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EXCERPTS FROM:

Vegetation Community Analysis and Preparation of a Working Vegetation Map of Natural Bridges National Park

Final Report

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Introduction

Natural Bridges National Monument lies in the heart of Cedar Mesa, Utah, where dense, short-canopy piñon-juniper (*Pinus edulis-Juniperus osteosperma*) communities form on mesa tops, and riparian assemblages, primarily dominated by *Populus fremontii*, occur in the washes. Elevations range from 5500-7050 feet. The majority of the Monument overlays Cedar Mesa Sandstone, although a small piece of Moenkopi Formation juts out of the extreme western section. Three canyons, White, Armstrong, and Tuwa, cut through the sandstones, and sandstone bridges were formed by the water's erosional effects on the sandstone. The Monument serves to protect three spectacular sandstone bridges and numerous archeological sites, as well as the surrounding plant communities.

Natural Bridges National Monument is surrounded by lands under the jurisdiction of the Bureau of Land Management. This area of southeastern Utah, known collectively as Cedar Mesa, has supported grazing of cattle since the late 1800's. Much of the piñon-juniper woodlands in Utah, New Mexico, Arizona and Colorado, have been converted to "more productive grazing land", generally by chaining or herbicide treatment. The conversion often reduces soil infiltration rates and alters understory characteristics (Busby and Gifford, 1981). Invading piñon and juniper stands tend to be unnaturally even aged (a result of growth from small trees which slip beneath the chain) and in this region, trees are young. Harvesting of piñon and juniper trees increases the yield of desirable grass species, particularly on the microsites once associated with trees. Conversion may reduce by nine times the area required per animal unit month (Everett and Sharrow, 1985), so it is not surprising that the practice is widespread outside the Monument borders (Busby and Gifford, 1981). Grazing within the Monument itself was documented in the records of Zeke Johnson during the early 1940's (Natural Bridges Annual Reports), and trespass cattle are occasionally cited in the riparian habitats today (McKinlay-Jones, personal communication). However, the numbers of trespass events are low, with access primarily from the southern boundary, so the Monument is considered relatively protected, compared with the surrounding piñon-juniper woodlands of Cedar Mesa. Microbial soil development is particularly pronounced in the Monument, exemplifying the lack of disturbance by grazing or human activity. Fencing of the Monument has been partially undertaken and it is the intent of Resource Managers to exclude cattle from the Monument in the near future (Belnap, personal communication).

The native understory vegetation within the Monument is of special interest as it represents a relict of native, relatively undisturbed, habitat. Little is known about the native understory flora, or of the successional pattern of understory replacement following disturbances in piñon-juniper woodlands (see Everett, R.L. (Ed), 1986). Succession of understory species in chained piñon-juniper woodlands has been investigated (Everett, Sharrow and Meeuwig, 1983); understory response to fire follows an unpredictable pattern of immediate perennial dominance in some piñon-juniper areas (Floyd-Hanna, Heil and Romme, 1991).

In addition, native plant communities are of interest in the context of the archeological resources on Cedar Mesa. The potential vegetation available to Anasazi populations who inhabited this region from shortly after 1 A.D through 1300 A.D. may be surmised from the native vegetation today. The archeological resource itself is protected from the devastating disruption of woodland conversion, and the more subtle disturbance of livestock presence.

Throughout the southwest, recent emphasis has been given to riparian communities, as they represent a remnant of a much more extensive pre-settlement ecosystem. Arizona and New

Mexico have lost 90 % of their original riparian areas, which never covered more than 1-2 % of the landscape of the southwest (Johnson, 1989). Much of the biological diversity depends on these unique waterways. In Natural Bridges National Monument, three canyons converge, each harboring a unique assemblage of riparian plant species. Annual flooding is required to maintain healthy riparian communities (Debano and Schmidt, 1990). In Natural Bridges National Monument, annual flooding is particularly high at periodic intervals, most recently in 1989 and 1992.

Negative impacts on riparian corridors, in general, include water diversions, conversions to pasture, exotic plant invasion (particularly tamarisk and Russian Olive) and livestock grazing (Johnson, 1989). The native Bighorn Sheep, which no doubt grazed the riparian areas of the Monument, have not been sighted since the 1960's. Cattle tend to trespass in these sites. Visitation along riparian areas of the Monument is high, as the scenic Natural Bridges, for which the Monument was established, bridge the riparian ecosystems. Therefore, a definition of riparian areas is critical for management decisions.

In 1992, the National Park Service requested a study of plant communities within Natural Bridges National Park. This report outlines twelve distinct plant communities and maps their location. Along with the flora of Natural Bridges (Heil, 1990), this will provide a basis from which to gauge the effects of grazing and woodland removal on the landscape of southeastern Utah.

Materials and Methods

An overlapping color aerial photograph series, flown Sept 8, 1977, was available for the Monument, and was used to determine stereoscopic images of the vegetation. Orthophoto quadrangles (1:24,000) were used to outline visually distinct vegetation types. Landsat imagery was not used because of the small size of the Monument (approximately 25 sq mi). Vegetation classes were proposed from the remote data and sampling points were selected within each class. A semi-quantitative relevé analysis (Moore and Chapman, 1986; Mueller-Dombois and Ellenburg, 1974) was used to define communities at these sites. The relevé analysis was statistically analyzed with a multivariate cluster analysis to define vegetation communities.

The relevé analysis was carried out in square plots (the number determined by the spatial extent and homogeneity of the vegetation in a given area, generally 3 per site), aligned along transects bisecting proposed homogeneous vegetation units. Data were collected in late May, July, and October, 1992. Plot size was determined by minimum-area techniques, and varied from 10 sq meters to 40 sq meters. The cover and abundance of each species was estimated using Braun Blanquet's Cover/Abundance Scale as follows:

- 5 Any number, with cover >75% of reference area
- 4 Any number, with 50-75% cover
- 3 Any number, with 25-50% cover
- 2 Any number, with 5-25 % cover
- 1 Numerous, but less than 5% cover or scattered with cover up to 5%
- + Few, with small cover
- r solitary, with small cover

The first four scales refer only to the vertical crown or shoot area projected on the ground, while the lower three scales estimate abundance (actual numbers), therefore this is called a combined estimate scale (Mueller-Dombois and Ellenburg, 1974). Site characteristics, slope,

aspect, geologic formation, soil type and microbial characteristics were collected at each relevé sampling site.

Data were arranged in a sample-by-species data matrix for multivariate analysis (see below). A cluster analysis was run with TWINSpan, a divisive multivariate analysis program developed by Cornell University (Gausch, 1972). The distribution of sampling points in each cluster type was overlain on the proposed vegetation classes, and adjustments were made to accommodate the original spatial extent of visually-distinct classes, as determined from aerial coverage. Raw data were submitted to Dr. Jayne Belnap. Finally, each community was named (at this stage, proposed) using the Brown, Lowe and Pase nomenclature system (Draft 3.42) adopted by the Colorado Plateau Vegetation Advisory Group. The committee is in the process of defining the proper Colorado Plateau Associations, therefore we will only tentatively suggest BLP nomenclature, pending the action of this committee.

With the aerial photography available, it was impossible to delineate the spatial extent of the riparian communities. Therefore, the working map will require further definition in this region, and we have digitized the map so that Monument personnel can improve on the riparian corridor, and perhaps other areas, in the future, and improve upon the working map. David Hanna digitized the working map using TOSCA, a digitizing program compatible with IDRISI, a PC-based GIS system. The map will be converted to an ASCII format, which can then be read into GRASS IV, the GIS software available in Canyonlands National Park's Moab office.

Results

From visually distinct units in the 1977 color aeriels and on the USGS orthophotquads, we initially defined 7 vegetation types within the Monument. Extensive ground-truthing allowed us to modify this to a total of 12 plant communities (Figure 1 and 2) primarily by defining vegetation patterns within the visually obscured (from aeriels) riparian and canyon systems with the multivariate cluster analysis (summarized in Appendix A).

The communities on the mesa tops and sandstone shelves are best defined in the Brown, Lowe, and Pase system for the Colorado Plateau (CPVAC, Draft 3.42) as within the Great Basin Conifer Woodland (122.4) Associations and Subassociations, and many within the Piñon-Juniper Series (122.41). The riparian and associated communities will fall within the Warm Temperate Swamp and Riparian Forest (223.) Interior Southwestern Riparian Deciduous Forest and Woodland (222.2) Associations and Subassociations.

1. Vegetation Communities within the Canyon Systems

Riparian Communities

In the intermittent streams cutting White, Armstrong and Tuwa Canyons, we defined clusters of four distinct riparian communities. Within and immediately adjacent to streams in these systems is a true riparian community consisting of *Populus fremontii* and *Salix amygdaloides*, with scattered *Salix exigua*, *Solidago sparsiflora*, and *Scirpus* species. Other species include *Oenothera* sp., *Cirsium* sp, *Heterotheca villosa* and *Gutierrezia sarothrae*. The riparian community is flat (lacking slope), it is generally found from 5700-6240 foot elevations in the Monument, and the ground cover ranges from 30-40 %. Soils are sandy. This community falls in the defined 223.21 series of the Brown, Lowe, Pase system (Draft 3.42).

The second community consists of *Populus acuminata* and *P. fremontii-Salix* sp. (223.21) series with *Amelanchier utahensis* as a critical component. We suggest 223.21x

Populus-Salix-Amelanchier association. This community also includes *Cercocarpus montanus* and *Quercus gambellii* scattered in the shrub association, and understory includes *Carex* sp. *Heterotheca villosa*, *Castilleja linariifolia*, *Ephedra viridis*, *Haplopappus scopulorum*, *Solidago sparsiflora* and *Swertia utahensis*. The *Populus-Salix-Amelanchier* community is found in the Monument at 5800-6000 foot elevations. Although appearing relatively dense, bare ground occupies from 25-75 % of the area. The community lacks stratification and soils are sandy.

Another community of the stream environment, residing on the first bench above the water, consists of *Populus fremontii*, *Acer negundo* with scattered *Quercus gambellii*, *Chrysothamnus nauseosus*, *C. viscidiflorus*, *Atriplex canescens*, occasional *Fraxinus anomala* and *Symphoricarpos oreophilus*. Other species include grasses *Agropyron cristatum*, *Bromus tectorum*, *Elymus canadensis* and forbs *Clematis linguistifolia*, *Artemisia ludoviciana*, *Haplopappus scopulorum*, *Lepidium montanum*, *Stanleya pinnata* and *Ephedra viridis*. This community occurs at 5780-5800 feet and along slopes up to 15 %. The ground cover varies from 10-60 %; microbial soils are not common. We suggest association 223.21x for this community.

The fourth community in Natural Bridges National Monument associated directly with water are the "hanging garden" communities (Figure 2). Moisture is continuously provided by seeps from the sandstones. Hanging gardens are found near 6000 foot elevations. The vegetative cover is dense, with bare ground less than 5 % in most cases. These protected clusters consist of the following species: *Swertia utahensis*, *Heterotheca villosa*, *Solidago sparsiflora*, *Galium coloradoense*, *Cirsium* sp. and herbs *Habenaria zothecina*, *Erigeron kachinensis*, *Aquilegia micrantha*, and *Zygadenus vaginatus*. Occasionally, scattered trees, *Pinus edulis*, and shrubs, *Cercocarpus montanus* and *Rhamnus* sp. may be found in the garden. *Carex* species and *Pachystima myrsinites* may also be present. We suggest association 223.21x for hanging garden communities.

The demography and reproduction of *Habenaria zothecina* has recently been studied by Linda Reeves. Although numerous individuals are found in all size classes and reproduction is robust, a significant number are lost to predation (Heil and Floyd-Hanna, 1992).

Figure 1 outlines the extent of each community. However, in the canyon areas, the four riparian types could not be spatially defined because the aerial coverage available obscured these canyons in shadow. Further field inventory will be needed to determine precisely the physical extent of each riparian community defined above.

Grassland and Transitional Grassland Communities

On benches at elevations immediately above the streambeds we find, where soils have accumulated, a community dominated by grasses *Oryzopsis hymenoides*, *Stipa comata*, *Agropyron cristatum*, and *Aristida purpurea*. Among the grasses are scattered *Quercus gambellii*, *Ephedra viridis*, *Yucca baccata*, *Hymenopappus filifolius*, and forbs *Machaeranthera canescens*, *Lesquerella* sp, *Senecio multilobatus*, *Commandra pallida* and *Castilleja* and *Penstemon* species. Cacti include *Sclerocactus parviflorus* and *Opuntia polycantha*. The area lacks well-developed microbial soils, and bare ground can be found up to 50 % of the relevé sampling area. The slope reaches 15 % in some sites, and aspect varies from southeast to northeast. The elevation varies from 5700-6000 feet. Ground cover exceeds 50 % in most sites. This community may fall within 142.23, Ricegrass Series; we propose *Oryzopsis-Stipa* (142.23x) association.

As the elevation increases beyond the grassland, the community grades eventually into a Piñon-juniper woodland of the mesa top, and a Piñon-grassland transitional community is

Piñon-Juniper Slickrock Community

The piñon-juniper community tolerates thin soils in shallow pockets which develop in the Cedar Mesa sandstone. Isolated patches of a few trees, shrubs, or cacti are found, not unlike the composition of the piñon-juniper mixed shrub community of deeper soils. In the northern section of the park, the percent of bare ground is so high (greater than 70 %) that extensive patches were defined as Piñon-Juniper Slickrock by the cluster analysis. Trees are dwarfed and shrubs rarely attain their normal height. The soils lack litter and duff, and microbial crusts are extensive. *Pinus edulis*, *Juniperus osteosperma*, *Arctostaphylos patula*, *Fraxinus anomala*, *Solidago petradoria*, *Yucca angustissima*, *Ephedra viridis*, and *Cercocarpus intricatus* are common inhabitants of these pockets. Herbaceous plants include *Helianthella uniflora*, *Commandra umbellata*, *Euphorbia fendleri*, *Erioneuron pulchellum*, *Gilia roseata*, *Gutierrezia microcephalus*, *Lomatium parryi*, *Eriogonum microthecum* and *Hymenoxys acaulis*. Rarely these sandstone communities support shrubs typical of the deeper loess sites, including *Chrysothamnus Greenei*, *Berberis fremontii*, *Artemisia biglovii*, and *Amelanchier utahensis*. We propose a association 122.42 for this community.

Piñon-Juniper Buffalo Berry Community

The piñon-juniper-buffalo berry, *Pinus edulis*, *Juniperus osteosperma*, *Shepherdia rotundifolia* community is a unique plant assemblage found on the limited Moenkopi Formation, southwest of the highway cut through the Monument. The overstory is scattered trees of mid-ages, and there is much open area. Grass cover is sparse, consisting of *Oryzopsis hymenoides* and *Stipa comata*. The buffalo berry shrub layer is accompanied by *Ephedra viridis*, *Fraxinus anomala*, *Berberis fremontii*, *Symphoricarpos oreophilus*, and *Amelanchier utahensis*, and the herbaceous layer consists of *Happlopappus species* and *Physaria newberryi*. We suggest subsassociation 122.414Xx for the Piñon-Juniper-Shepherdia community.

Discussion

Natural Bridges National Monument has been established since 1908 in the once inaccessible southeast corner of Utah known as Cedar Mesa. Today it is surrounded by Piñon-juniper woodlands under the jurisdiction of the Bureau of Land Management, and hence is an ungrazed and relatively unaltered "island" in a multiple-use area. The vegetation of Natural Bridges National Monument was studied in 1992 using a multivariate cluster analysis, and twelve plant communities were defined.

The most diverse section of the Monument lies in the canyon systems, of which there are three: Whites, Armstrong, and Tuwa. We defined 8 communities as either riparian or closely dependent on an intermittent water source. In the stream bed lies a true riparian Cottonwood-Willow community, dominated by *Populus fremontii* and *Salix amygdaloides*. Another community near the streams, but slightly above the water level is a Cottonwood-Willow - Serviceberry dominated by *Populus fremontii*, several *Salix* species, and *Amelanchier utahensis*. Still higher, on benches overlooking the streambed, occurs a Cottonwood-Box Elder community, with *Acer negundo* and *Quercus gambelii*. Finally, in alcoves or near seeps in the sandstones are well developed Hanging Gardens, housing *Zygadenas*, *Aquilegia*, *Habenaria* and many other hydrophilic species. As you climb away from the streams in any of the three canyon systems, benches of sandstone may accumulate sandy soils. Where this occurs, a Grassland

community develops, made up principally of *Oryzopsis hymenoides* and *Stipa comata*. This community gradually gives way to a "savannah" of grassland piñon-juniper woodland at slightly higher elevation. The "savannah" gives way to true piñon-juniper communities as the elevation rises and the distance to the streambed increases. On steep, north-facing slopes, moist sites within the canyons support a douglas-fir community. These stands consists of a dense stand of *Pseudotsuga menziesii* and scattered *Populus fremontii*. Because the aerial coverage available for this study did not allow spatial delineation of the riparian areas, we have digitized the working map and it is now available as a GIS layer for modification and improvement as future work in these areas proceeds.

A poorly developed stand of Ponderosa pine and scattered Cottonwood resides in the shallow head of a tributary to White Canyon called Rattlesnake Gully. Several mature Ponderosa Pines are accompanied by dense shrub understory, scattered mature cottonwoods, and a few sapling Ponderosa pines. It is hypothesized that this stand was once associated with a relatively mesic microsite in this locale, and that only relict individuals survive in a drier site today.

On the Mesa tops of Natural Bridges are loess soils of various depths. Although piñon-juniper *Pinus edulis* and *Juniperus osteosperma* woodlands are found throughout the Mesa top, three distinct communities are formed. In the eastern part of the Monument, a Piñon-Juniper-Sagebrush community has limited distribution, confined to approximately 6400 foot elevation and deep loess. The Mesa central to the Monument is the extensive site of the Piñon-Juniper-Mixed Shrub community, which includes shrubs such as *Fraxinus anomala*, *Chrysothamnus nauseosus* and others. These two piñon-juniper woodlands occur on Cedar Mesa Sandstones.

The final plant community is of limited distribution in the Monument, as its substrate, the Moenkopi Formation rarely occurs. On this Formation in the extreme western corner of the Monument, lies the Piñon-Juniper-Buffaloberry (*Shepherdia rotundifolia*) community.

These twelve associations demonstrate the array of vegetation types that potentially occur in undisturbed sites in southeastern Utah at elevations surrounding 6200 feet. These may also represent the native vegetation of the nearby Kane Gulch Ranger District or of southwestern Colorado, landscapes which have been converted to farmland or grazing areas. The riparian communities protected within the Monument boundary are of special significance as they are part of a dwindling riparian corridor that once twisted along all southwestern waterways and are rapidly becoming lost to numerous water diverting projects. The riparian communities within the Monument require periodic flooding, and the extent to which land management practices outside the Monument have altered drainage, cause erosion, and otherwise affect the riparian communities is not known. This community survey is an initial attempt to document the natural resources within Natural Bridges National Monument, so that subsequent changes in the area can be monitored, and the protected communities can remain relicts of native biota in this geographic region.

Finally, we must caution Resource Management specialists in the extent to which they presently rely on the working map of Natural Bridges National Monument. Although well-defined in the field analyses, the riparian communities and Douglas Fir communities were obscured in shadow and could not be delineated from the aerial coverage available for the study. Obtaining new aerial coverage or further ground truthing (perhaps with a Global Positioning System, which could allow delineating of each vegetation type) will be necessary.

Figure 2:
Position of Hanging Garden plant communities, Natural Bridges National Monument

