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Integrated Upland Vegetation and Soils Monitoring for Chaco Culture National Historical Park

2012 and 2014 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2016/1038

ON THE COVER
Sandy Loam ecological site at Chaco Culture National Historic Park
Photography by NPS

Integrated Upland Vegetation and Soils Monitoring for Chaco Culture National Historical Park

2012–2014 Summary Report

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1 Introduction

The National Park Service Inventory and Monitoring (I&M) Program was designed to determine the status and monitor the conditions of park natural resources, providing park managers with a scientific foundation for making decisions and working with other agencies and the public to protect park ecosystems. The Southern Colorado Plateau Network (SCPN) is monitoring vegetation and soils as overall indicators of upland ecosystem integrity (Thomas et al. 2006).

SCPN and park staff selected the Sandy Loam ecological site for long-term monitoring of upland vegetation and soils at Chaco Canyon National Historical Park (CHCU). An ecological site is a landscape division with characteristic soils, hydrology, plant communities, and disturbance regimes and responses. Its classification is based on soil survey data (Butler et al. 2003). The Sandy Loam ecological site comprises a large area of the upland grassland ecosystem at CHCU. It faces numerous threats, including soil erosion, climate change, and invasion by nonnative species.

In this report, we document monitoring activities in the CHCU Sandy Loam ecological site during the 2012 and 2014 field seasons, and report these data in the context of the data that we collected in the year that the plots were established, which occurred during different years from 2007 to 2011. For the complete set of data collected at CHCU during these years, see the data summary reports, available from the SCPN website (http://science.nature.nps.gov/im/units/scpn/publications.cfm?tab=2). Between 2007 and 2011 we established and sampled 30 plots in the Sandy Loam ecological site. In 2012 we implemented a panel design incorporating these plots into it, and resampled two different subsets of 20 plots in 2012 and 2014.

2 Methods

2.1 Sampling frame

We derived our base sampling frame for the Sandy Loam ecological site (Figure 1) from the SSURGO soils map of the ecological site, which was developed by the U.S. Natural Resources Conservation Service (see Methodology in Appendix A of DeCoster et al. 2012). The sampling frame is the area from which we randomly select our sites, and hence the area to which statistical inferences can be made.

While making final adjustments to our sampling frame, we modified the map of the ecological site using Geographical Information System (GIS) to remove areas that were

- outside of the target ecological site (i.e., roads)
- at risk for erosion as a result of sampling (slopes ≥20%)

We generated a set of spatially distributed sampling points using the Generalized Random Tessellation Stratified (GRTS) design (Stevens and Olsen 2004). Park staff reviewed the sampling points and rejected those points that landed too close to archeological sites and other sensitive resources. The integrated upland crew visited the first 35 GRTS points and conducted an ecological site assessment, rejecting sites that deviated substantially from the ecological site description, had a slope greater than 20%, or contained a major disturbance. We rejected 4 sites: 2 points were in proximity to archeological sites, one was in proximity to a power line and associated road, and one point fell in an inaccessible area. We later decommissioned a plot that we had sampled in 2011 because it deviated substantially from the ecological site description.

2.2 Field methods

SCPN integrated upland vegetation and soils (referred to as integrated upland for the remainder of this report) monitoring plots are 0.50 ha in size (measuring 71 × 71 m) and consist of 3 parallel 50 m transects spaced 25 m apart. We collected data for shrub and herbaceous species cover and frequency, functional group cover, soil surface feature cover, soil stability, and basal gaps along all 3 transects within each plot. Detailed field methodology is provided in the SCPN integrated upland monitoring protocol (DeCoster et al. 2012). In all years we conducted

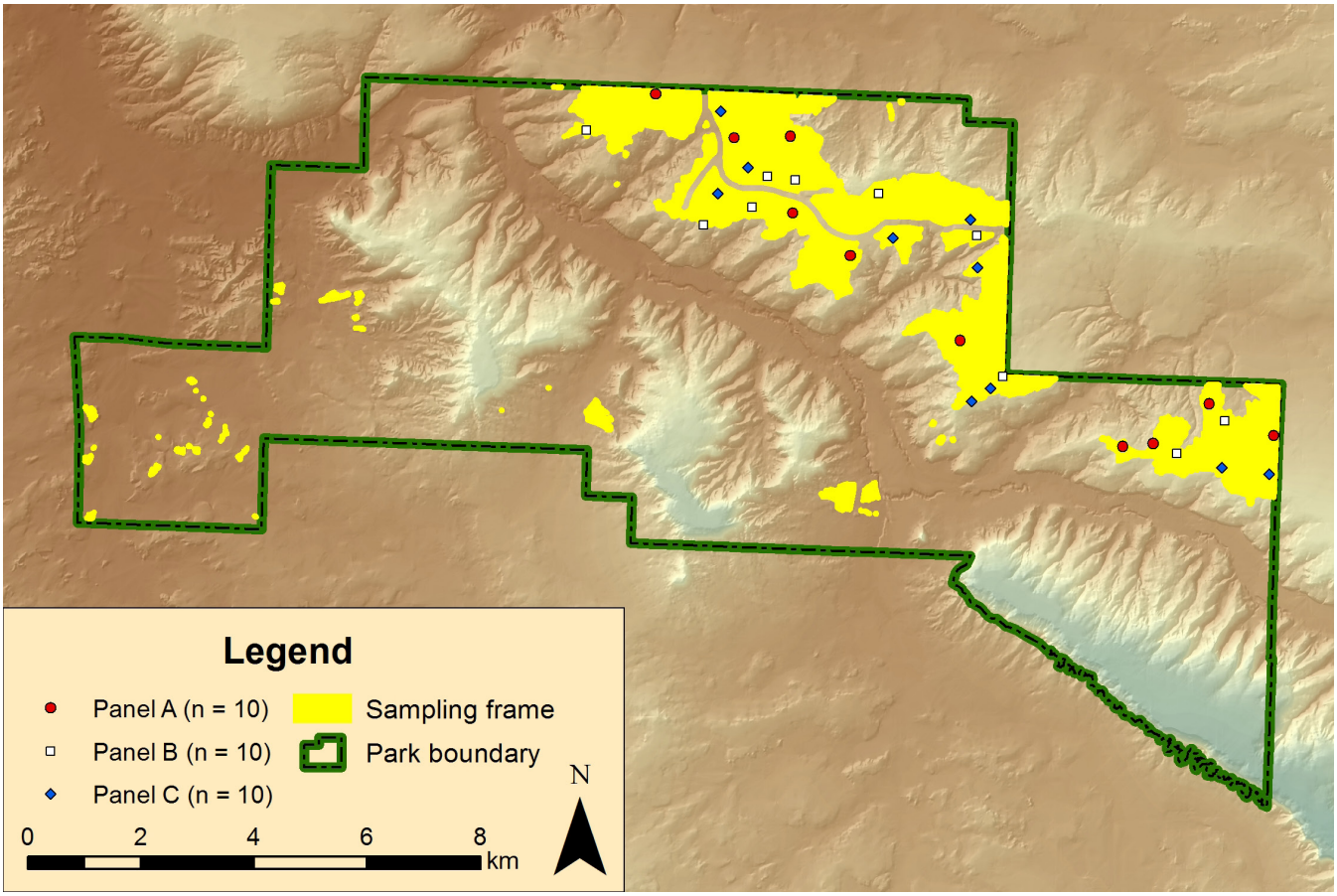


Figure 1. Sampling frame of Sandy Loam ecological site at Chaco Culture NHP showing the 10 plots in each panel.

our field work in late September and early October, except 2007, when we sampled in late October.

2.2.1 Shrub and herbaceous vegetation

We sampled shrub and herbaceous vegetation within 5 sets of nested quadrats that were placed at 10 m intervals along each of the three transects in a plot. The largest quadrat size was 10 m^2 (2 × 5 m), with 4 successively smaller quadrats nested inside (0.01 m^2, 0.1 m^2, 1 m^2, 5 m^2). We recorded the presence of every herbaceous and shrub species within each nested sub-quadrat, and estimated the percent cover of each species in the 10 m^2 quadrat, assigning each to one of 12 cover classes (e.g., 2%–5%, 5%–10%, etc.). We also estimated the percent cover and assigned cover classes for functional groups (e.g., perennial grasses, forbs, shrubs) in the 10 m^2quadrats.

2.2.2 Soils

We estimated the percent cover of soil surface features in the 1 m^2 quadrats and recorded the cover in one of 12 cover classes. In addition, we measured soil stability in 18 samples taken at random locations along the transects for each plot. Occasionally, we omitted soil stability sampling for plots in which soils were wet and unable to be dried in the field. We also measured basal gaps as the distance between bases of perennial plants along each transect, although we do not report these data here.

2.3 Panel design and implementation

A rotating panel design is a sampling strategy sometimes used when estimates are produced regularly over time. Under such a design, equally sized sets of plots, or 'panels', are brought in and out of the sampling schedule through time in a specified pattern. In essence, this approach seeks to reduce monitoring costs by optimizing the balance between two desirable but competing monitoring qualities–sampling of sufficient frequency to detect temporal change, and a sample size large enough to capture the spatial heterogeneity of the target ecosystem.

The panel design allows for an estimate of change for every pair of years included in the sample; this is termed a "temporally connected" sampling design. It provides greater power to detect trends through time than do designs that are not temporally connected.

SCPN implemented a rotating panel design for integrated upland monitoring in 2012, incorporating most plots that had been previously established into the new resampling plan. In this design, the total number of monitoring plots is partitioned into three equal panels, with 2 of the 3 panels sampled every other year. Table 1 illustrates this panel design for the 30 plots within the Sandy Loam ecological site at CHCU. To maintain spatial balance, plots are assigned to panels according to their GRTS numbers; i.e. the plots with the 10 lowest GRTS numbers are assigned to Panel A; the second consecutive set of GRTS numbers are assigned to Panel B, etc.

Table 1. Panel design for resampling monitoring plots in the Sandy Loam ecological site at Chaco Culture NHP. Each panel comprises 10 plots for a total of 30 plots across 3 panels for the ecological site. Dashes indicate no sampling.

Panel	Year											
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
A	10	-	-	-	10	-	10	-	-	-	10	-
B	10	-	10	-	-	-	10	-	10	-	-	-
C		-	10	-	10	-	-	-	10	-	10	-
Total	20	0	20	0	20	0	20	0	20	0	20	0

2.4 Initial sampling: 2007–2011

Because we are implementing upland monitoring across 15 ecological sites in 10 parks, plot establishment occurred over several years. The 30 monitoring plots in the Sandy Loam ecological site at CHCU were established between 2007 and 2014 (Figure 2). In 2007, we established 10 plots and sampled them for 3 consecutive years (2007–2009) to document annual variability. We established a total of 20 additional plots in 2010 (6) and 2011 (14). We later decommissioned one of the plots established in 2011 as it differed substantially from the ecological site description, and replaced it in 2014. Panel A consists of 10 plots established in 2007. Panel B consists of 10 plots established in 2010 and 2011. Panel C consists of 10 plots established in 2010, 2011, and 2014. In 2012 we sampled panels A&B; in 2014 we sampled panels B&C. We present data collected from 2007 to 2011 in this report to provide context for the data collected in 2012 and 2014. We emphasize that data presented from the establishment period were collected over the course of 5 years and therefore do not represent a single sampling event. The full benefit of the panel design will not be realized until we have collected data through several cycles of the panel design.

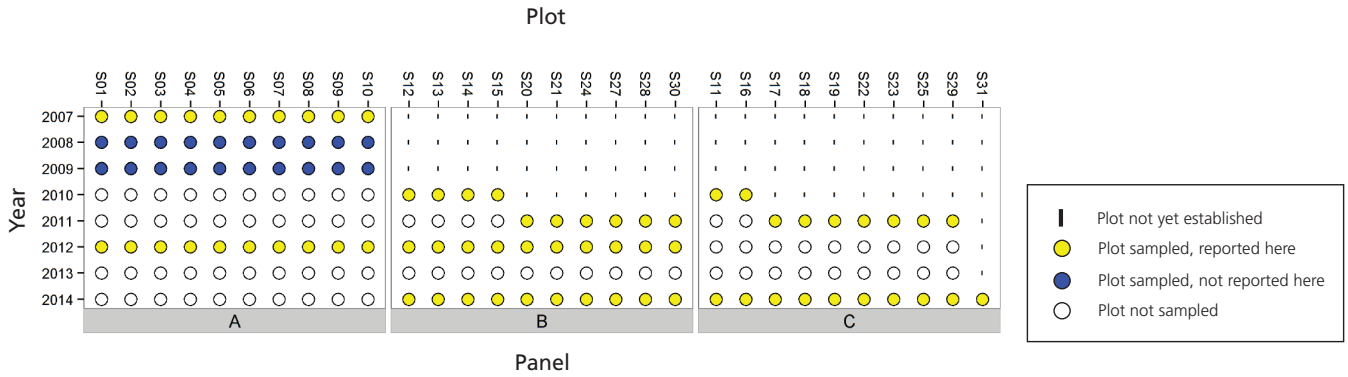


Figure 2. Sampling year and panel assignment for plots used in the panel design for integrated upland vegetation and soils monitoring at Chaco Culture NHP, 2007-2014. First year of sampling is the year the plot was established.

2.5 Data summary

We first summarized data at the level of the plot, which is the sample unit, and then calculated the mean and standard deviation for most metrics from the plot means for each panel and time period (initial sampling year, 2012 and 2014). Three metrics—plot frequency, site richness and beta diversity—were calculated across all plots and were therefore not calculated by averaging plot values.

2.5.1 Shrub and herbaceous species, functional groups and soil surface features

For herbaceous and shrub vegetation, we estimated percent foliar cover for each species from the cover class midpoints, e.g., 7.5% for cover class 5%–10%. We calculated mean percent foliar cover for each plot and year, and the mean and standard deviation for each panel and time period. Mean cover and standard deviation of functional groups and soil surface features were calculated in a similar fashion.

For each panel and time period, we calculated both mean quadrat frequency and plot frequency for each species. Quadrat frequency is the percentage of 10 m^2 quadrats per plot in which a species occurs. Plot frequency is the percentage of plots in which the species occurs. We also combined and summarized plot frequency and foliar cover for species and functional groups, for panels A&B in 2012, and panels B&C in 2014 to provide a summary of the status for each year.

2.5.2 Species diversity

We calculated four diversity measures (Magurran 1988) for herbaceous and shrub species for each panel and time period—first for all species and then for native species only.

(1) Species richness (S) is the number of species at a given spatial scale. This was calculated at both the level of the plot and at the level of the panel (i.e., all plots within the panel).

(2) The Shannon Diversity Index (H´) provides a measure of species diversity that takes into account the relative abundance of each species:

$$H = -\sum_{i=1}^{n} p_i \ln p_i$$

where p_i is the abundance of each species.

(3) Species evenness (E) is a measure of the degree to which all species are equal in abundance and ranges from 0 to 1:

$$E = H' / \ln(S)$$

(4) Beta diversity (β) is a measure of within-site heterogeneity and ranges between 1 and 5

$$\beta = S_e / (S_p - 1)$$

where S_e is the total number of species found in the panel, and S_p is the mean number of species found per plot.

We calculated plot richness, Shannon diversity, and evenness for each plot and year, and we then calculated mean and standard deviation for the panel and time period. Panel richness and beta diversity, which are not based on plot means, were calculated for each panel and time period.

2.5.3 Soil stability

We calculated the mean soil aggregate stability index for each plot and year, and then calculated the mean and standard deviation for each panel and time period. The index ranges from 1 to 6, where 1 indicates low aggregate stability and 6 indicates high aggregate stability. The index was also calculated separately for samples with vegetative cover and for samples without vegetative cover.

Results

3.1 Shrub and herbaceous vegetation

We examined foliar cover of functional groups, foliar cover and frequency of species, and species diversity, presenting the 2012 and 2014 data in the context of the data collected during the first year of sampling.

3.1.1 Functional group cover

Foliar cover of functional groups indicates broad patterns in cover for shrub and herbaceous vegetation. Perennial grasses dominated cover in the Sandy Loam ecological site. In 2012, for both panels A&B combined, the mean total live foliar cover of all plots in both panels was 6.56% and the mean foliar cover of perennial grass was 4.38% (Figure 3). Mean foliar cover of shrubs was 1.63%, of forbs was 0.773%, and of annual grasses and cacti/succulents was less than 0.1%.

Perennial grasses also were dominant in 2014—the mean total live foliar cover of all plots in both panels B and C was 12.81% and the mean foliar cover of perennial grass was 8.84% (Figure 3). Mean foliar cover of shrubs was 3.18% and of forbs was 0.48%. Cacti were minor components, with a mean foliar cover of 0.11%. There was no annual grass cover recorded. Standard deviations were generally large, indicating large among-plot variability.

Figure 4 presents the mean foliar cover of each functional group by panel for 2012, 2014, and the initial sampling period (2007-2011). Data values for Figure 4 are available in Appendix A.

3.1.2 Species foliar cover and frequency

Examination of foliar cover and frequency of individual species allows for more thorough understanding of the structure and dynamics of the vegetation in the CHCU Sandy Loam ecological site.

In 2012, for panels A&B combined, the two species with the greatest foliar cover were perennial grasses: *Bouteloua gracilis* (blue grama) and *Hilaria jamesii* (James' galleta) (Figure 5). Other dominant perennial grasses included *Sporobolus* spp. (dropseed) and *Achnatherum hymenoides* (Indian ricegrass). Dominant shrubs were *Atriplex canescens* (fourwing saltbush), *Krascheninnikovia lanata* (winterfat), *Chrysothamnus greenei* (Greene's

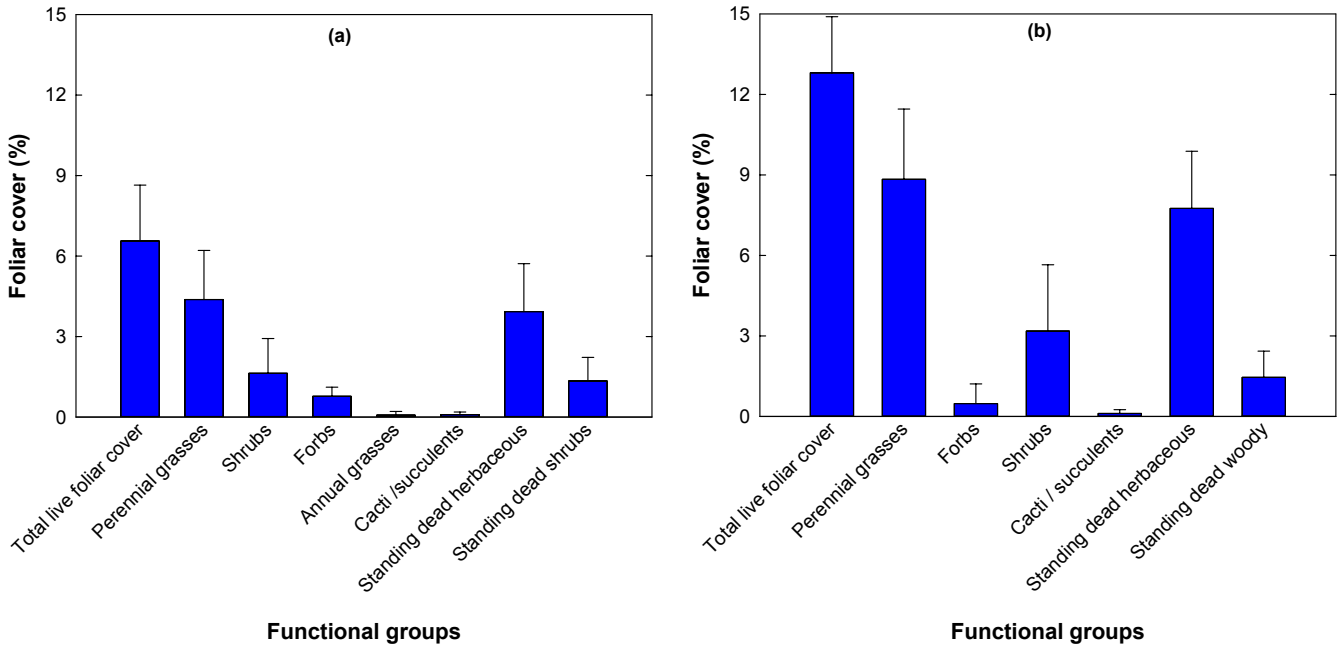
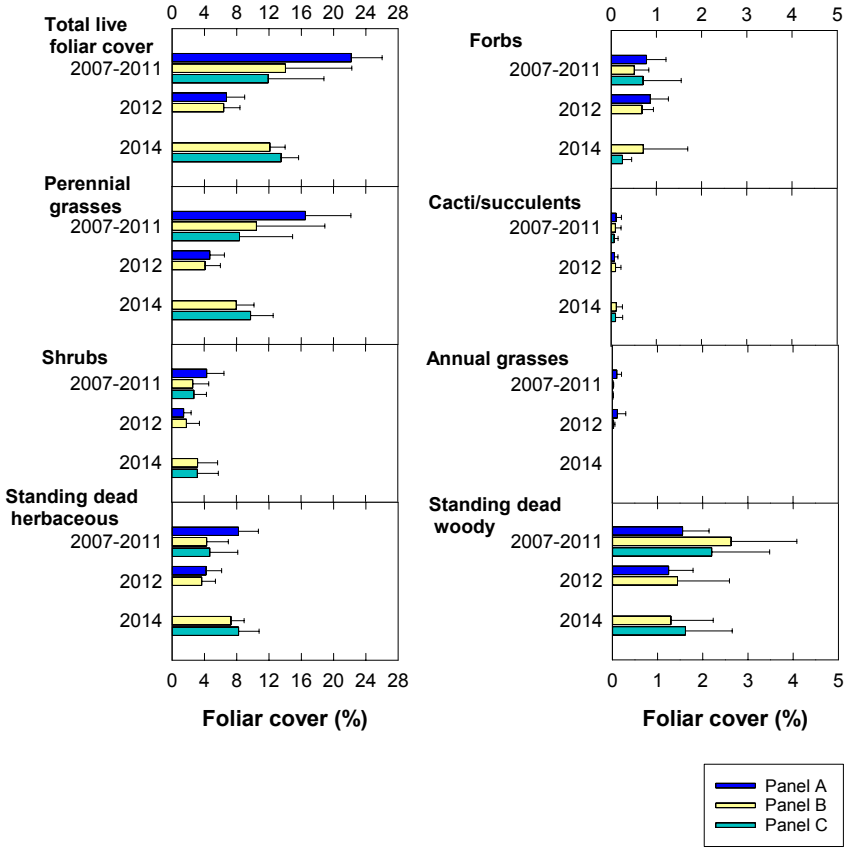


Figure 3. Mean percent foliar cover of functional groups for (a) all 20 plots in panels A&B, combined, in 2012 and (b) all 20 plots in panels B&C, combined, in 2014 in the Sandy Loam ecological site at Chaco Culture NHP. Error bars represent 1 standard deviation. Note: Annual grass cover was not encountered in Panels B&C in 2014.

Figure 4. Mean percent foliar cover of functional groups, by panel for 2012 and 2014, and for the initial sampling year for all plots (2007–2011) in the Sandy Loam ecological site at Chaco Culture NHP. Error bars represent 1 standard deviation. Note the scales are different on the 2 columns. For panel C in 2007–2011, n = 9 ; for all other panels and time periods, n =10.



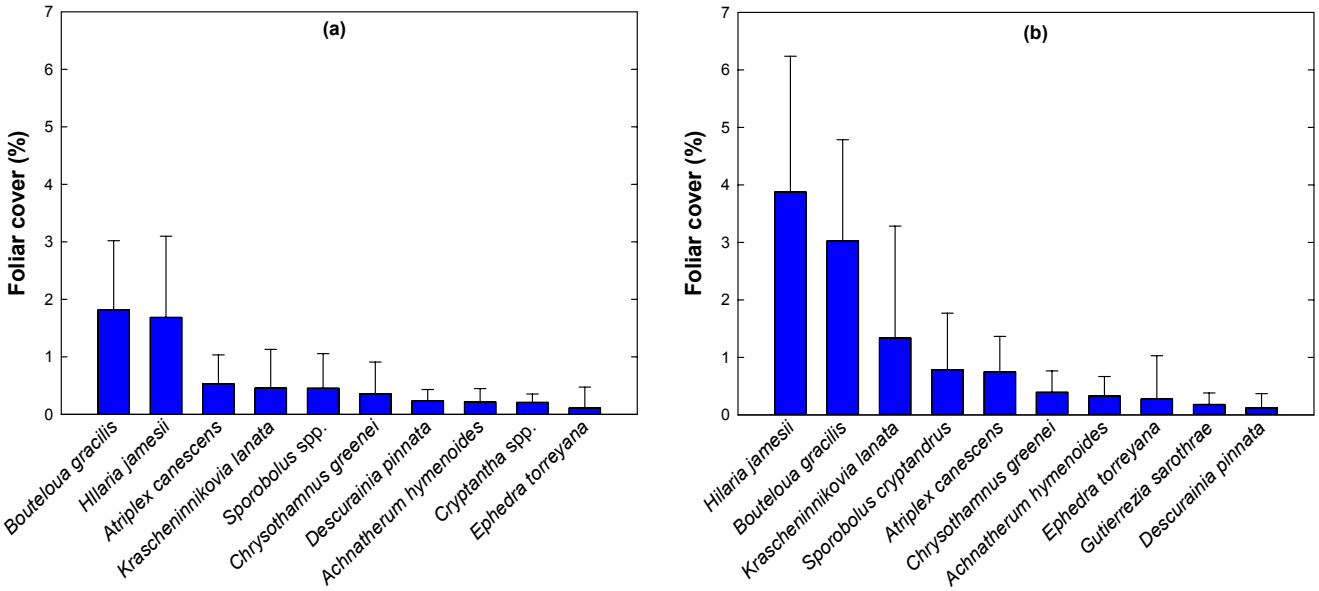
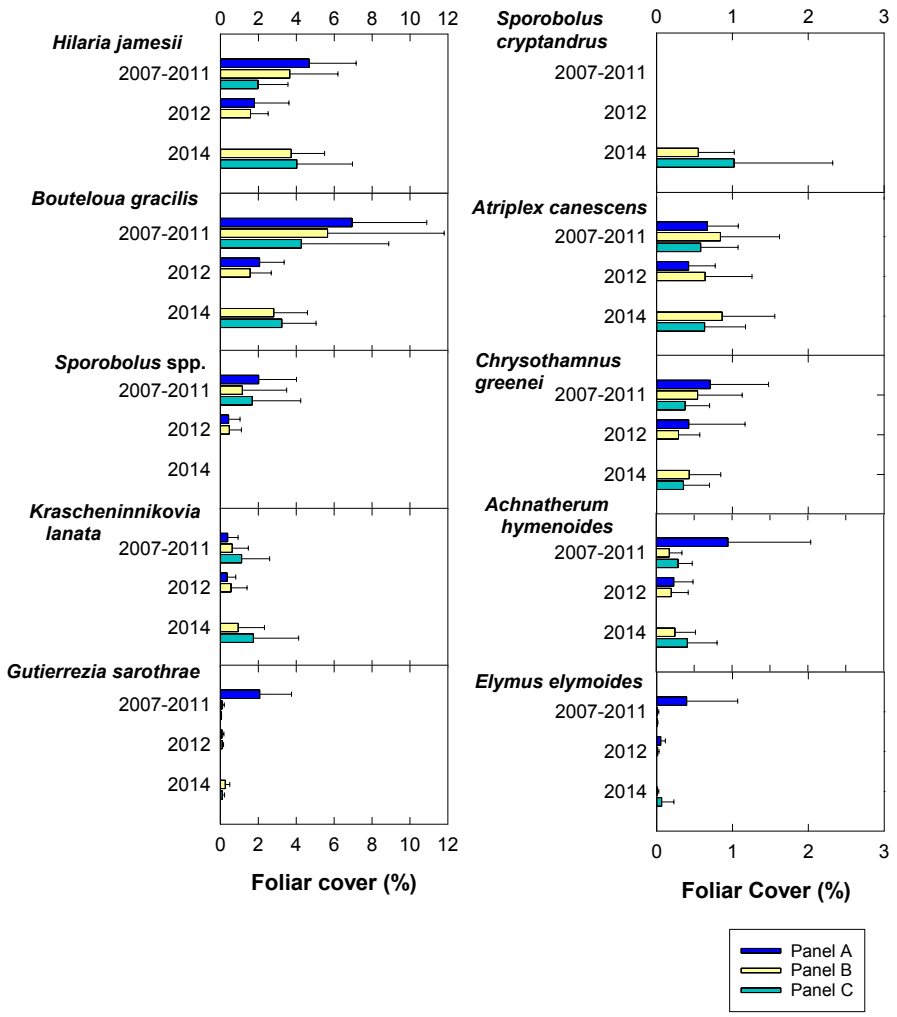


Figure 5. Mean percent foliar cover of the 10 most abundant shrub and herbaceous species for (a) all 20 plots in panels A&B in 2012 and (b) for all 20 plots in panels B&C in 2014 in the Sandy Loam ecological site at Chaco Culture NHP. Error bars represent 1 standard deviation.

Figure 6. Mean percent foliar cover of most abundant shrub and herbaceous species for 2012 and 2014, and for the initial sampling year for all plots (2007–2011) in the Sandy Loam ecological site at Chaco Culture NHP. Includes species with a foliar cover >0.375% in at least one panel. Note that scales are different for each column. Error bars represent 1 standard deviation. For panel C in 2007-2011, n = 9, n = 10 for all other panels.



rabbitbrush) and *Ephedra torreyana* (Torrey's jointfir). Common herbs were *Descurainia pinnata* (western tansy-mustard) and *Cryptantha* spp. (cryptantha).

Three nonnative species were found in panels A&B in 2012 (Table 2). *Salsola tragus* (prickly Russian thistle) was the most abundant, occurring in 30% of plots in panel A and 50% of plots in panel B. Mean foliar cover was 0.099% and 0.006% for panels A&B. *Bromus tectorum* (cheatgrass) and *Portulaca oleracea* (little hogweed) were sparse, and occurred in trace amounts in panel A. *Salsola tragus* and *Bromus tectorum* both occurred in the initial sampling.

In 2014, for panels B&C combined, the two species with the greatest foliar cover were again *Hilaria jamesii* and *Bouteloua gracilis* (Figure 5). *Sporobolus cryptandrus* and *Achnatherum hymenoides* were also abundant and the field crews were able to identify *Sporobolus* to species level. The most abundant shrubs were *Krascheninnikovia lanata*, *Atriplex canescens*, *Chrysothamnus greenei*, *Ephedra torreyana* and *Gutierrezia sarothrae* (broom snake-weed). *Descurainia pinnata* was the most abundant forb, and *Opuntia* spp. (prickly pear) was the most abundant cactus/succulent. The *Sporobolus cryptandrus* identified in 2014 was previously grouped with other species of *Sporobolus* in the initial sampling and in 2012.

Salsola tragus was the only nonnative species that was found in plots in 2014. Mean foliar covers were 0.019% and 0.071% for panels B&C. It occurred in 60% of plots in panel B and 30% of plots in panel C.

Figure 6 and Table 2 present mean foliar cover of the most abundant species for the 3 sampling periods, by panel. Most species had moderately large standard deviations, indicating large among-plot variability. Figure 7

Table 2. Foliar cover and plot frequency of shrub and herbaceous species in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots (2007–2011). "Abundant species" includes only species with a mean foliar cover >0.25% in any of the panels. All nonnative species occurring in panels are included. Species are arranged in descending order based on their mean foliar cover in 2014 for both panels combined.

	Initial sampling year between 2007 and 2011						2012				2014			
	Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
	Mean cover (%)	Plot frequency (%)	Mean cover (%)	Plot frequency (%)	Mean cover (%)	Plot frequency (%)	Mean cover (%)	Plot frequency (%)	Mean cover (%)	Plot frequency (%)	Mean cover (%)	Plot frequency (%)	Mean cover (%)	Plot frequency (%)
Abundant species														
Hilaria jamesii	4.679	100	3.653	100	1.976	100	1.800	100	1.582	100	3.730	100	4.028	100
Bouteloua gracilis	6.939	100	5.651	100	4.266	100	2.072	100	1.568	100	2.816	100	3.242	100
Krascheninnikovia lanata	0.387	70	0.62	70	1.123	88.9	0.353	80	0.562	70	0.936	80	1.743	90
Sporobolus cryptandrusa	0	0	0	0	0	0	0	0	0	0	0.550	100	1.021	100
Atriplex canescens	0.67	100	0.843	100	0.582	100	0.423	100	0.64	100	0.865	100	0.634	100
Chrysothamnus greenei	0.707	80	0.542	70	0.378	88.9	0.424	90	0.289	70	0.431	70	0.354	80
Achnatherum hymenoides	0.946	100	0.173	80	0.288	100	0.232	100	0.198	90	0.247	100	0.411	90
Ephedra torreyana	0	0	0.362	20	0.199	22.2	0	0	0.222	20	0.353	20	0.202	20
Gutierrezia sarothrae	2.074	100	0.089	90	0.034	88.9	0.081	90	0.093	100	0.258	100	0.103	100
Descurainia pinnata	0	0	0.013	60	0.01	66.7	0.266	100	0.207	90	0.196	100	0.049	90
Elymus elymoides	0.396	100	0.009	40	0.006	44.4	0.054	90	0.013	80	0.011	80	0.066	80
Sporobolus spp.[a]	2.018	100	1.16	100	1.683	100	0.436	100	0.473	100	0	0	0	0
Nonnative species														
Salsola tragus	0.018	20	0.006	30	0.003	44.4	0.099	30	0.006	50	0.019	60	0.071	30
Bromus tectorum	0.032	60	0	0	0	0	0.001	20	0	0	0	0	0	0
Portulaca oleracea	0	0	0	0	0	0	0.005	10	0	0	0	0	0	0

a Perennial Sporobolus spp. were combined in the 2007-2011 and 2012 data

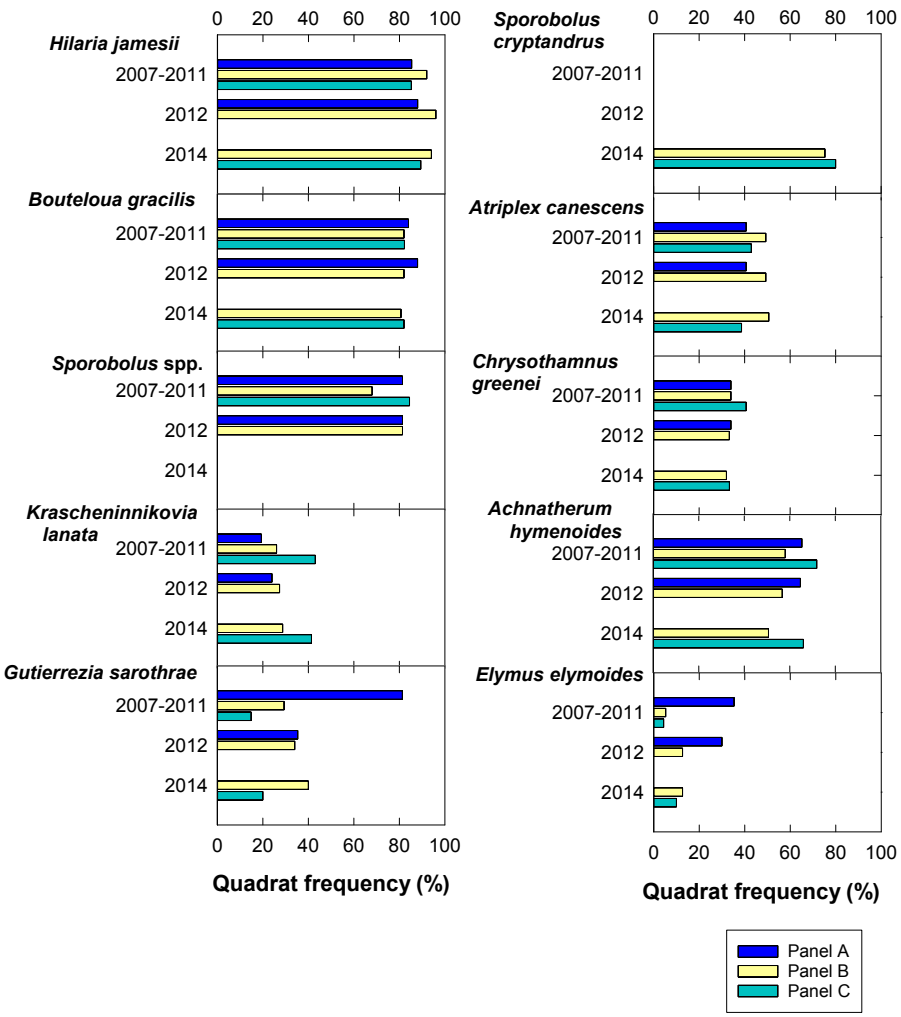


Figure 7. Mean quadrat frequency of shrub and herbaceous species with foliar cover >0.375%, by panel, for 2012 and 2014, and for the initial sampling year for all plots (2007–2011) in the Sandy Loam ecological site at Chaco Culture NHP. For panel C in 2007-2011, n = 9; for all other panels and time periods, n = 10.

and Table 2 present quadrat frequency of the most abundant species for all panels for the 3 sampling periods by panel. Appendix B lists all species that occurred in the ecological site with common names, mean foliar cover, and plot frequencies by panel and sampling period.

The number of species in each plot frequency class provides another means to understand the community composition of the vegetation. Most plant communities are dominated by a small number of species, with the majority of species having low abundance, and this is true of the Sandy Loam ecological site at CHCU. In 2012 and in 2014, the majority of the species had low plot frequencies–half of the species occurred in 20% of the plots or less (Figure 8). Only 8% (5) of the species occurred in all of the plots in 2014.

3.1.3 Species diversity

In 2012, the species diversity indices show moderately low diversity on the scale of the plot and moderate diversity on the scale of the site (Table 3 and Figure 9). On the scale of the plot, mean plot richness was 25.6 for both panels A&B. Shannon diversity (which takes the relative abundance of each species into account and generally ranges between 1.5 and 3.5) was 2.01 and 2.09, for panels A&B, respectively. Evenness values (the degree to which all species are of equal abundance, ranging between 0 and 1) were 0.63 for panel A and 0.64 for B. On the scale of the panel, richness values were 57 for panel A and 55 species for B. For panels A&B combined, a total of 71 species were encountered in 2012. When we calculated the metrics using only native species, they showed only small differences.

In 2014, mean plot richness was 22.0 for panel A and 19.6 for panel B. Shannon diversity was 1.77 for panel A and

Table 3. Species diversity metrics for all species and for native species only, by panel, in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots (2007–2011). SD = standard deviation. Note: richness and diversity values from the initial sampling period (2007-2011) were calculated using slightly different species groupings than were used for the 2012 and 2014 sampling periods. Therefore reported values from the initial period are not directly comparable to the later values. This discrepancy will be resolved in future reports.

	Initial sampling year between 2007 and 2011						2012				2014			
	Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
All species	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Plot richness	20.0	2.2	21.6	4.7	21.8	2.7	25.6	5.4	25.6	4.1	22.0	6.1	19.6	2.3
Shannon diversity	1.83	0.32	1.65	0.35	1.83	0.29	2.01	0.33	2.09	0.37	1.77	0.39	1.60	0.26
Evenness	0.61	0.10	0.54	0.088	0.59	0.09	0.63	0.10	0.64	0.09	0.58	0.08	0.54	0.08
Native species														
Plot richness	19.2	2.2	21.3	4.6	21.3	2.6	25.0	5.1	25.1	3.7	21.4	5.9	19.3	2.1
Shannon diversity	1.82	0.31	1.65	0.34	1.83	0.28	2.00	0.33	2.09	0.37	1.77	0.40	1.58	0.26
Evenness	0.62	0.11	0.54	0.09	0.60	0.09	0.62	0.10	0.65	0.09	0.58	0.08	0.54	0.08

	Initial sampling year between 2007 and 2011			2012		2014	
All species	**Panel A, n=10**	**Panel B, n=10**	**Panel C, n=9**	**Panel A, n=10**	**Panel B, n=10**	**Panel B, n=10**	**Panel C, n=10**
Panel richness	40	54	50	57	55	56	37
Beta diversity	1.95	2.57	2.36	2.11	2.07	2.67	1.99
Native species							
Panel richness	38	53	47	54	54	55	36
Beta diversity	1.92	2.56	2.36	2.04	2.08	2.70	1.97

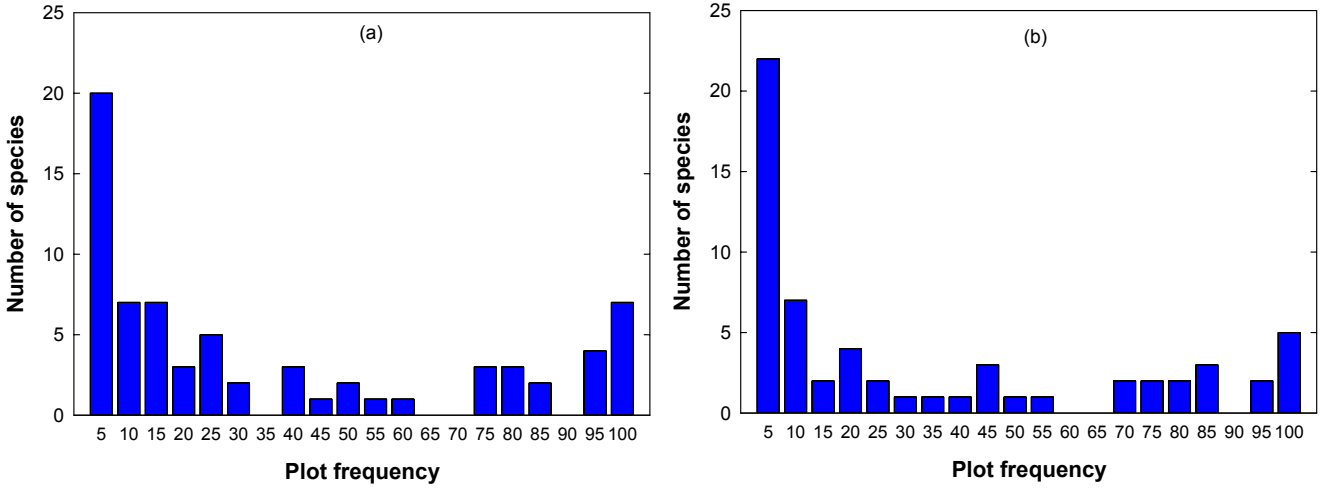


Figure 8. Number of species in each plot frequency class for (a) all 20 plots in panels A&B in 2012, and (b) all 20 plots in panels B&C in 2014 in the Sandy Loam ecological site at Chaco Culture NHP.

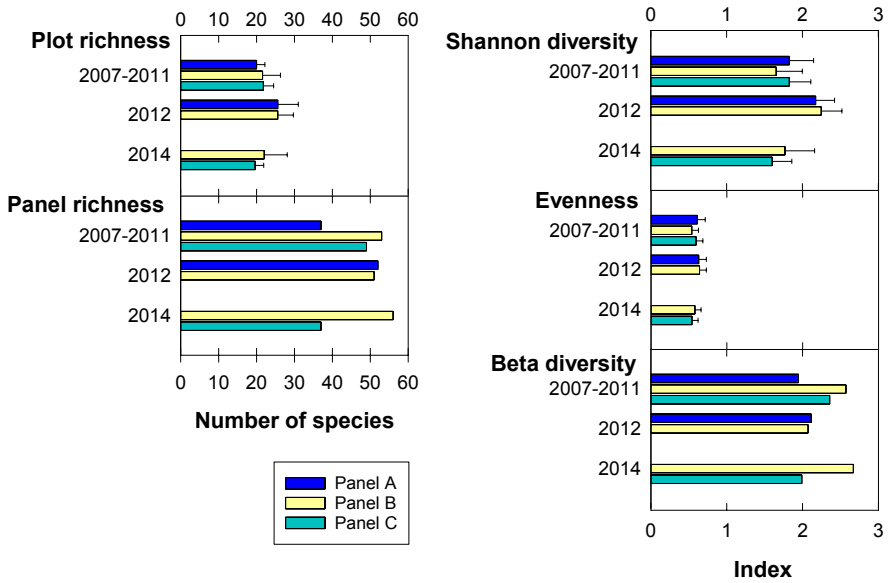


Figure 9. Diversity indices for all species by panel in the Sandy Loam ecological site in Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots (2007–2011). SD = standard deviation. For panel C in 2007-2011, n = 9; forall other panels and timeperiods, n = 10. Panel richness and beta diversity are not calculated from plot means and therefore do not have standard deviations.

1.60 for panel B. Evenness values were 0.58 and 0.54. On the scale of the panel, richness values were 56 species for panel B and 37 for panel C. For panels B&C combined, 61 species were encountered in 2014. When we calculated the metrics using only native species; they showed only small differences.

3.2 Soil stability and hydrologic function

We measured the amount of soil surface potentially subject to soil erosion using cover estimates of soil surface features. We measured the stability of the exposed soil using the soil aggregate stability test.

Undifferentiated crust (including both non-biologic physical crust and undifferentiated biological crusts) and bare soil were the dominant soil surface features in 2012 (Figure 10). Because these two features are hard to distinguish from each other in wet conditions, combining them allows for easier interpretation of the data. In 2012, when combined, these 2 features had a mean cover value of 87.0% and 88.2% for panels A&B, respectively. We summarize the remaining categories here but not all are individually distinguished or displayed in Figure 10. Data values are available in Appendix C. Live and dead plant bases (including both herbaceous and woody components), and litter and woody debris ranged in cover from 2% to 5%, for both panels A&B, in 2012. Biological soil crust components (cyanobacteria, moss and lichen), and rock components (fine gravel, coarse gravel, cobble and stone/ bedrock), had mean covers of less than 2%.

In 2014, combined undifferentiated crust and bare soil was again the dominant feature, comprising 86.7% of the ground surface in panel B and 85.8% in panel C. Live plant base, dead plant bases (including both herbaceous and woody components), and combined litter and woody debris ranged in cover from 2 to 6% for panels B&C in 2014. Biological soil crust components (cyanobacteria, moss and lichen), and rock components (fine gravel, coarse gravel, cobble and stone/ bedrock), had a combined mean cover of less than 1%.

In 2012, mean soil stability ratings for all samples in a plot were 3.42 and 2.49 for panels A&B, respectively (Figure 11). All data values corresponding to Figure 10 are available in Appendix D. Values were greater for samples under perennial vegetative cover than for those without cover. Standard deviations, indicating among-plot variation, were moderate.

In 2014, mean soil stability ratings for all samples in a plot were 3.14 and 3.01 for panels B&C, respectively. Figure 11 provides soil stability ratings by panel for 2012 and 2014, and for the initial sampling year for all plots. SD = standard deviation. All data values corresponding to Figure 11 are available in Appendix D. Ratings were greater for samples under vegetative cover than for those without cover. Standard deviations, indicating among-plot variation, were moderate.

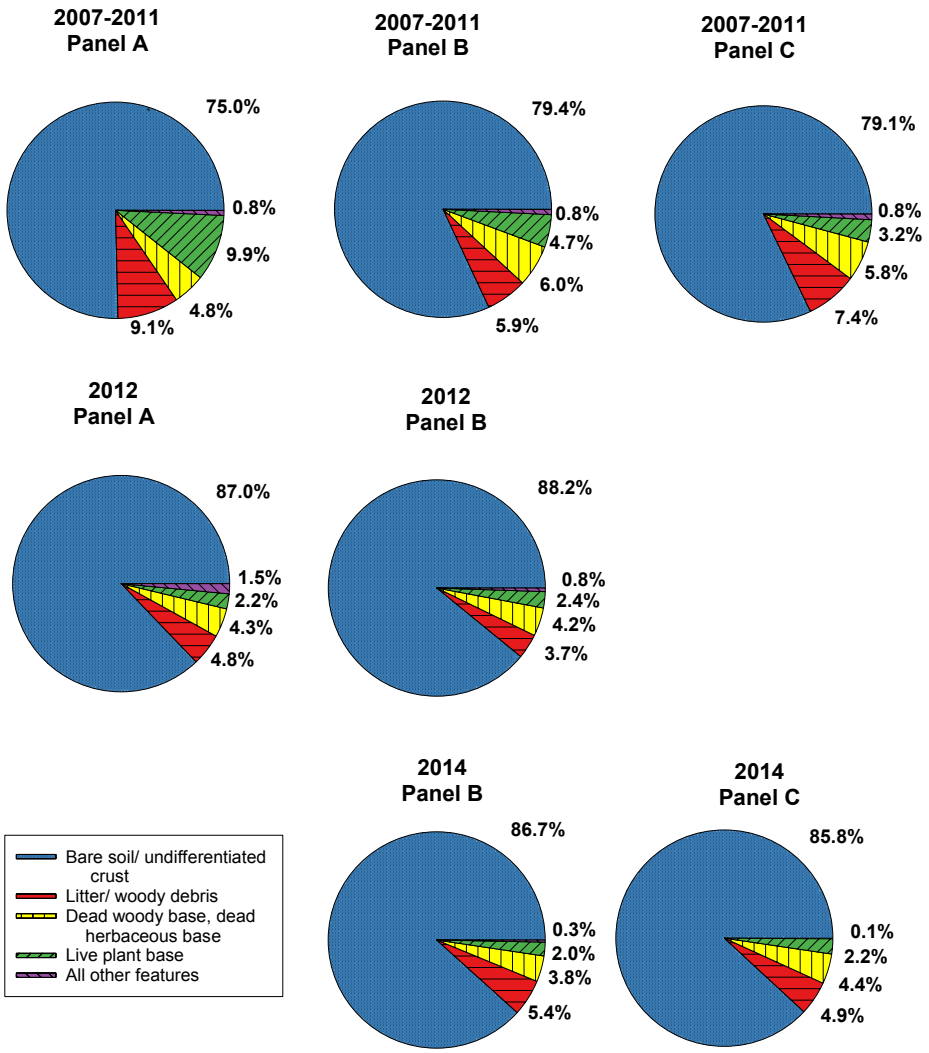


Figure 10. Mean percent cover of soil surface features, by panel, for 2012 and 2014, and for the initial sampling year for all plots (2007–2011) in the Sandy Loam ecological site at Chaco Culture NHP. Note: the soil surface features do not add up to 100% because the calculations were made from cover class midpoints. For panel C in 2007–2011, n = 9; for all other panels and time periods, n = 10.

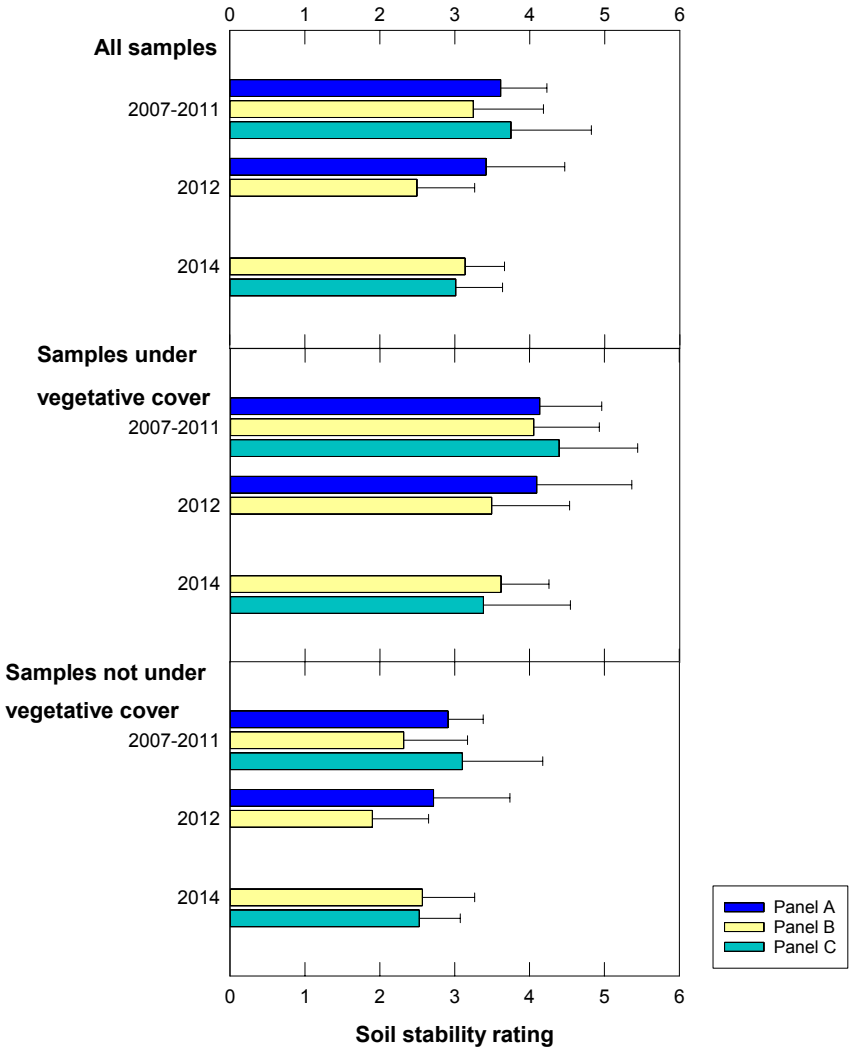


Figure 11. Mean soil stability ratings, by panel, for 2012 and 2014, and for the initial sampling year for all plots (2007–2011) for the Sandy Loam ecological site at Chaco Culture NHP. SD = standard deviation. Ratings are for all samples and for samples under and not under vegetative cover. Error bars represent 1 standard deviation. Ratings range from 1 to 6, with 1 being the lowest stability and 6 being the highest. For panel C in 2007-2011, n = 9 ; for all other panels and time periods, n = 10.

4 Discussion

The data summarized in this report represent the beginning of panel-based monitoring of vegetation and soils in the Sandy Loam ecological site at CHCU. The shrub and herbaceous data demonstrate that this ecological site is an example of relatively undisturbed grassland with a shrub component. Three non-native species were present with low to sparse abundances in 2012, but only one was encountered in 2014. Species diversity was moderately low to moderate on the scale of the plot, and moderate at the landscape scale. The soils data indicate that there is some potential for erosion. The majority of the soil surface was comprised of bare soil and undifferentiated crust, and the cover of biological soil crust (cyanobacteria, lichen and moss) was low. Soil stability ratings were moderate.

We stress that while we present data for 3 time periods, one must be careful in making comparisons and interpreting differences as signs of change based on only a few data points, particularly in light of the annual variability in species abundance. Data from our repeat sampling of the 10 plots for panel A between 2007 and 2009 demonstrated moderate variation in species foliar cover and frequency from year to year that appeared to be at least partially the result of variation in precipitation over those years (DeCoster and Swan 2011). Annual variation in herbaceous species abundance suggests that data from multiple points in time are needed in order to identify meaningful vegetation trends. Since the initial sampling data from panels B&C were collected over two years (2010 and 2011), data from those panels include both spatial and temporal variation.

According to the SCPN panel design, we will visit this ecological site every other year, sampling 2 panels (20 plots) on each visit. After several years of collecting data using our panel design, variation among plots within a year will represent spatial variation, and the variation within a panel across sampling periods will represent temporal variation. As we collect more data over a longer time period, we will begin to examine trends in the condition of vegetation and soils for the Sandy Loam ecological site at CHCU.

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Appendix A: Foliar cover of functional groups in the Sandy Loam ecological site at Chaco Culture National Historical Park

Table A-1. Foliar cover of functional groups by panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots. The means for the live functional groups do not add up to the total live foliar cover because the calculations were made from cover class midpoints, components may overlap. "SD" is the standard deviation.

Functional group	Initial sampling year between 2007 and 2011						2012				2014			
	Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel c, n=10	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
Total live foliar cover	22.19	3.82	14.03	8.22	11.89	6.91	6.73	2.25	6.39	2.01	12.11	1.88	13.50	2.16
Perennial grasses	16.51	5.65	10.45	8.48	8.36	6.58	4.67	1.82	4.08	1.90	7.95	2.20	9.73	2.80
Annual grasses	0.10	0.10	0.01	0.02	0.01	0.01	0.11	0.19	0.03	0.03	0	0	0	0
Forbs	0.78	0.43	0.51	0.32	0.70	0.84	0.87	0.40	0.68	0.25	0.71	0.98	0.25	0.20
Shrubs	4.31	2.15	2.59	1.97	2.74	1.55	1.46	0.93	1.81	1.61	3.19	2.48	3.17	2.60
Cacti/succulents	0.11	0.12	0.10	0.13	0.07	0.09	0.07	0.08	0.10	0.12	0.12	0.13	0.10	0.16
Standing dead herbaceous	8.22	2.47	4.28	2.68	4.66	3.47	4.21	1.93	3.65	1.70	7.28	1.62	8.23	2.54
Standing dead shrubs	1.55	0.59	2.63	1.45	2.20	1.28	1.25	0.54	1.44	1.15	1.30	0.94	1.62	1.03

Appendix B: Plant species list for the Sandy Loam ecological site at Chaco Culture National Historical Park, 2007–2014

Table B-1. Plant species list with mean foliar cover and plot frequency for each panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots.

		Initial sampling year between 2007 and 2011						2012				2014			
		Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
Species	**Common name**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**
Achnatherum hymenoides	Indian ricegrass	0.946	100	0.173	80	0.288	100	0.232	100	0.198	90	0.247	100	0.411	90
Allium macropetalum	largeflower onion	0	0	0	0	0	0	<0.001	10	0	0	0	0	0	0
Amaranthus powellii	Powell's amaranth	0	0	0	0	0	0	0.002	10	0	0	0	0	0	0
Aristida purpurea	Fendler's threeawn	0.101	50	0.08	60	0.033	55.6	0.038	40	0.029	60	0.051	50	0.030	50
Artemisia bigelovii	Bigelow sage	0.112	30	0.005	10	0.039	33.3	0.074	30	0.026	20	0.025	20	0.057	30
Artemisia filifolia	sand sagebrush	0.219	20	0.007	20	0.134	11.1	0.06	20	0	0	0	0	0.130	10
Artemisia frigida	fringed sagebrush	0.183	50	0.081	50	0.029	44.4	0.064	30	0.061	50	0.112	50	0.047	60
Artemisia tridentata	basin big sagebrush	0	0	0	0	0.093	11.1	0	0	0	0	0.000	0	0.060	20
Asclepias macrotis	longhood milkweed	0	0	<0.001	10	0	0	0	0	0	0	0	0	0	0
Astragalus mollissimus	woolly locoweed	0	0	0	0	0	0	0	0	0	0	0.001	10	0.001	20
Astragalus spp.	milkvetch	0.002	40	0.009	60	0.001	11.1	0.006	50	0.004	60	0.001	10	0	0
Atriplex canescens	fourwing saltbush	0.67	100	0.843	100	0.582	100	0.423	100	0.64	100	0.865	100	0.634	100
Boechera spp.	rockcress	0	0	0	0	0	0	<0.001	10	0	0	0	0	0	**0**
Bouteloua barbata	sixweeks grama	0	0	0	0	0	0	0	0	0.002	10	0.050	10	0	0
Bouteloua gracilis	blue grama	6.939	100	5.651	100	4.266	100	2.068	100	1.568	100	2.816	100	3.242	100
Bromus tectorum[a]	cheatgrass	0.032	60	0	0	0	0	0.001	20	0	0	0	0	0	0
Chaetopappa ericoides	rose heath	0.055	70	0.038	100	0.033	77.8	0.031	70	0.033	90	0.041	70	0.029	70

a Nonnative species

Table B-1. (*continued*) Plant species list with mean foliar cover and plot frequency for each panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots.

		Initial sampling year between 2007 and 2011						2012				2014			
		Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
Species	**Common name**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**
Chamaesaracha coronopus	greenleaf five eyes	0	0	0.003	20	0	0	0.002	10	0.004	20	0.003	10	0	0
Chenopodium fremontii	Fremont's goosefoot	0	0	0.013	40	0.323	33.3	0	0	0.002	20	0	0	0	0
Chenopodium leptophyllum	narrowleaf goosefoot	0.045	50	0.019	30	0.025	44.4	0.001	20	0.005	10	0.040	10	0	0
Chenopodium spp.	goosefoot	0	0	0.113	30	0	0	0	0	0.001	20	0.011	30	0.007	30
Chrysothamnus greenei	Greene's rabbitbrush	0.707	80	0.542	70	0.378	88.9	0.424	90	0.289	70	0.431	70	0.354	80
Chrysothamnus pulchellus	southwestern rabbitbrush	0	0	<0.001	10	0	0	0	0	0.005	10	0	0	0	0
Comandra umbellata	bastard toadflax	0	0	0.002	10	0	0	0	0	0.003	10	<0.001	10	0	0
Cryptantha spp.	cryptantha	0	0	0.046	90	0.173	77.8	0.206	100	0.207	100	0.171	80	0.034	80
Descurainia pinnata	western tansymustard	0	0	0.013	60	0.01	66.7	0.266	100	0.207	90	0.196	100	0.049	90
Dieteria canescens	hoary tansyaster	0.008	30	<0.001	10	<0.001	11.1	0.008	20	0.005	30	0.004	10	0	0
Echinocereus triglochidiatus	kingcup cactus	0.005	10	0	0	0	0	0.006	30	0	0	0	0	0	0
Elymus elymoides	squirreltail	0.396	100	0.009	40	0.006	44.4	0.054	90	0.013	80	0.011	80	0.066	80
Ephedra torreyana	Torrey's jointfir	0	0	0.362	20	0.199	22.2	0	0	0.222	20	0.353	20	0.202	20
Ephedra viridis	mormon tea	0	0	0.051	10	0	0	0	0	0.059	10	0.129	10	0	0
Ericameria nauseosa	rubber rabbitbrush	0.08	20	0	0	0.037	22.2	0.037	20	0	0	0	0	0.035	20
Eriogonum cernuum	nodding buckwheat	0.004	10	0.025	50	0.016	33.3	0.001	10	0.014	40	0.005	30	0.002	10
Eriogonum corymbosum	crispleaf buckwheat	0	0	0.003	20	0.002	11.1	0	0	0.003	20	0.004	20	0	0
Erysimum capitatum	sanddune wallflower	0	0	0	0	0	0	0	0	0.006	10	0	0	0.003	20

a Nonnative species

Table B-1. (*continued*) Plant species list with mean foliar cover and plot frequency for each panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots.

		Initial sampling year between 2007 and 2011						2012				2014			
		Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
Species	**Common name**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**
Escobaria vivipara	spinystar	0	0	0.001	20	0	0	0.001	20	0.002	40	<0.001	10	0.003	30
Euphorbia fendleri	Fendler's sandmat	0	0	0.002	10	<0.001	11.1	0	0	0	0	0	0	0	0
Euphorbia spp.	sandmat	0.004	30	0.095	50	0.111	66.7	0.018	40	0.022	60	0.001	30	0.001	20
Evolvulus nuttallianus	shaggy dwarf morning-glory	<0.001	10	0	0	0	0	0	0	0	0	0	0	0	0
Gilia spp.	gilia	0	0	0	0	0	0	0.002	30	0	0	0	0	0	0
Gutierrezia sarothrae	broom snakeweed	2.074	100	0.089	90	0.034	88.9	0.081	90	0.093	100	0.258	100	0.103	100
Helianthus annuus	common sunflower	0	0	0.004	10	0.001	11.1	0	0	0	0	0	0	0	0
Hesperostipa comata	needle and thread	0.066	70	0.03	30	0.017	55.6	0.013	40	0.025	40	0.038	40	0.013	40
Hilaria jamesii	James' galleta	4.679	100	3.653	100	1.976	100	1.789	100	1.582	100	3.730	100	4.028	100
Hymenopappus filifolius	fineleaf hymenopappus	<0.001	10	0	0	0	0	0	0	0	0	0	0	0	0
Ipomopsis pumila	dwarf ipomopsis	0	0	0	0	0	0	0	0	0.001	10	0	0	0	0
Krascheninnikovia lanata	winterfat	0.387	70	0.62	70	1.123	88.9	0.353	80	0.562	70	0.936	80	1.743	90
Lappula occidentalis	flatspine stickseed	0	0	0.012	60	0.066	66.7	0.07	100	0.05	100	0.022	80	0.010	70
Lappula spp.	stickseed	0	0	0	0	0	0	0	0	0	0	0	10	0	0
Linum puberulum	plains flax	0	0	0.002	10	0	0	0	0	<0.001	10	0	0	0	0
Lorandersonia pulchella	spearleaf rabbitbrush	0	0	0	0	0	0	0	0	0	0	0.002	10	0	0
Lycium pallidum	pale desert-thorn	0.028	10	0	0	0.002	11.1	0.011	20	0	0	0	0	0.002	10
Mentzelia albicaulis	whitestem blazingstar	0	0	<0.001	10	0.011	11.1	0	0	0	0	0	0	0	0
Muhlenbergia pungens	sandhill muhly	0	0	0.033	10	0	0	0	0	0.047	10	0.020	10	0	0

a Nonnative species

Table B-1. (*continued*) Plant species list with mean foliar cover and plot frequency for each panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots.

		Initial sampling year between 2007 and 2011						2012				2014			
		Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
Species	**Common name**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**
Muhlenbergia torreyi	ring muhly	0.066	50	0.068	40	0.05	33.3	0.027	50	0.043	40	0.067	40	0.168	50
Munroa squarrosa	false buffalograss	0.003	20	0.011	50	0.01	55.6	0.068	60	0.022	60	0	0	0	0
Nama dichotoma	wishbone fiddleleaf	0	0	0	0	0	0	<0.001	10	0	0	0	0	0	0
Oenothera spp.	evening primrose	0	0	0	0	0.001	11.1	0.098	90	0.047	60	0.003	20	0	0
Opuntia spp.	prickly pear	0.106	90	0.099	70	0.069	77.8	0.068	90	0.097	70	0.115	90	0.091	80
Orobanche ludoviciana	Louisiana broomrape	0	0	0.001	10	<0.001	11.1	<0.001	10	0	0	0	0	0	0
Penstemon sp.	penstemon	0	0	0	0	0.002	11.1	0	0	0	0	<0.001	10	0	0
Penstemon angustifolius	narrowleaf penstemon	0	0	0	0	<0.001	11.1	0	0	0	0	0	0	0	0
Phacelia spp.	scorpionweed	0.056	40	<0.001	10	0	0	0.051	50	0.023	60	0.001	20	<0.001	10
Plantago patagonica	woolly plantain	0.139	100	0.007	40	0.016	77.8	0.086	100	0.042	100	0.027	80	0.005	60
Portulaca oleraceaa	little hogweed	0	0	0	0	0	0	0.005	10	0	0	0	0	0	0
Rumex hymenosepalus	canaigre dock	0	0	0.008	30	0.003	22.2	0.002	20	0.006	20	0.007	40	0.013	30
Salsola tragus[a]	prickly Russian thistle	0.018	20	0.006	30	0.003	44.4	0.099	30	0.006	50	0.019	60	0.071	30
Sanvitalia abertii	Abert's creeping zinnia	0	0	0	0	0	0	0.006	10	0	0	0	0	0	0
Schkuhria multiflora	many-flower false threadleaf	0.01	40	0.001	20	<0.001	11.1	<0.001	10	0	0	0	0	0	0
Senecio spartioides	broomlike ragwort	0	0	0	0	0.002	11.1	0	0	0	0	0	0	0	0
Solanum jamesii	wild potato	0	0	<0.001	10	0	0	0	0	0	0	0	0	0	0
Sphaeralcea coccinea	scarlet globemallow	0.256	100	0.046	60	0.065	66.7	0.084	90	0.066	100	0.038	80	0.034	90

a Nonnative species

Table B-1. (*continued*) Plant species list with mean foliar cover and plot frequency for each panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots.

		Initial sampling year between 2007 and 2011						2012				2014			
		Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
Species	**Common name**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**	**Foliar cover (%)**	**Plot frequency (%)**
Sphaeralcea incana	grey globemallow	0	0	0	0	0	0	0	0	0	0	0.082	10	0	0
Sphaeralcea spp.	globemallow	0.014	10	0.081	40	0.04	22.2	0.003	20	0.029	10	0.001	20	0	0
Sporobolus contractus	spike dropseed	0	0	0	0	0	0	0	0	0	0	0.017	30	0.010	10
Sporobolus coromandelianus	Madagascar dropseed	0	0	0	0	0	0	0	0	0.002	10	0	0	0	0
Sporobolus cryptandrus	sand dropseed	0	0	0	0	0	0	0	0	0	0	0.550	100	1.021	100
Sporobolus spp.	dropseed	2.018	100	1.16	100	1.683	100	0.436	100	0.473	100	0	0	0	0
Stephanomeria exigua	small wirelettuce	0	0	0	0	0	0	0	0	0	0	<0.001	10	0	0
Stephanomeria spp.	wire lettuce	<0.001	10	0	0	0	0	0.01	30	0.008	40	0	0	0	0
Tetradymia canescens	spineless horsebrush	0	0	0.007	10	0.011	11.1			0.002	10	0.005	10	0	0
Townsendia annua	annual Townsend daisy	0	0	0.005	40	0.016	44.4	0.027	90	0.037	80	0.029	30	0.007	60
Verbesina encelioides	golden crownbeard	0	0	0	0	0	0	0.001	10	0	0	0	0	0	0
Vulpia octoflora	sixweeks fescue	0.076	100	0.002	30	0.001	44.4	0.051	80	0.007	70	0.002	20	0	0

a Nonnative species

Appendix C. Cover of soil surface features by panel in the Sandy Loam ecological site at Chaco Culture National Historical Park, 2007–2014

Table C-1. Cover of soil surface features by panel in the Sandy Loam ecological site at Chaco Culture NHP for 2012 and 2014, and for the initial sampling year for all plots. The soil surface features do not add up to 100% because the calculations were made from cover class midpoints. "SD" is the standard deviation.

	Initial sampling year between 2007 and 2011						2012				2014			
	Panel A, n=10		Panel B, n=10		Panel C, n=9		Panel A, n=10		Panel B, n=10		Panel B, n=10		Panel C, n=10	
Soil surface feature	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Live plant base	9.87	2.72	4.72	5.40	3.20	1.92	2.24	0.84	2.40	1.06	2.01	0.61	2.17	0.72
Dead woody base	0.49	0.28	0.40	0.29	0.32	0.19	0.25	0.14	0.36	0.26	0.18	0.13	0.20	0.11
Dead herbaceous base	4.31	1.70	5.64	3.92	5.46	4.08	4.04	1.48	3.85	1.12	3.64	1.12	4.18	1.76
Bare soil	9.35	6.31	42.09	33.77	42.86	34.42	3.34	2.35	3.63	4.60	5.83	10.48	2.71	1.49
Litter	9.09	3.03	5.95	2.33	7.35	3.25	4.79	3.23	3.66	1.83	5.34	3.42	4.90	3.02
Undifferentiated crust	65.62	13.22	37.35	36.83	36.20	34.69	83.62	7.37	84.57	5.08	80.88	12.63	83.12	3.34
Moss	0.08	0.25	0.01	0.02	0	0	0.07	0.12	0.18	0.41	0.03	0.05	0.01	0.02
Lichen	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyanobacteria	0.01	0.02	0.55	1.74	0.78	2.34	0.01	0.02	<0.01	0.01	0.01	0.03	0.03	0.05
Fine gravel (0.2 to <2 cm)	0.40	0.59	0.13	0.13	0.02	0.01	0.56	1.11	0.25	0.17	0.19	0.17	0.05	0.03
Coarse gravel (2.0 to <7.5 cm)	0.20	0.35	0.07	0.09	0.01	0.01	0.63	1.37	0.10	0.09	0.06	0.08	0.01	0.01
Cobble (7.5 to < 25 cm)	0.04	0.08	0.01	0.02	0	0	0.04	0.11	<0.01	0.01	0	0	0	0
Stone, bedrock (≥25 cm)	0.03	0.09	0	0	0	0	0.20	0.63	0	0	0	0	0	0
Woody debris	0	0	<0.01	0.01	0.04	0.04	0.02	0.05	0.02	0.02	0.02	0.03	0.04	0.08

Appendix D. Soil stability ratings for the Sandy Loam ecological site at Chaco Culture National Historical Park, 2007–2014

Table D-1. Soil stability ratings for all samples, and for samples under and not under vegetative cover, by panel, for 2012, 2014, and for the initial sampling period (2007–2011) in the Sandy Loam ecological site at Chaco Culture National Historical Park. Ratings range from 1 to 6 with 1 being the lowest stability and 6 being the highest. Sample sizes were reduced in panels B and C in 2010–2011, panel B in 2012 and panel C in 2014 because soils were too wet to conduct the test. "SD" is standard deviation.

	Initial sampling year between 2007 and 2011						2012				2014			
	Panel A, n=10		Panel B, n=9		Panel C, n=8		Panel A, n=10		Panel B, n=9		Panel B, n=10		Panel c, n=9	
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD
All samples	3.61	0.62	3.25	0.94	3.75	1.07	3.42	1.05	2.49	0.77	3.14	0.52	3.01	0.62
Samples under vegetative cover	4.14	0.83	4.06	0.88	4.39	1.05	4.10	1.27	3.50	1.04	3.62	0.64	3.38	1.16
Samples not under vegetative cover	2.91	0.47	2.32	0.85	3.10	1.07	2.72	1.02	1.90	0.75	2.57	0.70	2.53	0.55

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