

VEGETATION STUDIES AT CHACO CULTURE NATIONAL HISTORIC PARK

Final Report 1994

Submitted to:

Southwest Parks and Monument Association
Chaco Culture National Historic Park, Resource Management

February 13, 1995

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INTRODUCTION

In 1992, Chaco Culture National Historic Park acquired tracts of the surrounding Navajo Reservation and Bureau of Land Management lands. These included Chacra Mesa and portions of South and West Mesas as well as land in the southwest portion of the park near Kin Klizhin Ruin. While a vegetation map was available for the older park boundary (Kelly and Potter, 1974), the botany of the new acquisitions is unsurveyed. The long-term objective of this study, established by Frank Hays, Resource Manager, is to inventory all the plant communities at Chaco Culture National Historic Park. This is being accomplished in discrete phases.

In 1993, the vegetation communities occurring on Chacra Mesa were defined and mapped in a GIS layer (Floyd-Hanna et. al., 1993, report on file with SPMA). The GIS division of the Southwest Region, National Park Service, provided a digitized copy of the 1974 vegetation map which covered the original park boundary. The vegetation map of Chacra Mesa was appended onto the original vegetation map.

The second phase of this study began in 1994. The vegetation of South Mesa, Wijiji Mesa, the new acquisitions near Pueblo Alto, as well as the extreme southwest section of the Park, were surveyed. We also began an analysis of the previously mapped vegetation communities as defined and delineated by Kelley and Potter (1974). Many of the vegetation types defined in the Kelley and Potter study extend to the new acquisitions, yet the current procedures adopted by the National Park Service, the current nomenclature (modified Brown-Lowe-Pase system), and 20 years of vegetation change make it necessary to reevaluate earlier work in the smaller park boundary. Under the 1994 funding, we have not carried out this reevaluation except in a limited number of sites. These communities were ground-truthed to assist the GIS modeling (using vegetation type and known limits of slope, aspect, and elevation) described within.

Working closely with Dr. Loren Potter (who has provided us with all his notes, sketches, and data sheets collected in 1972-1974) we have *initiated* a study to determine (1) changes in species composition, dominance characteristics, or spatial distribution in the last 20 years, and (2) assessment of the suitability of the broad scale used in the older map, given today's GIS technology. The feasibility of this successional study has been evaluated by locating 3 of Dr. Potter's original study points and re-analyzing the vegetation with the methods outlined.

The vegetation map which is produced within is a "work-in-progress", with several procedures required for its completion:

1. Vegetation of the older park boundary must be fully sampled (some areas are blank if the GIS modeling did not produce convincing vegetation classes from the TWINSpan classification, slope, elevation modeling)
2. Twenty year successional trends should be evaluated using all of Kelly and Potter's original points.
3. An accuracy assessment of the vegetation classification must be accomplished.

PHYSICAL SETTING AND CLIMATE

Chaco Culture National Historical Park is located near the center of the broad bowl-shaped San Juan Basin on the southeastern corner of the Colorado Plateau. It is approximately 10 miles long and is a narrow flood plain surrounded by high mesa sandstone cliffs which are sporadically topped with eolian sand. The Park's lowest elevation is found in the southeastern riparian bottoms at 1917 meters and it stretches in elevation to the piñon-juniper covered Chacra Mesa at 2087 meters. It is characterized by high mesa tops, tall sandstone cliffs, steep slopes, wide canyon bottoms, narrow river beds, and seeps within the sandstone. Cliff House sandstone is interspersed with Lewis and Tongues shale and a thin coal bearing layer of the Menefee shale also is exposed. The Cliff House sandstone, the upper member of the Mesa Verde group, forms the high cliffs found on the mesas. The Formation is derived from beach sand deposited at or near the shoreline of a Cretaceous sea, approximately 70 million years ago. The Cliff

House is approximately 122 meters thick in the area, but is interfingered with the softer Menefee Formation. Consequently, weathering has often produced two cliffs separated by a bench, as, for example, on Chacra Mesa. The Cliff House sandstone is underlain by the coal-bearing Menefee Formation between the base of the cliff walls and the edge of the valley floor. The Menefee Formation is approximately 80 million years old and was laid down as sand, mud, and plant debris in coastal swamps and on alluvial plains. The southern sections of the Park drop away from the sandstone cliffs into an expanse of Naha, Tsegi and Sheetwash alluvium. The geologic types are distinguishable in the 1:3000 aerial photography provided by the park. This broad spectrum of geographical features provides a large variety of microclimates that supports numerous different community types.

The soils of the canyon bottoms consist of textured clay loams and silty clay loams (USDA, SCS 1980). The soils are deep, slowly permeable, formed in alluvium derived from sandstone and shale. These soils are highly susceptible to erosion and piping. The soil cover on the mesa itself is generally thin and easily eroded when vegetation is disturbed. However deeper, well-drained sandy soils do occur on the gentler slopes.

Chaco Canyon is located in a semi-arid region with an average annual precipitation of approximately 22 cm. Monthly precipitation is greatest in late summer. Winter precipitation, often in the form of snow, is heavier than fall or spring precipitation. The annual temperature averages from 10 to 13 °C with an average frost free period of approximately 150 days. Maximum temperatures rarely exceed 34 °C. Minimum temperatures often fall below -18 °C in the winter.

METHODS

FIELD STUDIES

In order to provide a visual context to guide field sampling efforts, aerial photographs at a scale of 1:3000 and orthophotoquads at a scale of 1:24,000 were used. The orthophotoquads are merged and georeferenced, and therefore provide a useful base map for field inquiry. These were scanned by David Hanna on a flatbed scanner and appended together in the raster-based GIS program IDRISI. New park boundary vectors were digitized by Ross Martin.

On a gray-scale of 0-255, distinct vegetation types such as riparian communities, piñon-juniper woodlands, and greasewood areas were distinguished on the computer screen. Other vegetation types cannot be visualized with clarity. Therefore, the 1:3000 scale overlapping aerial series was used with stereoscopic visualization to determine the extent of the vegetation types in many areas.

To ground truth this image, numerous transects were established in May and September, 1994. The principal investigator was accompanied by David Hanna and a group of students from Prescott College-Kerstin Alicki, Lee Michaelson, Vijay Doshi, Sue Simone and Marc Clausen performed the field work in May, 1994. The September field crew consisted of Kerstin Alicki, Christopher Clack, Alan Hastings, Ross Martin, Chris Bergh, and Mike Jenkins.

Sampling transects were located on West Mesa, South Mesa, and Wijiji Mesa, in the vicinity of the northern and southern entrance of the park, along the slopes between Pueblo Bonito and Pueblo Alto, and in the flats on top of the mesas and in the canyon bottoms and the southwest extreme of the Park near Kin Klizhin Ruin. Seeps, which occur at the head of many of the canyons, draining off of mesas, were also sampled, as were the canyon slopes immediately below the seeps. We also took two points in Chaco Wash. A total of 251 sampling releve plots were established in 1993 and 1994.

All ground points were located with a Trimble Navigation's Pathfinder Basic+ Global Positioning Unit (GPS). They were immediately corrected against the NPS base station in Albuquerque and 180 points were averaged at each site. Processing was carried out by the Park Service GIS laboratory in Albuquerque (Dr. M. Fletcher). The sampling locations are shown in Figure 1.

The vegetation was sampled along each transect in 15 by 15 meter plots using the releve method of Braun-Blanquet (Mueller-Dombois and Ellenberg, 1974). The relative cover and abundance of each species was recorded for each 15 by 15 meter releve plot as shown in Table 1.

Information on location, soil, slope, and elevation were also recorded and correlations were calculated between plant distribution and physical characteristics.

Table 1: Braun-Blanquet Cover and Abundance Scale

Value	Criterion
5	greater than 75% cover, any number of individuals
4	between 50-75% cover, any number of individuals
3	between 25-50% cover, any number of individuals
2	between 5-25% cover, any number of individuals
1	numerous but less than 5% cover
+	few individuals, small cover
r	solitary with little cover

STATISTICAL ANALYSIS

The vegetation data were analyzed using the Cornell Ecological Program TWINSpan (Gausch, 1982, Gausch and Whittaker, 1981; Hill, 1979). This is a divisive, hierarchical multivariate clustering program. The various releves were thus grouped according to similarities in floristic composition. Data from the 1993 field season were reanalyzed together with the data collected in May and September, 1994 to provide a comprehensive evaluation of vegetation in the new acquisitions.

GIS ANALYSIS

The spatial distribution of the floristically defined vegetation communities was cartographically modeled in a GIS environment. All releve sampling sites were located with a GPS. This provided the ability to extract various parameters from existing databases as they related to the floristic communities. The information used in this modeling effort for the Chaco project are as follows: (1) Orthophoto quadrangles (1:24,000) for the Chaco area were scanned on a flatbed scanner, patched together in a mosaic to provide a basemap, (2) A GIS layer depicting the geology of the Park was made available by the Park's Resource Management Staff (Rory Gauthier, pers. comm), (3) Digital Elevation Model (DEM) data of the Park was provided in raw DEM format from the GIS division, SW Region of National Park Service (Dave Frederick and Milford Fletcher, pers. comm), and 4) a slope map was generated from the DEM information. In addition to the digital data, overlapping B/W aerial coverage (1:3000) of the Park, taken in 1982, were available to clarify the extent of vegetation communities which could not be detected in one of the above images.

Using the DEM information layers, we extracted the range of elevation and slope for our sampling releves within each vegetation cluster as defined by TWINSpan. A cross-tabulation analysis of vegetation clusters and geologic types was performed to establish the dominant geologic formation for each floristic community. Tables 2 and 3 show the results of ANOVA analyses on the elevation and slope data and the cross-tabulation with geologic information respectively. These analyses were performed with SPSS statistical software. Boolean GIS analyses were carried out to determine the extent of overlap of geologic substrates which support each vegetation type within the elevation and slope ranges defined by our field sampling. These areas of coincident elevation, slope and geology were used to depict the spatial extent of the floristic clusters. Adjustments were made in the intersected areas as dictated by our field data and observations. The resulting preliminary vegetation map (Figure 2) will require re-definition within the older park boundary, as this area has not yet been extensively sampled in the current study.

The GIS analysis was carried out using Clark University's GIS program IDRISI. The results were subsequently exported to the GIS program EPPL7 (State of Minnesota, Land Management Information Center) for use by the park's resource managers.

RESULTS

The following vegetation delineation was determined from the species abundance matrix using the multivariate clustering program TWINSpan (Gausch, 1989; Hill, 1979). From this classification, 13 distinct vegetation types were defined for Chaco Culture National Historic Park in the areas studied in Phases 1 and 2 during 1993 and 1994. Each of the 13 vegetation associations is described below. In several cases, the spatial delineation of these vegetation types cannot be accurately depicted from the aerial coverage available. Therefore, we have aggregated groups of associations into 8 visually distinct vegetation communities on the map in Figure 2.

We caution that additional vegetation types may be defined in the older Park boundary once the Kelly and Potter work (1974) is evaluated with the currently accepted scale and nomenclature (Rowlands et.al., 1994). Alternatively, some of these classes may be aggregated with further information. What follows is an assessment of a work in progress.

Each vegetation classification is described below. The X or Y following the association name implies that the Colorado Plateau Vegetation Advisory group name is not yet available. Planning is in process to organize and assign new plant association names and when that work is complete, permanent numerals will be assigned. Descriptions are organized by their relationship into series in the Colorado Plateau version of the Brown-Lowe-Pase classification (Spence et al, 1995).

The physical characteristics used to direct a boolean analysis of geology, slope, and elevation by sampling sites are found in Table 2 and 3. The area covered by each spatially explicit vegetation community is tabulated in Table 4.

Table 4: Area of coverage for each vegetation community.

Veg. Class	Area (Ac)	Area (ha)
Riparian Wash	485.94	196.65
<i>A. tridentata</i> / <i>C. nauseosus</i>	347.39	140.58
<i>Sarcobatus vermiculatus</i> associations	1613.05	652.77
Piñon-Juniper associations	2812.67	1138.23
<i>A. nova</i> - <i>J. monosperma</i> - <i>C. visidiflorus</i>	4589.41	1857.24
<i>A. nova</i> - <i>G. sarothrae</i> - <i>C. greenei</i>	4069.22	1646.73
<i>Sporobolus airoides</i> associations	9131.22	3695.22
<i>Hilaria jamesii</i> Series	6792.48	2748.78
Sandstone Cliffs	530.64	214.74
Active Dunes	285.34	115.47

RIPARIAN AND SEEP COMMUNITIES

1401.04 *Populus angustifolia* / *Populus fremontii* Series

Vegetation Class 1A

1401.05X *Populus fremontii*/*Chrysothamnus nauseosus*-*Artemisia campestris* Association

Chaco Wash, between the Kin Kletso Ruin and the Visitor Center, supports a riparian community consisting of mature *Populus fremontii*, broadleafed cottonwood, trees and dense *Chrysothamnus nauseosus* and *Artemisia tridentata* rabbit brush and sagebrush. *Gutierrezia sarothrae*, snakeweed, is common, and its presence often indicates a disturbed habitat. We have not sampled the vegetation

throughout the extent of Chaco Wash, and it is likely from initial observations that while the shrubs will extent throughout the drainage, the cottonwoods are less extensive. The introduced phreatophyte *Tamarix pentandra* (= *T. ramosissima* Ledebour) has invaded many areas of Chaco Wash and although it's distribution is not yet extensive in much of the riparian habitat. However, given it's known rate of spread, coupled with a lack of *Populus* seedling and sapling, the presence of *Tamarix* should be cause for concern for Resource Managment. The dominant ground cover species is the grass *Agropyron smithii*. Scattered herbs include *Bromus tectorum*, *Ipomopsis aggregata*, and *Sedum stenopetalum*. This vegetation type is supported by sandy soils and intermittent moisture.

This vegetation community is found in Chaco Wash at elevations between 1893 and 1901 meters in Chaco Canyon National Historic Park. The vegetation of Chaco Wash was well-studied by Kelly and Potter, and during 1996 we will complete our sampling and determine successional changes. In our few samples, slopes vary from 4.7 to 12.4 degrees. The geological substrate supporting this vegetation type is Alluvium (Qal). The map (Figure 2) shows the Alluvium (Qal) as potential habitat for this vegetation type.

Vegetation Class 1 B

1401.04X *Populus angustifolia*-*Foresteria neomexicana* Association.

This vegetation community is confined to seeps in the sandstone ledges and the area immediately surrounding seeps which are scattered throughout the higher elevations on Chacra, South, and West Mesas. *Populus* and *Foresteria* are the dominant trees and a variety of low shrubs, such as *Artemisia tridentata*, *Ribes cereum*, *Cercocarpus montanus*, *Amelanchier utahensis*, *Chrysopsis villosa* and *Chrysothamnus nauseosus* form the understory. Adjacent to the seeps, sagebrush is joined by *Chrysothamnus greenei* and *Petradoria pumila*. Herbaceous elements include *Parthenocissus inserta*, *Castilleja chromosa*, *Clematis lingustifolia*, *Eriogonum umbellatum*, *Artemisia frigida*, *Sporobolus aeroides*, and *Gutierrezia sarothrae*. *Lathyrus* species are also members of this moist, isolated, habitat. Grasses include *Sitanion hystrix* and *Poa fendleriana*.

This vegetation community is found at elevations between 1939 and 1963 meters on lower member of the Cliff House Sandstone (Kch) or on tongues of Lewis Shale (Kl). It is generally flat, with slopes between 2.1 and 3.4 degrees. We sampled six plots supporting this vegetation association.

1401.10 *Forestiera neomexicana* Series

Vegetation Class 1C

1401.10X *Forestiera neomexicana*/*Juniperus monosperma* Association

The seep communities in Chaco Canyon National Historic Park are separated floristically into two types. Unlike the previously described seep community, the seeps at higher elevations lack *Populus* species and include *Juniperus*, indicating relatively lower moisture condition. *Forestiera neomexicana* and *Juniperus monosperma* are accompanied by *Rhus trilobata*, *Ribes cereum*, *Amelachier utahensis*, and *Prunus virginiana*. In some areas it also includes scattered *Sarcobatus vermicualtus* and *Chrysopsis villosa*. Herbs include *Artemisia ludoviciana*, *Senecio multilobatus*, *Brickellia scabra*, *Astragalus acaulis*. *Poa fendleriana* is the most common grass, and *Oryzopsis hymenoides* is also present.

This vegetation community is found on the geologic substrate Cliff House Sandstone (Kch) from which seeps are common. Elevations range from 1909 m to 1979 meters in the Park on slopes of 2.1 to 12.6 degrees. We sampled nine of these associations.

Note: The three riparian or seep communities have been grouped as vegetation type 1 in Figure 2.

1402.01 *Artemisia tridentata* Series

Vegetation Class 2

1402.01X *Artemisia tridentata*/*Chrysothamnus nauseosus* Association

Above Chaco Wash and ascending to the floodplain is found a tall shrubland community that favors deep sandy soils. *Artemisia tridentata*, *Chrysothamnus nauseosus*, *Artemisia campestris* and *Gutierrezia sarothrae* make up the dominant woody shrubland species. In some areas, *Atriplex canescens* may be found. Herbs include *Leucelene ericoides*, *Cymopterus fendleri*, *Eriogonum leptophyllum*. Grasses are mainly represented by *Hilaria jamesii* and *Oryzopsis hymenoides*. Within this vegetation type scattered throughout the floodplain are disturbed patches which support the weedy *Salsola iberica*, Russian thistle.

This vegetation type is found on Cliff House Sandstones (Kch) and on Naha and Tsegi Alluviums (Qnt). Elevations range from 1979 m to 1990 m. These sites are usually flat, and sample points were found on slopes between 2.1 to 3.9 degrees. We sampled four of these associations.

MESA TOP AND SANDSTONE LEDGE AND SLOPE COMMUNITIES

1401.01 *Pinus edulis* Series

Vegetation Class 4A

1401.01X *Pinus edulis*-*Juniperus monosperma* Association

The piñon-juniper association is common on Chacra Mesa, and scattered on West Mesa. Shrub species include *Cercocarpus montanus*, *Cowania mexicana*, dense clusters of *Artemisia nova*, and scattered patches of *Ephedra viridis*. *Petradoria pumila*, *Opuntia polycantha*, *Yucca angustifolia*, *Cymopterus fendleri*, *Aletes macdougalii* and *Eriogonum leptophyllum* are some of the more common herbaceous species present. Grasses include *Bouteloua gracilis*, *Poa fendleriana*, and *Oryzopsis hymenoides*.

The piñon-juniper association is found primarily on the upper and lower members of the Cliff House Sandstones (Kch and Kchu)), but it can also occur on the Kirtland Formation (Kf) and on Meniffee Shales (Kmf). The latter geologic types support a woodland which has few piñon pines and a higher density of juniper than the Cliff House Sandstones. The elevation ranges from 1859 m to 2073 m. and slopes vary from flat to 28 degrees.

1401.03 *Juniperus monosperma* Series

Vegetation Class 4B

1401.03X *Juniperus monosperma*-*Artemisia nova*/*Ephedra torreyana* Association

Juniper trees in this association are small and shrubby and share dominance with many shrub species such as *Artemisia* and *Ephedra torreyana*. *Ephedra viridis* is also present, as is *Yucca harrimaniae*, *Cercocarpus montanus*, *Rhus trilobata*, and occasionally *Pinus edulis*. Important elements of the herbaceous understory are *Astragalus amphioxys*, *Descurainia pinnata*, *Phacelia heterophylla* and *Petradoria pumila*. This association can mainly be found in pockets of Cliff House Sandstone outcrops around the edges of mesas, and although it is floristically similar to the piñon-juniper association described above, piñon pines are lacking and it is confined to elevations between 1839 m and 1910 meters on slopes averaging 11 degrees. We sampled 70 releve plots in these two associations.

The two piñon and juniper vegetation associations have been aggregated spatially into vegetation type 4 in Figure 2.

1403.07 *Artemisia nova* Series

Vegetation Class 5

1403.07X *Artemisia nova*-*Juniperus monosperma*-*Chrysothamnus viscidiflorus* Association

The slope communities of Chaco Canyon have not been of focus in past vegetation studies, and new Park acquisition has increased the extent and importance of the slope areas. They support an array of unique species, particularly those in the Polygonaceae. The slopes trap deep sandy soils which support also scattered stunted *Juniperus monosperma* trees at low density. The dominant shrubs are *Artemisia nova*, *Eriogonum corymbosa*, *Chrysothamnus viscidiflorus*, *Ephedra torreyana*, *Gutierrezia sarothrae* and *Atriplex confertifolia*. The common grasses include *Bouteloua gracilis*, *Stipa comata* and *Hilaria jamesii*. Common forbs are *Eriogonum umbellatum*, *E. lonchophyllum*, and *Cryptantha flava*.

This vegetation association occurs in a wide elevational range, from 1872 m to 2055 m. It is confined to the Kirtland Formation (Kk) and the lower Cliff House Sandstones on slopes averaging 9 degrees. We sampled twenty-six of these slope associations.

Vegetation Class 6

1403.07Y *Artemisia nova*-*Gutierrezia sarothrae*-*Chrysothamnus greenii* Association.

This vegetation type is similar to the previous one in floristic composition, however it lacks *Juniperus*. It is an open, low shrubland typical of the mesa tops and northern exposures of upper elevations on South Mesa, Chacra Mesa, and Wijiji Mesa. Large expanses of this vegetation community are interrupted by patches of *Artemisia-Juniperus/Chrysothamnus* defined above. Shrub species include *Artemisia nova*, *Gutierrezia sarothrae*, *Chrysothamnus greenii*, and *Tetradymia canescens*. The dominant grasses are *Oryzopsis hymenoides* and *Bouteloua gracilis*.

This vegetation association occurs on a variety of geologic types. While most of our samples were confined to the Cliffhouse Sandstone (Kch and Kchu), a few were found on Eolian Sand (Qes) and Sheetwash Alluvium (Qsw). Elevations range from 1888 m to 2078 m. It occurs on slopes of 2.1 to 28 degrees.

ALKALI FLAT COMMUNITIES:

1402.03 *Sarcobatus vermiculatus* Series

Vegetation Class 3A

1402.03X *Sarcobatus vermiculatus*/*Atriplex canescens*/*Hilaria jamesii* Association

Several native plant communities at Chaco are subject to invasion of exotic species, particularly in the lowland areas which sustain heavy visitation. These are also communities which support an extremely high density of archeological sites. For example, the greasewood-saltbush community is common near the paved road along the canyon bottom. Disturbance is indicated by a dense cover of *Salsola iberica* and the grass species *Bouteloua gracilis*. In addition, native species such as the grasses *Sporobolus airoides*, *Sitaniun hystrix*, *Oryzopsis hymenoides* and *Hilaria jamesii* can be found in this greasewood flat community.

Sheetwash Alluvium (Qsw) supports this vegetation type in the low elevations of the Park, from 1873 m to 1908 m. Slopes vary from 7.8 to 20.8 degrees. We sampled twenty five of these associations.

Vegetation Class 3B

1402.03Y *Sarcobatus vermiculatus*-*Lycium pallida*-*Sporobolus airoides*/*Atriplex gardneri*
Association

This community includes the shrubs *Sarcobatus*, *Lycium*, *Atriplex gardneri* and *Atriplex canescens*. It is found in a highly impacted area on the southwest corner of the Park near Kin Klizhin Ruin in a dam site built by the Anasazi. *Lycium pallidum* is often considered a site indicator species. Weedy species such as *Salsola iberica* are present. *Tamarix pentandra*, an non-native, invasive phreatophyte is found in patches of this vegetation community. Forbs are absent, and grasses include *Sporobolus airoides*, *Hilaria jamesii*, and *Oryzopsis hymenoides*.

This vegetation association may be found on Naha and Tsegi Alluviums (Qnt) as well as on Alluvium (Qal). In the Park, it is found at elevations averaging 1908 m and a broad range of 1844 m to 2060 m. We sampled ten of these associations.

Vegetation associations 3A, and 3B have been spatially aggregated into one vegetation community, vegetation type 3, in Figure 2.

1404.07 *Sporobolus airoides* Series

Vegetation Class 7A

1404.07Y *Sporobolus airoides*-*Atriplex canescens* Association

This open shrubland is co-dominated by four-winged saltbush and alkali saccaton grass. The archeological site indicator *Lycium pallidum* is also present. The presence of *Atriplex canescens* indicates saline soils. Other important shrubs include *Sarcobatus vermiculatus*, *Chrysothamnus Greenei*, *Artemisia tridentata*, and *Ceratoides lanatum*. Herbs include *Eriogonum microthecum* and *Stanleya pinnata* (possibly indicating selenium-rich soil). Patches of *Atriplex gardneri* occur in this vegetation type in the southwest section of the park, near Kin Klizhin Ruin. Grasses include *Hilaria jamesii* and *Oryzopsis hymenoides* in addition to *Sporobolus*. It is important that *Hilaria jamesii* can occur in locally dominant patches throughout this vegetation association.

This vegetation community occurs on many different geologic substrates—upper and lower Cliff House Sandstones (Kch and Kchu), Kirtland Formation (Kk), and Menefee Formation (Kmf), although it is favored by the Naha and Tsegi Alluviums (Qnt) and the Sheetwash Alluvium (Qsw). Elevations range from 1844 m to 2077 and slopes are fairly flat, averaging 6 degrees. We sampled eighty points in this vegetation association which is common in the low-lying areas of Chaco Canyon.

Vegetation Class 7B

1404.07Z *Sporobolus airoides* Association

Restricted areas of the lowlands in Chaco between 1826 and 1905 meters are dominated by *Sporobolus airoides* in early monospecific patches. The few herbaceous species that invade these grasslands include *Leucelene ericoides*, *Descurainia pinnata*, and *Oenothera caespitosa*.

This vegetation community is found on Cliff House Sandstones (Kch), on the Menefee formation (Kmf), and most frequently on the Naha and Tsegi Alluviums (Qnt). The terrain is flat, with an average slope of 3.6 degrees. We sampled four of these associations.

The *S. airoides* associations 7a and 7b have been aggregated spatially in Figure 2.

1404.04 *Hilaria jamesii* Series

Vegetation Class 8

1404.04 *Hilaria jamesii*/ *Sarcobatus vermiculatus*-*Bouteloua gracilis*-*Oryzopsis hymenoides* Association

This open, grassy area with scattered shrubs is also spotted with *Lycium pallidum*, an indicator of the presence of archeological sites. In addition to *Sarcobatus vermiculatus*, *Atriplex canescens* can be found, as can *Tetradymia canescens* and *Artemisia tridentata*. *Astragalus aucaulis* and *Lappula redowski* are important forbs in this community. The widespread grasses *Hilaria jamesii*, *Bouteloua gracilis*, and *Oryzopsis hymenoides* dominate the vegetation association.

This vegetation association occurs on the Naha and Tsegi Alluviums (Qnt). The slopes average 6.7 degrees, and elevations range only between 1846 m and 1976 m in Chaco Canyon National Historic Park. We sampled nineteen of these associations.

The vegetation of Chaco Culture National Historic Park is being investigated in a multi-phase study. An in-progress vegetation analysis is based on species cover/abundance values gathered in 251 plots during 1993 and 1994 and GIS analyses. The 1993 study was confined to the vegetation of Chacra Mesa. The 1994 study focused on South and West Mesas as well as new acquisitions near Kin Klizhin Ruin and Wijiji Mesa. We describe thirteen vegetation community types. They can be grouped as "Seep and/or Riparian," "Mesa Tops and Sandstone Ledges," "Alkali Flats," and "Slope" categories. After classifying the vegetation based on clusters of species cover/abundance values (Gausch, 1982), several classes were aggregated in order to depict their spatial extent with the available digital GIS data. Both 1:24,000 orthophotoquads and 1:3000 B/W aerial photographs were used to differentiate the spatial extent of the defined vegetation classes. Finally, Digital Elevation Model (DEM) information on elevation and slope as well as Chaco Canyon geology were used to map the eight visually distinct vegetation communities.

A preliminary GIS based vegetation map is presented in this report. We caution that the older park boundary has not been fully studied, and in some cases, the spatial extent of vegetation associations defined in TWINSpan has been determined by a combination of the original Kelly/Potter map and modeling in the GIS environment. Finally, several of the Kelly/Potter sampling points were re-located to test the possibility of performing a 20-year successional study based on the original map of the old Park Boundary. This is a feasible and important goal to consider in future studies of Chaco Canyon.

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