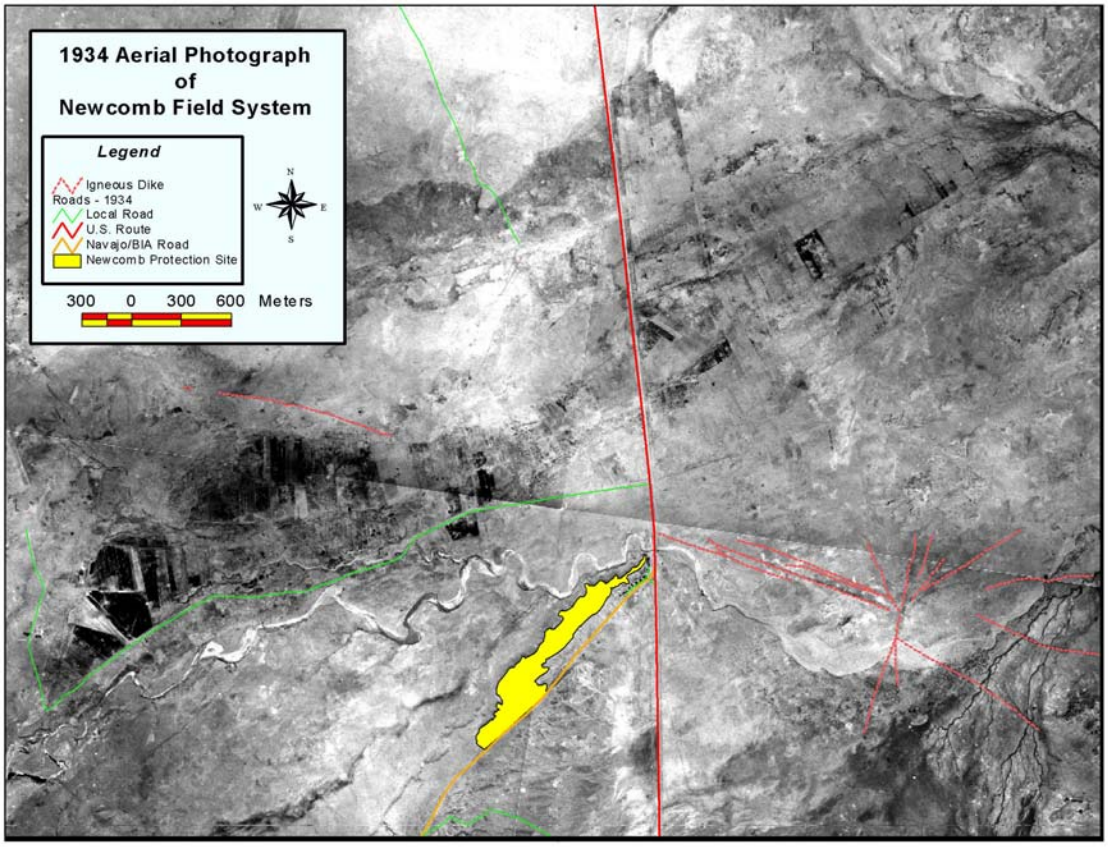
Figure 2
Pre-Columbian Irrigation System on the Navajo Nation at Newcomb, New Mexico



Conclusion

The Newcomb field system provides an excellent example of an efficient irrigation system. Any excess water from one field is immediately captured and diverted through the system to the next group of fields down slope. Water can be utilized through the entire system starting with the first group of fields or can be channeled directly to any portion of the system with a minimum of loss. The Newcomb field system is an outstanding example of large-scale pre-Columbian agricultural engineering and adaptation to an arid climate susceptible to environmental changes.

Figure 3
1934 Aerial Photograph of Newcomb Field System



The results of the satellite image analysis were very impressive. The buffered vegetation data was found to be a better tool for prediction analysis than the data derived from the slope/vegetation analysis. The data derived from the slope/vegetation analysis lost important microenvironment information due to the coarse sampling in the creation of the TIN from the DEM. Several of the locations identified through the analysis proved to be field systems similar to the Newcomb field system (pre-Columbian systems with contemporary use). The other locations checked were areas that had strong vegetation, indicating that enough moisture may be present in reliable quantities to sustain agricultural development.

The information generated by this project is not only useful for understanding how Native peoples have adapted to an arid and unpredictable environment; it also represents an extremely significant contribution to southwestern archaeology. Prior to this investigation, the largest documented contiguous agricultural system in the Chaco Anasazi System encompassed an area of 5.4 hectares (13 acres or .02 square miles). The Newcomb system alone is 150 times larger than the largest previously identified Chaco–Anasazi agricultural system.

Richard A. Friedman, Director
McKinley County Computer Services/GIS Center
2105 East Aztec Ave.
Gallup, New Mexico 87301
505-863-9517
gismc@cia-g.com

John R. Stein, Chief Archaeologist/Program Director
Navajo Nation Historic Preservation Department
Chaco Protection Sites Program
P.O. Box 4950
Window Rock, Arizona 86515
520-871-6437

Taft Blackhorse Jr., Archaeologist
Navajo Nation Historic Preservation Department
Chaco Protection Sites Program
P.O. Box 4950
Window Rock, Arizona 86515
520-871-6437