



Integrated Upland Vegetation and Soils Monitoring for Petrified Forest National Park

2009 Summary Report

Natural Resource Data Series NPS/SCPN/NRDS—2011/173



ON THE COVER

Sandy Loam ecological site at Petrified Forest National Park
Photograph by: Megan Swan

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James K. DeCoster
Megan C. Swan

National Park Service
Southern Colorado Plateau Network
Northern Arizona University
P.O. Box 5765
Flagstaff, AZ 86011-5765

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The corresponding author and project manager for this project is Jim DeCoster (jim_decoster@nps.gov). Megan Swan is the botanist and crew leader for the project. Other contributions were made by the SCPN staff. The 2009 field crew consisted of Teresa DeKoker, Lara Dickson, Hillary Hudson, and Steve Till.

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Introduction and Background

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 strong scientific foundation that informs resource management decisions. 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 two ecological sites for long-term monitoring of upland vegetation and soils at Petrified Forest National Park (PEFO): Clayey Fan and Sandy Loam. An ecological site is a landscape division with characteristic soils, hydrology, plant communities, and disturbance regimes and responses, and its classification is based on soil survey data (Butler et al. 2003). These ecological sites both represent large areas of the park, but they are relatively distinct from each other. They face numerous threats, including climate change, soil erosion, and invasion by nonnative species.

In 2007 the Integrated Upland Monitoring program of SCPN began monitoring upland sites at PEFO with the installation of 10 plots in the Clayey Fan ecological site and 20 plots in the Sandy Loam ecological site. In 2008 and 2009, all 10 plots in the Clayey Fan ecological site were read, but only 10 of the 20 plots in the Sandy Loam ecological were read. We have sampled the quadrats and gap intercept transects annually for three years to determine the range of temporal variability for key metrics. In this report, we document monitoring activities in the 2009 field season and compare these data with the data collected in 2007 and 2008.

Methods

Sampling frame

We derived the sampling frame from the maps of the Clayey Fan and Sandy Loam ecological sites, which were developed by the US Natural Resources Conservation Service (See Appendix A of DeCoster et al. in review). The sampling frame is the area from which we randomly select our sites, and hence the area to which statistical inferences can be made. To create the sampling frame, we modified the map of the ecological site using Geographical Information System (GIS) by removing slopes that exceeded 20% and roads, buildings, and other infrastructure (fig. 1).

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 had the opportunity to reject those points that landed too close to archaeological sites and other sensitive resources. Before establishing a plot, the Integrated Upland crew conducted an ecological site assessment for each sampling point and rejected sites that did not fall within the ecological site, had a slope greater than 20%, or contained a major disturbance.

Field methods

In 2009, the SCPN Upland Monitoring crew sampled 20 plots that were established at PEFO in 2007, 10 plots for each ecological site. The plots were 0.50 ha in size, measuring 71 × 71 m. Shrub and herbaceous data and soil data were collected on three 50 m transects, spaced 25 m apart, within each plot. In 2007 the crew collected the data in all the plots between mid-September and early October, but in 2008 and 2009 they collected data in mid-October. Field methodology is provided in detail in the SCPN Integrated Upland Protocol (DeCoster et al., in review).

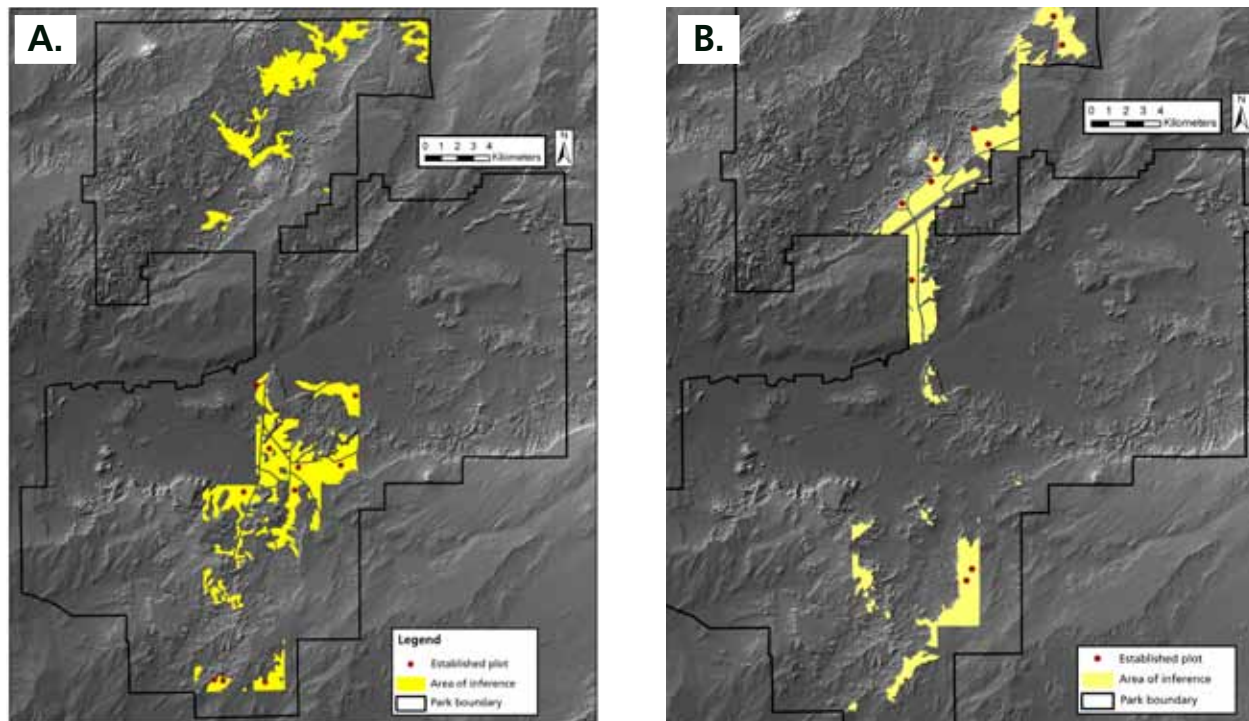


Figure 1. Sampling frame of A) Clayey Fan and B) Sandy Loam ecological sites each showing 10 plots sampled in 2007, 2008 and 2009

Shrub and herbaceous vegetation

The crew sampled shrub and herbaceous vegetation within five sets of nested quadrats at 10 m intervals along each transect. The largest quadrat size was 10 m² (2 × 5 m), with four smaller quadrats nested inside (0.01 m², 0.1 m², 1 m², 5 m²). For each nested sub-quadrat we recorded the presence of individual vascular species. For each 10 m² quadrat we estimated percent cover for herbaceous and shrub species and recorded it as one of 12 cover classes (e.g. 2%–5%, 5%–10%, etc.). We also estimated the percent cover for functional groups (e.g. perennial grasses, forbs, shrubs) in the 10 m² quadrats and recorded the cover class for each.

Overstory trees and saplings

There were no trees in any of the plots.

Soil stability and hydrologic function

To measure the amount of bare soil, the crew recorded the length of basal gaps (the space between plant bases) along each transect. Percent cover of soil surface features was estimated in the 1 m² quadrats in conjunction with shrub and herbaceous data and recorded in one of 12 cover classes. A soil aggregate stability test was conducted in 2007, using 18 soil samples collected along the transects. This procedure was not repeated in 2008 or 2009.

Data summary

The sample unit for summary and analysis is the plot; hence, we summarized data at the level of the

plot. In order to calculate summary statistics for the ecological site, means and standard deviations were calculated from the plot means.

For herbaceous and shrub vegetation, cover was calculated for each species from the cover class midpoints, e.g. using 7.5% for cover class 5%–10%. The mean cover was calculated for each plot, and the mean and standard deviation (SD) were calculated for the ecological site from the plot means. Species frequency was calculated for quadrats (mean percentage of quadrats per plot where the species occurs) and for plots (percentage of plots where the species occurs). Mean cover and SD of functional groups and surface features were calculated in a similar fashion.

We calculated four diversity measures for herbaceous and shrub species (Magurran 1988), first for all species and then for native species only.

(1) Species richness (S) is the number of species at a given spatial scale, and it was calculated at the level of the plot and at the level of the ecological site.

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

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

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:

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

(4) Beta diversity (β_w) is a measure of within-ecological site heterogeneity:

$$S_e / (S_p - 1)$$

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

We made five calculations for the basal gaps data: median basal gap size, percentage of transects comprised of gaps and plant bases, percentage of transects comprised of each size class, and total number of gaps. Mean and SD were calculated for each metric.

Results

Clayey Fan ecological site

Shrub and herbaceous vegetation

Perennial grasses dominated the vegetation of the Clayey Fan ecological site at PEFO (table 1 and fig. 2), with less cover of shrubs, forbs, and cacti/succulents. Over the three years of sampling, the mean cover of total live vegetation ranged between 9.54% and 14.91%, with perennial grasses ranging from 6.82% to 9.13%. All functional groups decreased in cover over the three years, with annual grasses

Table 1. Mean foliar cover of functional groups for 2007, 2008 and 2009 in the Clayey Fan ecological site

Functional groups	Foliar cover (%)					
	2007		2008		2009	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Total live foliar cover	14.91	(5.58)	11.94	(3.67)	9.54	(2.89)
Perennial grasses, graminoids	9.13	(5.10)	8.32	(3.13)	6.82	(2.14)
Annual grasses	2.31	(2.74)	0.05	(0.09)	0	(0)
Forbs	1.50	(1.52)	0.42	(0.54)	0.11	(0.16)
Shrubs	3.05	(3.02)	2.58	(2.91)	2.28	(2.28)
Cacti, succulents	0.04	(0.03)	0.03	(0.03)	0.02	(0.02)
Standing dead herbaceous	4.09	(1.11)	2.20	(0.68)	2.24	(1.00)
Standing dead woody	0.86	(0.71)	0.82	(0.93)	0.71	(0.79)

Note: Understory tree cover was only measured in 2007, and was included in the total foliar cover

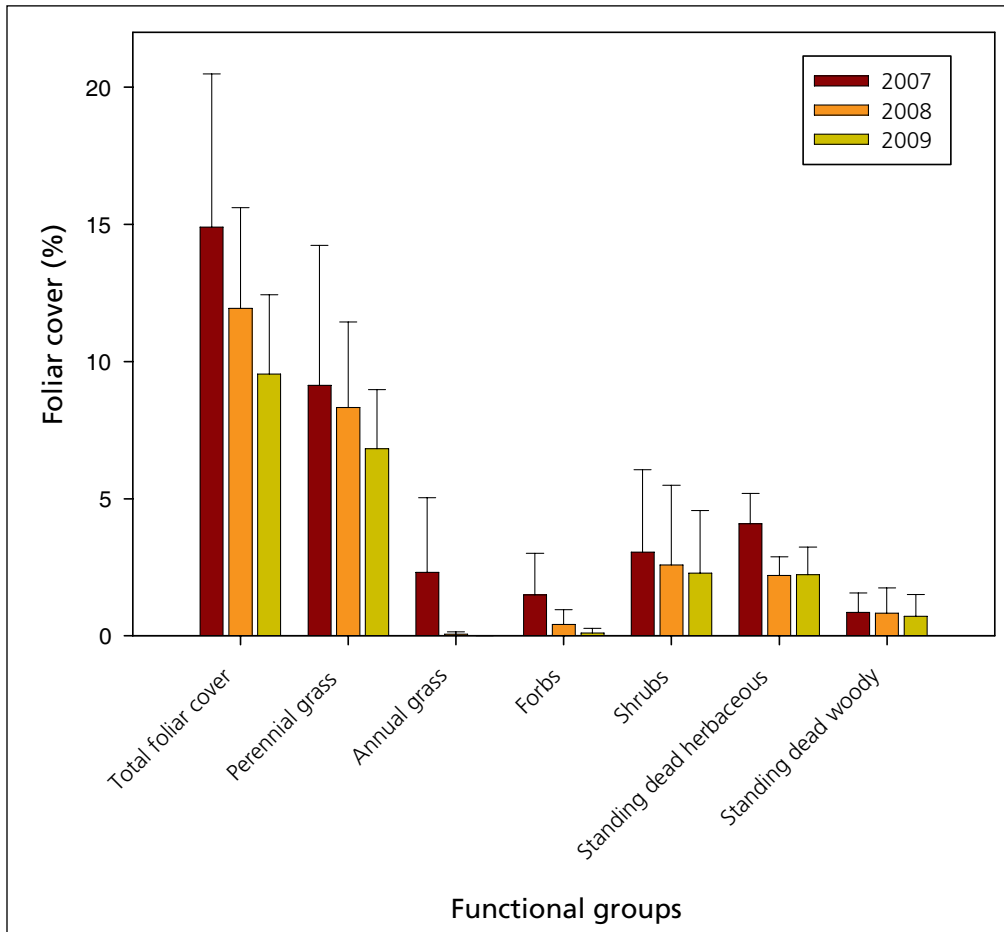


Figure 2. Mean cover of functional groups at the Clayey Fan ecological site in 2007, 2008, and 2009. Error bars represent one standard deviation.

and forbs decreasing by the most. Annual grasses had a mean foliar cover of 2.31% in 2007 and decreased to 0.05% in 2008. No annual grasses were found in the plots in 2009. Forbs decreased from 1.50% to 0.11% over the three years. Dead herbaceous cover decreased in 2008.

Dominant perennial grasses included *Sporobolus airoides* (alkali sacaton), *Pleuraphis jamesii* (James' galleta), and *Bouteloua gracilis* (blue grama). Annual grasses included *Sporobolus coromandelianus* (Madagascar dropseed) and *Bouteloua barbata* (sixweeks grama). Dominant shrubs included *Atriplex obovata* (mound saltbush) and *Atriplex canescens* (fourwing saltbush). Cover of individual species differed among the three years, but most of these changes were quite small, especially considering the large standard deviations (table 2 and fig. 3). Exceptions include *Sporobolus airoides*, which showed a large decline from 2007 to 2008, *Salsola tragus* (prickly Russian thistle) which decreased over the three years, the annual grasses, and *Chamaesyce* spp., (a group of annual sandmats based on morphological characteristics), which showed sharp declines in 2008 and did not occur in 2009.

Quadrat and plot frequencies did not change substantially between years except for those species that also showed large declines in foliar cover. There were, however, a number of species that were not present in the plots in all three years. Some species were present in only one of the three years and are referred to here as unique species. Others were present in two of the three years. In 2007 there were 11 unique species (not including the unknowns), in 2008 there were 7 (not including the unknown), and in 2009 there were 5 (See Appendix A).

Table 2. Foliar cover and frequency of the fifteen most abundant vascular species and all nonnative species in 2007, 2008, and 2009 at the Clayey Fan ecological site

Species	2007				2008				2009			
	Mean cover (%)	SD	Quad freq	Plot freq	Mean cover (%)	SD	Quad freq	Plot freq	Mean cover (%)	SD	Quad freq	Plot freq
<i>Sporobolus airoides</i>	6.181	6.117	92.00	100	3.902	3.006	92.67	100	3.895	2.500	90.67	100
<i>Atriplex obovata</i>	1.589	1.453	58.00	90	1.264	1.255	56.67	100	1.306	1.373	54.67	90
<i>Pleuraphis jamesii</i>	1.266	1.172	54.67	100	1.713	1.277	61.33	100	1.237	0.839	56.00	100
<i>Sporobolus coromandelianus</i>	1.251	1.692	36.00	80	0.039	0.081	18.67	50	0	0	0	0
<i>Bouteloua gracilis</i>	1.210	1.588	50.67	90	1.385	1.834	54.00	90	1.114	1.638	49.33	90
<i>Bouteloua barbata</i>	1.062	1.24	55.33	90	0.034	0.07	20.00	70	0	0	0	0
<i>Salsola tragus</i> ^a	0.973	1.618	60.67	100	0.376	0.535	56.67	100	0.089	0.165	30.67	60
<i>Atriplex canescens</i>	0.565	1.03	21.33	50	0.529	0.921	21.33	50	0.350	0.611	17.33	60
<i>Sarcobatus vermiculatus</i>	0.293	0.928	4.00	10	0.173	0.548	4.00	10	0.155	0.490	4.00	10
<i>Chamaesyce</i> spp. Group A	0.196	0.263	61.33	100	0.006	0.011	8.00	30	0	0	0	0
<i>Achnatherum hymenoides</i>	0.165	0.167	34.67	90	0.255	0.193	39.33	90	0.346	0.254	42.00	90
<i>Atriplex confertifolia</i>	0.150	0.276	6.00	40	0.081	0.116	6.00	60	0.122	0.142	9.33	70
<i>Ericameria nauseosa</i>	0.119	0.178	5.33	40	0.064	0.100	4.67	40	0.055	0.083	4.67	40
<i>Gutierrezia sarothrae</i>	0.089	0.165	19.33	40	0.057	0.097	18.67	50	0.060	0.116	17.33	50
<i>Ephedra torreyana</i>	0.070	0.157	2.00	30	0.020	0.042	1.33	20	0.033	0.077	1.33	20
<i>Portulaca oleracea</i> ^a	0.044	0.124	12.00	60	0	0	0	0	0	0	0	0
<i>Bromus tectorum</i> ^a	0.004	0.008	5.33	40	0.001	0.002	2.00	20	0	0	0	0

Note: Species are arranged in descending order by their 2007 cover.

^a Nonnative species.

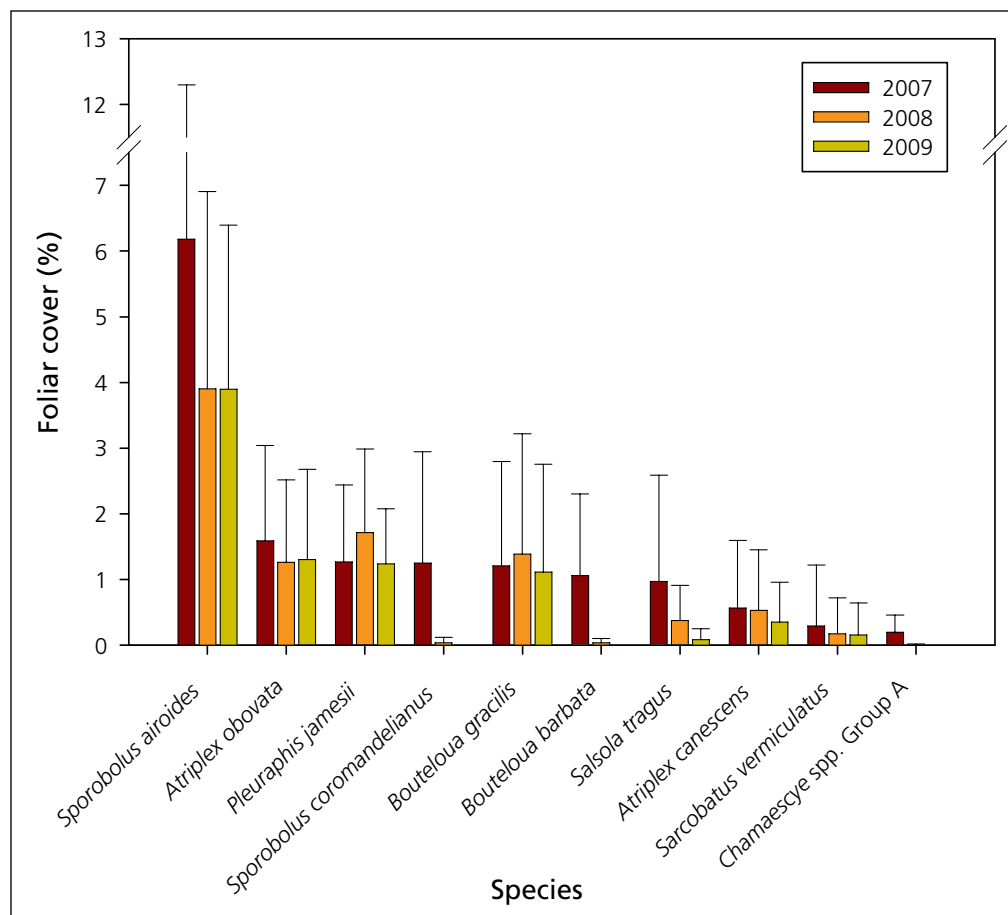


Figure 3. Mean foliar cover of the ten most abundant shrub and herbaceous species in 2007, 2008, and 2009 in the Clayey Fan ecological site. Error bars represent one standard deviation.

We found three nonnative species in the plots: *Salsola tragus*, *Bromus tectorum* (cheatgrass), and *Portulaca oleracea* (little hogweed). *Salsola tragus* decreased in cover and frequency over the three year period, as mentioned above. *Bromus tectorum* decreased in cover and frequency in 2008, and did not occur in 2009. *Portulaca oleracea* only occurred in 2007, with low cover and frequency. Appendix A lists all species, along with common names, families, mean foliar covers, and plot frequencies by year.

The diversity indices showed fairly high variation among years (table 3). On the scale of the plot, species richness decreased over the three years from 24.3 to 13.8 species per plot (table 3). Shannon diversity (which takes into account relative species abundance, and generally ranges between 1.5 and 3.5) ranged between 1.525 and 1.755, and evenness (the degree to which all species are of equal abundance, ranging from 0 to 1) ranged between 0.552 and 0.589 (Margalef 1972). On the scale of the ecological site, species richness decreased over the three years from 69 to 43 species, and beta diversity (a measure of within site heterogeneity, generally ranging between 1 and 5) ranged between 2.961 and 3.359 (McClune and Grace 2002). When these indices were recalculated using only native species, they did not change substantially.

Soil stability and hydrologic function

The crew monitored the amount of exposed soil in two ways: cover estimates of soil surface features in quadrats and measurements of basal gaps along transects. These measurements were undertaken in all three years. As expected, most changes in the surface features were relatively small (table 4 and fig. 4). Two features, however, showed large variation among years: undifferentiated crust and bare

Table 3. Species diversity metrics for all species and for native species only at the Clayey Fan ecological site

	2007		2008		2009	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
All species						
Plot						
Plot richness	24.3	(7.1)	19.2	(7.3)	13.8	(4.8)
Shannon diversity	1.755	(0.506)	1.657	(0.379)	1.525	(0.380)
Evenness	0.552	(0.143)	0.569	(0.081)	0.589	(0.090)
Ecological site						
Ecological site richness	69		61		43	
Beta diversity	2.961		3.352		3.359	
Native species						
Plot						
Plot richness	22.3	(7.4)	18.0	(7.2)	13.2	(4.6)
Shannon diversity	1.706	(0.503)	1.593	(0.373)	1.492	(0.367)
Evenness	0.554	(0.148)	0.561	(0.80)	0.586	(0.086)
Ecological site						
Ecological site richness	66		59		42	
Beta diversity	3.099		3.471		3.443	

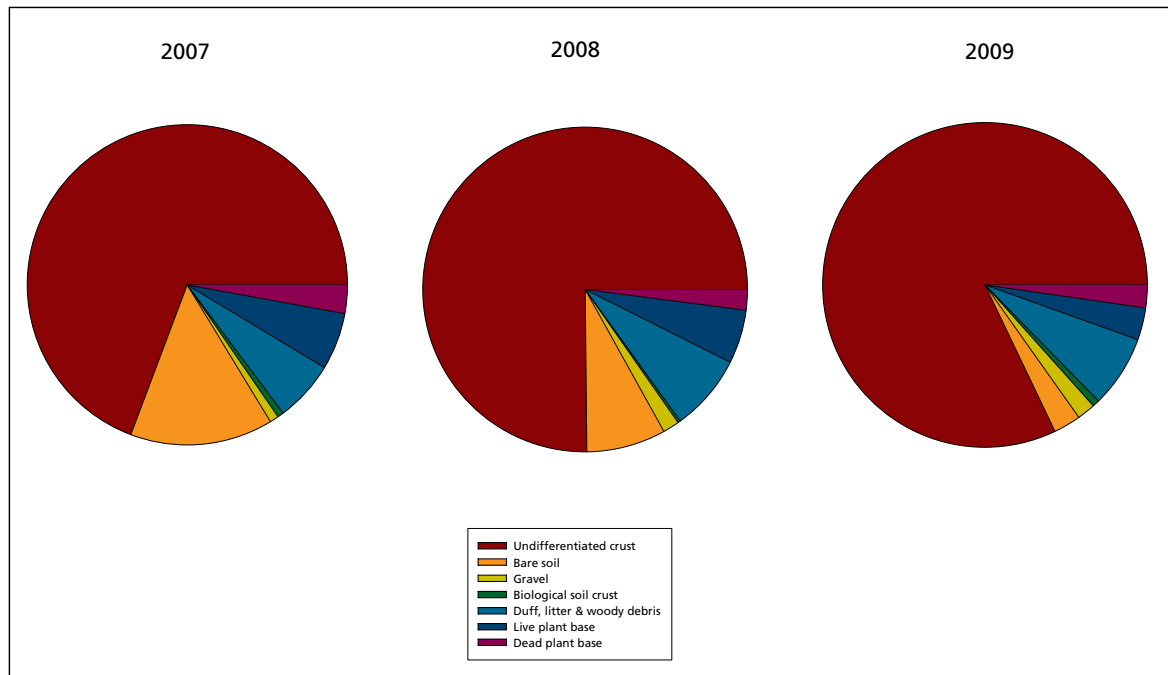


Figure 4. Mean cover of soil surface features at the Clayey Fan ecological site in 2007, 2008, and 2009. Biological soil crusts include moss, lichen, and cyanobacteria.

Table 4. Cover of soil surface features in the Clayey Fan ecological site

Surface feature	2007		2008		2009	
	Mean (%)	(SD)	Mean (%)	(SD)	Mean (%)	(SD)
Live plant base	5.86	(2.51)	5.10	(1.54)	3.11	(0.81)
Dead woody base	0.35	(0.26)	0.26	(0.46)	0.15	(0.27)
Dead herbaceous base*	2.59	(0.89)	1.70	(0.74)	2.07	(0.54)
Bare soil	14.68	(7.16)	7.52	(5.05)	2.64	(1.71)
Duff and litter	6.26	(3.65)	7.26	(4.75)	7.01	(5.81)
Undifferentiated crust	70.51	(6.57)	71.67	(7.99)	79.91	(6.02)
Moss	0.50	(0.93)	0.20	(0.44)	0.42	(1.04)
Lichen	0	(0)	0	(0)	0	(0)
Cyanobacteria	0.13	(0.42)	0.05	(0.09)	0.25	(0.62)
Fine gravel (0.2–2 cm)	0.78	(1.28)	0.95	(1.40)	1.67	(2.80)
Coarse gravel (2–7.5 cm)	0.14	(0.22)	0.61	(1.78)	0.10	(0.24)
Cobble (7.5–25 cm)	0	(0)	0	(0)	0	(0)
Stone, bedrock (>25 cm)	0	(0)	0	(0)	0	(0)
Woody debris	0	(0)	0.02	(0.05)	0.01	(0.04)

Note: The surface feature components do not add up to 100% because the calculations were made from cover class midpoints, and the estimations have observer error.

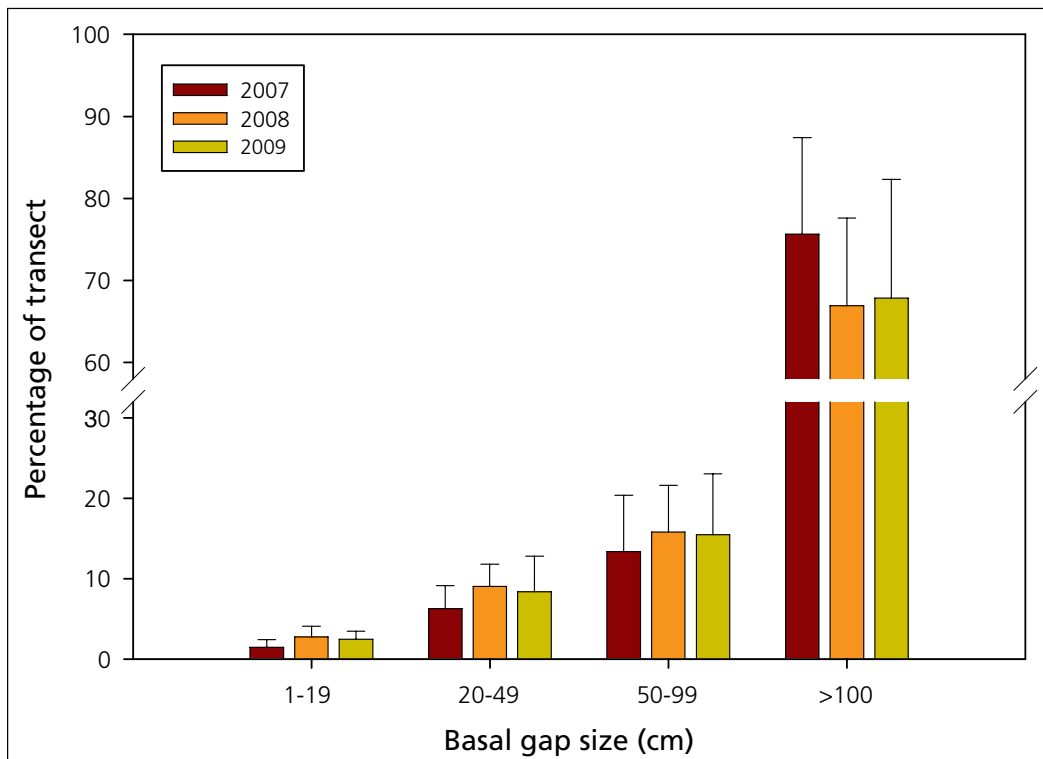


Figure 5. Percentage of transect in different gap sizes in 2007, 2008, and 2009 in the Clayey Fan ecological site. Error bars represent one standard deviation.

Table 5. Number of basal gaps, median gap size, and percentage of transect in different gap size classes in 2007, 2008, and 2009 at the Clayey Fan ecological site

Metric	2007		2008		2009	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Number of gaps	119.0	(42.1)	158.8	(39.5)	151.4	(51.8)
Median gap size (cm)	78.7	(29.6)	54.2	(24.0)	56.5	(22.7)
Percent of transect in gaps 0–19 cm	1.5	(0.9)	2.8	(1.3)	2.5	(1.0)
Percent of transect in gaps 20–49 cm	6.3	(2.9)	9.1	(2.7)	8.4	(4.4)
Percent of transect in gaps 50–99 cm	13.4	(7.0)	15.8	(5.8)	15.5	(7.6)
Percent of transect in gaps ≥100 cm	75.6	(11.8)	66.9	(10.7)	67.8	(14.5)
Percent of transect in gaps	96.7	(1.3)	94.6	(1.5)	94.2	(2.1)
Percent of transect in plant bases	3.3	(1.3)	5.4	(1.5)	5.8	(2.1)

soil. The basal gap data shows moderately high among-year variation for gap number, median gap size, and the percentage of transect occupied by the largest size class (table 5 and fig. 5). The differences between 2007 and 2008 are generally much greater than the differences between 2008 and 2009.

Sandy Loam ecological site

Shrub and herbaceous vegetation

Perennial grasses dominated the vegetation of the Sandy Loam ecological site at PEFO (table 6 and fig. 6), with less cover of shrubs, forbs, and cacti/succulents. Total live vegetative cover decreased over the three years from 18.58% to 13.90%. Perennial grasses showed slight decreases over the three years. Annual grasses and forbs, on the other hand, showed large decreases. Shrubs decreased

Table 6. Mean foliar cover of functional groups for 2007, 2008, and 2009 in the Sandy Loam ecological site

Functional Groups	Foliar cover (%)					
	2007		2008		2009	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Total live foliar cover	18.58	(5.33)	17.76	(3.51)	13.90	(4.13)
Perennial grasses, graminoids	11.21	(4.99)	10.99	(4.65)	10.26	(4.99)
Annual grasses	0.71	(2.03)	0.02	(0.03)	0.01	(0.03)
Forbs	0.92	(1.18)	0.81	(1.87)	0.13	(0.18)
Shrubs	5.35	(2.92)	5.19	(2.50)	3.59	(1.54)
Cacti, succulents	0.15	(0.15)	0.13	(0.15)	0.13	(0.16)
Standing dead herbaceous	5.01	(2.78)	1.94	(1.23)	3.57	(2.29)
Standing dead woody	1.23	(0.84)	1.32	(0.51)	1.64	(0.71)

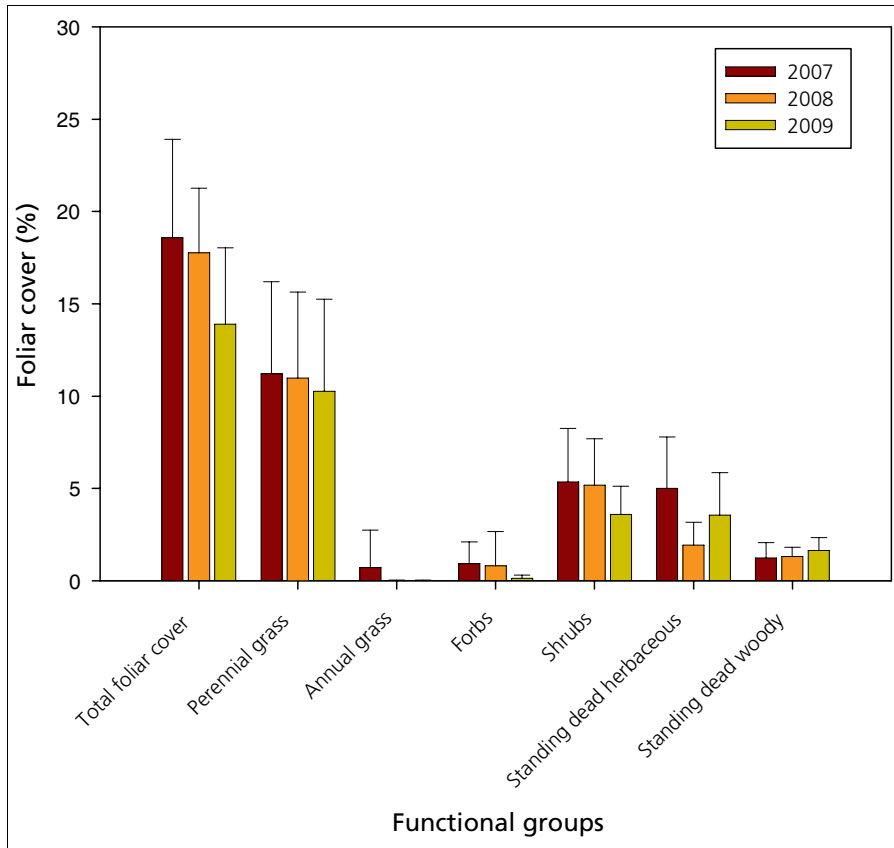


Figure 6. Mean cover of functional groups at the Sandy Loam ecological site in 2007, 2008, and 2009. Error bars represent one standard deviation.

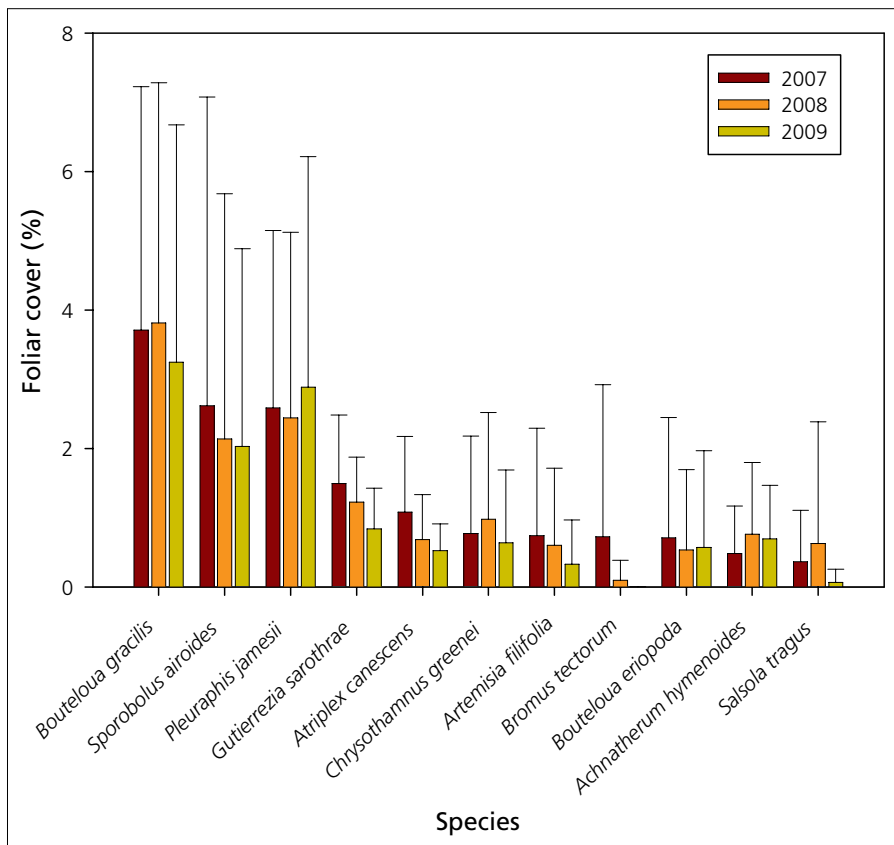


Figure 7. Mean foliar cover of the ten most abundant vascular species at the Sandy Loam ecological site in 2007, 2008, and 2009. Error bars represent one standard deviation.

Table 7. Foliar cover and frequency of the fifteen most abundant vascular species and all nonnative species in 2007, 2008, and 2009 at the Sandy Loam ecological site

Species	2007				2008				2009			
	Mean cover (%)	SD	Quad freq	Plot freq	Mean cover (%)	SD	Quad freq	Plot freq	Mean cover (%)	SD	Quad freq	Plot freq
<i>Bouteloua gracilis</i>	3.712	3.512	65.33	80	3.815	3.469	66.67	80	3.248	3.426	64.00	90
<i>Sporobolus airoides</i>	2.622	4.457	44.00	90	2.142	3.54	41.33	70	2.031	2.856	46.00	80
<i>Pleuraphis jamesii</i>	2.589	2.562	75.33	100	2.444	2.68	74.00	100	2.889	3.329	76.00	100
<i>Gutierrezia sarothrae</i>	1.495	0.99	70.67	90	1.225	0.651	72.00	90	0.839	0.591	66.00	90
<i>Atriplex canescens</i>	1.085	1.092	43.33	90	0.686	0.651	42.67	90	0.524	0.387	44.00	90
<i>Chrysothamnus Greenei</i>	0.776	1.405	22.00	50	0.980	1.54	24.67	60	0.639	1.053	21.33	60
<i>Artemisia filifolia</i>	0.743	1.551	14.67	30	0.602	1.115	15.33	30	0.331	0.641	14.67	30
<i>Bromus tectorum</i> ^a	0.726	2.198	20.67	60	0.098	0.291	10.00	50	0.001	0.003	2.67	20
<i>Bouteloua eriopoda</i>	0.714	1.735	20.67	60	0.536	1.159	22.00	60	0.572	1.397	15.33	60
<i>Achnatherum hymenoides</i>	0.484	0.685	50.00	90	0.764	1.036	59.33	90	0.698	0.771	56.67	90
<i>Salsola tragus</i> ^a	0.365	0.745	36.67	70	0.632	1.757	27.33	60	0.069	0.188	15.33	30
<i>Artemisia bigelovii</i>	0.363	0.783	13.33	30	0.364	0.833	14.67	40	0.405	0.829	13.33	30
<i>Ephedra torreyana</i>	0.279	0.425	12.00	60	0.306	0.354	11.33	60	0.242	0.340	12.00	60
<i>Hesperostipa comata</i>	0.256	0.403	26.00	60	0.323	0.544	27.33	60	0.377	0.651	22.67	60
<i>Sporobolus flexuosus</i>	0.224	0.694	6.67	20	0.012	0.032	2.00	20	3.248	3.426	64.00	90
<i>Portulaca oleracea</i> ^a	0.002	0.006	0.67	10	0	0	0	0	0	0	0	0
<i>Polygonum aviculare</i> ^a	<.001	0.001	0.67	10	0	0	0	0	0	0	0	0

Note: Species are arranged in descending order by their 2007 cover.

^aNonnative species.

in 2009. Standing dead herbaceous had the lowest cover over the three years in 2008, while standing dead woody increased slightly over the three years.

Dominant grasses included *Bouteloua gracilis* (blue grama), *Sporobolus airoides* (alkali sacaton), and *Pleuraphis jamesii* (James' galleta). Dominant shrubs included *Gutierrezia sarothrae* (broom snake-weed), *Atriplex canescens* (fourwing saltbush), *Chrysothamnus Greenei*, (Greene's rabbitbrush), and *Artemisia filifolia* (sand sagebrush). Foliar cover of individual species differed among the three years, with many decreasing over the three years. Most of these changes, however, were quite small, especially considering the large standard deviations (table 7 and fig. 7). Exceptions included *Bromus tectorum* (cheatgrass) and *Salsola tragus* (prickly Russian thistle).

Quadrat and plot frequencies did not change substantially between years, with the few exceptions of those species which showed large changes in foliar cover. There were 11 unique species in 2007 (not including the unknown), 2 unique species in 2008, and 3 unique species in 2009 (See Appendix B).

We found four nonnative species in the plots over the three years. *Salsola tragus* had its greatest foliar cover in 2008, but declined in both quadrat and plot frequencies over the three years. *Bromus tectorum* declined in foliar cover and frequencies over the three years. *Portulaca oleracea* (little hogweed) occurred only in 2007, in low cover and low frequencies. *Polygonum aviculare* (prostate knotweed)

Table 8. Species diversity metrics for all species and for native species only at the Sandy Loam ecological site

	2007		2008		2009	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
All species						
Plot						
Plot richness	23.6	(5.0)	20.9	(5.7)	16.3	(4.9)
Shannon diversity	1.859	(0.482)	1.789	(0.492)	1.745	(0.499)
Evenness	0.586	(0.125)	0.590	(0.125)	0.635	(0.116)
Ecological site						
Ecological site richness	63		55		40	
Beta diversity	2.788		2.764		2.614	
Native species						
Plot						
Plot richness	22.1	(4.8)	19.7	(5.4)	15.8	(4.8)
Shannon diversity	1.804	(0.493)	1.771	(0.500)	1.728	(0.492)
Evenness	0.581	(0.131)	0.597	(0.123)	0.636	(0.115)
Ecological site						
Ecological site richness	59		52		38	
Beta diversity	2.796		2.781		2.568	

occurred in 2007 and 2008 with low foliar cover and low frequencies. Appendix B lists all species, along with common names, families, mean foliar covers, and plot frequencies by year.

The diversity indices decreased over the three years with the exception of evenness, which increased (table 8). On the scale of the plot, species richness decreased from 23.6 to 16.3 species per plot. Shannon diversity (which takes into account relative species abundance, and generally ranges between 1.5 and 3.5) decreased from 1.859 and 1.745, and evenness (the degree to which all species are of equal abundance, ranging from 0 to 1) increased from 0.586 and 0.635 (Margalef 1972). On the scale of the ecological site, species richness decreased from 63 to 40 species, and beta diversity (a measure of within site heterogeneity, generally ranging between 1 and 5) decreased from 2.788 to 2.614 (McClune and Grace 2002). When these indices were recalculated using only native species, the indices did not change substantially.

Soil stability and hydrologic function

The crew monitored the amount of exposed soil in two ways: cover estimates of soil surface features in quadrats and measurements of basal gaps along transects. These measurements were undertaken in all three years. Undifferentiated crust, bare soil, and duff/litter were the dominant soil surface features. As expected, most changes in the surface features were relatively small (table 9 and fig. 8). Three features, however, showed large variation among years: undifferentiated crust, bare soil, and

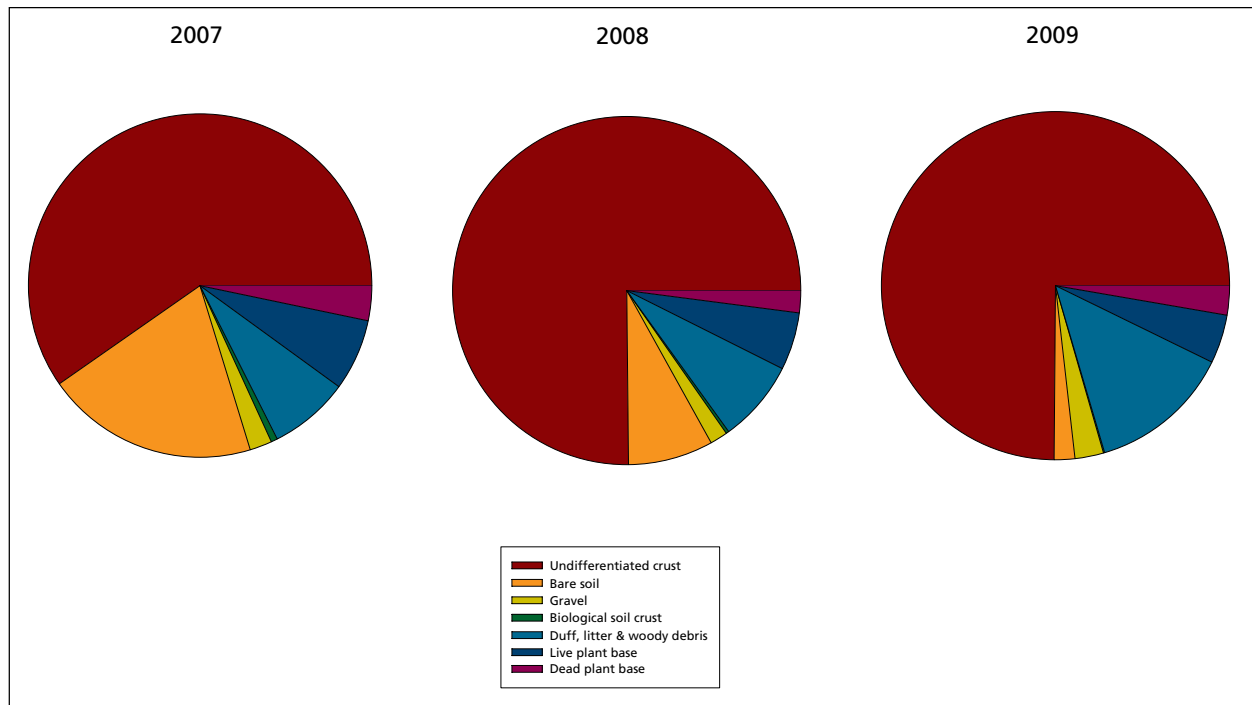


Figure 8. Mean cover of soil surface features at the Sandy Loam ecological site in 2007, 2008, and 2009. Biological soil crusts include moss, lichen, and cyanobacteria.

Table 9. Cover of soil surface features at the Sandy Loam ecological site

Surface feature	2007		2008		2009	
	Mean (%)	(SD)	Mean (%)	(SD)	Mean (%)	(SD)
Live plant base	6.69	(2.74)	7.48	(2.95)	4.47	(2.19)
Dead woody base	0.28	(0.34)	0.40	(0.42)	0.25	(0.23)
Dead herbaceous base	3.00	(1.61)	1.76	(1.19)	2.44	(1.19)
Bare soil	19.91	(20.06)	5.37	(3.30)	1.90	(1.50)
Duff and litter	7.00	(2.31)	8.03	(3.35)	13.07	(4.95)
Undifferentiated crust	59.39	(20.18)	73.07	(8.95)	74.19	(10.13)
Moss	0.10	(0.29)	0.04	(0.10)	0.10	(0.29)
Lichen	0	(0)	0.05	(0.15)	0.00	(0)
Cyanobacteria	0.50	(1.58)	0.01	(0.02)	0.01	(0.02)
Fine gravel (0.2–2 cm)	1.93	(5.82)	2.01	(6.10)	2.60	(7.67)
Coarse gravel (2–7.5 cm)	0.15	(0.45)	0.06	(0.16)	0.03	(0.09)
Cobble (7.5–25 cm)	0	(0)	0	(0)	0	(0)
Stone, bedrock (>25 cm)	0	(0)	0	(0)	0	(0)
Woody debris	0.52	(1.31)	0.05	(0.11)	0.02	(0.03)

Note: The surface feature components do not add up to 100% because the calculations were made from cover class midpoints, and the estimations have observer error.

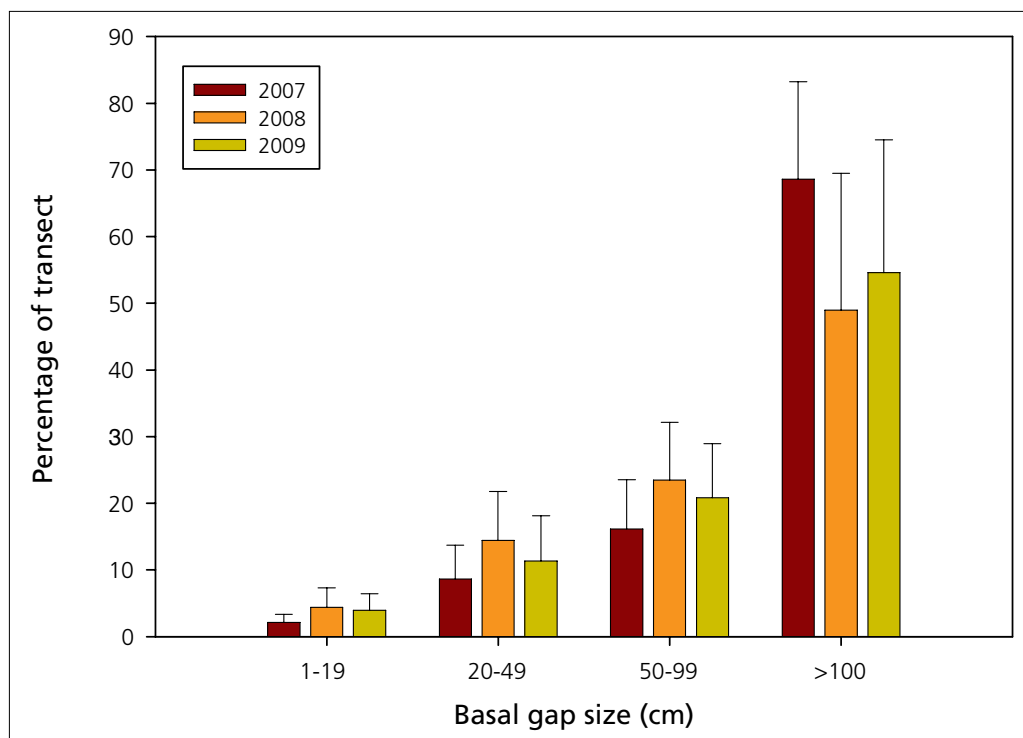


Figure 9. Percentage of transect in different gap sizes in 2007, 2008, and 2009 in the Sandy Loam ecological site. Error bars represent one standard deviation.

Table 10. Number of basal gaps, median gap size, and percentage of transect in different gap size classes in 2007, 2008, and 2009 at the Sandy Loam ecological site

Metric	2007		2008		2009	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Number of gaps	145.5	(51.3)	221.7	(85.9)	194.4	(76.0)
Median gap size (cm)	78.7	(61.2)	49.4	(31.2)	61.0	(45.2)
Percent of transect in gaps 0–19 cm	2.1	(1.2)	4.4	(2.9)	3.9	(2.5)
Percent of transect in gaps 20–49 cm	8.6	(5.1)	14.5	(7.3)	11.4	(6.8)
Percent of transect in gaps 50–99 cm	16.1	(7.4)	23.5	(8.6)	20.9	(8.1)
Percent of transect in gaps ≥100 cm	70.4	(14.6)	48.9	(20.5)	54.6	(20.0)
Percent of transect in gaps	95.5	(1.7)	91.3	(3.1)	90.7	(3.8)
Percent of transect in plant bases	3.7	(1.7)	8.7	(3.1)	2.5	(3.8)

duff/litter. The basal gap data shows that the majority of the transects were occupied by gaps greater than 100 cm. (table 10 and fig. 9). There is substantial among year variation in gap number, the percentage of the transect in gaps in the largest size class, and the median gap size.

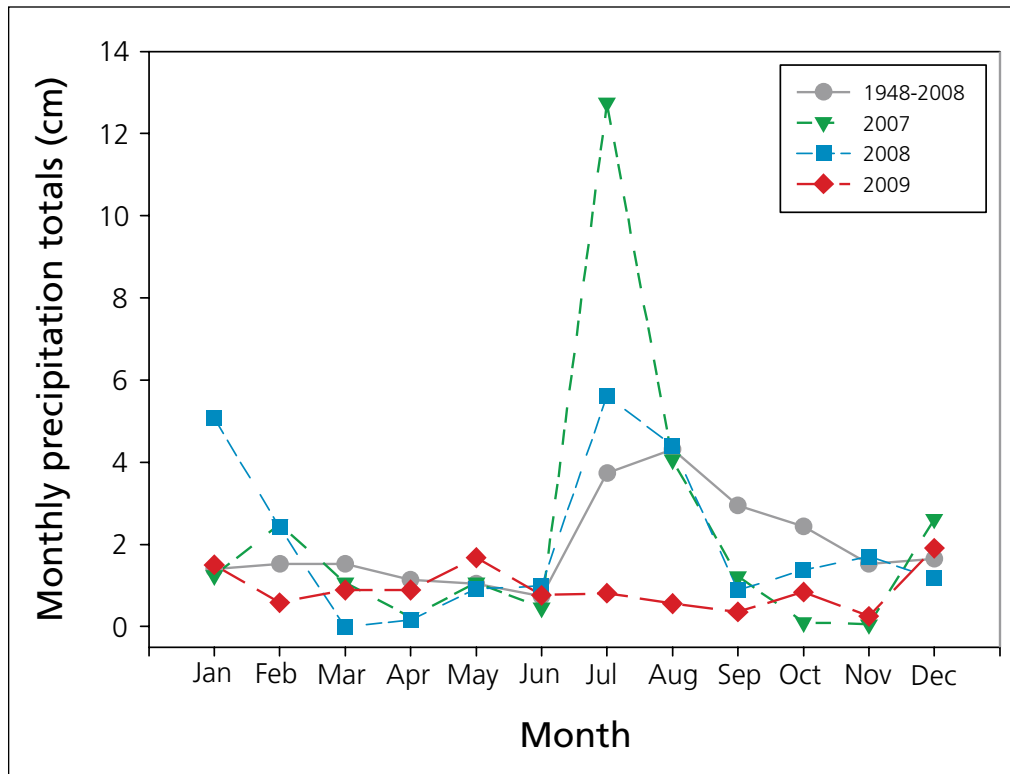


Figure 10. Total monthly precipitation for 2007, 2008, and 2009 with the mean monthly totals for 1948 through 2009 (WRCC 2010)

Discussion

The data presented here indicate moderate variation in the vegetation and surface features on the ecological sites among the years 2007, 2008, and 2009, particularly in the Clayey Fan ecological site. At both ecological sites, the largest variation occurred in the cover of forbs and annual grasses and in both plot and ecological site richness. Functional group and species cover, in addition to most of the diversity metrics demonstrated decreases over the three years, most likely a result of variation in precipitation. 2007 had a very strong summer monsoon, and 2008 had a moderate summer monsoon. 2009, in contrast, was a very dry year where the monthly precipitation exceeded the mean only in May (fig. 10). The timing and the amount of precipitation differentially influences germination, growth, and flowering of species. Annual species and perennial forbs, which are functional groups especially sensitive to precipitation, show the largest among year variation in frequency and cover. The decreases in species richness and in species cover over the three years should therefore be viewed as annual variation.

Cover of soil surface features showed little variation, except undifferentiated crust, bare soil, and duff/litter. The variation in bare soil and undifferentiated crust may be attributable to how soil surface features appear in wet conditions versus dry conditions. When the ground surface is wet, undifferentiated crust becomes more difficult to distinguish from bare soil. In addition, physical crust is formed by raindrop impact and decreases with time since the last rainfall. As a result of the particularly wet August in 2007, many of the plots were sampled during or shortly after precipitation events, which may have made it difficult for the crew to estimate the cover of soil surface features.

We stress that the differences noted between years are not indicative of any trend, since trends cannot be determined with only three years of sampling. Nor should they be interpreted as being eco-

logically significant. Differences are due to ecological variability, such as annual climatic fluctuation, or sampling errors inherent in the field sampling process. Cover estimation may vary among individuals (and crews), species may be mis-identified, slight differences between observers in applying sampling methods may go unnoticed, and the locations of transects and quadrats vary slightly from year to year. We strive to minimize these errors by ensuring that transect lines are as straight as possible, quadrats are placed correctly, and field crews are thoroughly trained on methods and species identification and remain calibrated on cover estimation.

We plan to conduct power analysis using the three years of data, which will help determine the total number of plots necessary to detect change in the key metrics. A temporal sampling design will then be implemented, with the installation of additional plots in subsequent years. Each year's data will be compared to the previously collected data to analyze changes through time in vegetation composition and structure and in soil stability and hydrologic function. Trend analyses will be conducted once sufficient data have been collected.

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Appendix A

Complete species list for the Clayey Fan ecological site with mean foliar cover and frequency for species in 2007, 2008, and 2009. Annual *Chamaesyce* spp. that were not identifiable to species in the field are placed in one of two groups based on leaf morphology.

Species	Common name	Family	2007			2008			2009		
			Foliar cover (%)	Plot frequency (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Plot frequency (%)
<i>Achnatherum hymenoides</i>	Indian ricegrass	Poaceae	0.165	90	90	0.255	90	90	0.346	90	90
<i>Aristida adscensionis</i>	sixweeks threeawn	Poaceae	0	0	0	0.001	10	10	0	0	0
<i>Aristida purpurea</i>	Fendler's threeawn	Poaceae	<0.001	10	10	<0.001	10	<0.001	<0.001	10	10
<i>Artemisia bigelovii</i>	Bigelow sage	Asteraceae	0.002	10	10	0.002	10	10	0.002	10	10
<i>Artemisia filifolia</i>	sand sagebrush	Asteraceae	0.005	10	10	0.010	10	10	0.005	10	10
<i>Astragalus</i> sp.	milkvetch	Fabaceae	0.017	60	60	0.002	40	40	<0.001	10	10
<i>Atriplex canescens</i>	fourwing saltbush	Chenopodiaceae	0.565	50	50	0.529	50	50	0.350	60	60
<i>Atriplex confertifolia</i>	shadscale saltbush	Chenopodiaceae	0.150	40	40	0.081	60	60	0.122	70	70
<i>Atriplex obovata</i>	mound saltbush	Chenopodiaceae	1.589	90	90	1.264	100	100	1.306	90	90
<i>Bouteloua barbata</i>	sixweeks grama	Poaceae	1.062	90	90	0.034	70	70	0	0	0
<i>Bouteloua eriopoda</i>	black grama	Poaceae	0.050	10	10	0.050	10	10	0.010	10	10
<i>Bouteloua gracilis</i>	blue grama	Poaceae	1.210	90	90	1.385	90	90	1.114	90	90
<i>Bromus tectorum</i> ^a	cheatgrass	Poaceae	0.004	40	40	0.001	20	20	0	0	0
<i>Calochortus aureus</i>	golden mariposa lily	Liliaceae	0	0	0	0.001	10	10	0	0	0
<i>Chaetopappa ericoides</i>	rose heath	Asteraceae	0.009	50	50	0.008	50	50	0.005	50	50
<i>Chamaesyce</i> spp. Group A	annual sandmats	Euphorbiaceae	0.196	100	100	0.006	30	30	0	0	0
<i>Chamaesyce</i> spp. Group B	annual sandmats	Euphorbiaceae	0.021	40	40	0	0	0	0	0	0
<i>Chamaesaracha coronopus</i>	greenleaf five eyes	Solanaceae	0.014	30	30	<0.001	10	10	0	0	0
<i>Chenopodium fremontii</i>	Fremont's goosefoot	Chenopodiaceae	0	0	0	<0.001	10	10	0	0	0
<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot	Chenopodiaceae	<0.001	10	10	0	0	0	0	0	0
<i>Cordylanthus wrightii</i>	Wright's bird's beak	Scrophulariaceae	0	0	0	0.002	10	10	0	0	0
<i>Cryptantha</i> sp.	cryptantha	Boraginaceae	0	0	0	0	0	0	<0.001	10	10
<i>Dalea candida</i>	white prairieclover	Fabaceae	0.027	30	30	0.002	10	10	0	0	0
<i>Dimorphocarpa wislizeni</i>	spectacle pod	Brassicaceae	0	0	0	<0.001	10	10	0	0	0

Appendix A continued

Species	Common name	Family	2007		2008		2009	
			Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)
<i>Elymus elymoides</i>	squirreltail	Poaceae	0.006	20	0.020	40	0.019	40
<i>Ephedra cutleri</i>	Cutler's jointfir	Ephedraceae	0.005	10	0.095	20	0.098	20
<i>Ephedra torreyana</i>	Torrey's jointfir	Ephedraceae	0.070	30	0.020	20	0.033	20
<i>Ephedra viridis</i>	mormon tea	Ephedraceae	0.050	10	0.050	10	0.050	10
<i>Eragrostis pectinacea</i>	desert lovegrass	Poaceae	0.031	10	0	0	0	0
<i>Eriastrum diffusum</i>	miniature woollystar	Polemoniaceae	<0.001	10	0	0	0	0
<i>Ericameria nauseosa</i>	rubber rabbitbrush	Asteraceae	0.119	40	0.064	40	0.055	40
<i>Erigeron concinnus</i>	Navajo fleabane	Asteraceae	0.001	10	<0.001	10	0	0
<i>Erigeron divergens</i>	spreading fleabane	Asteraceae	0	0	0.013	50	0	0
<i>Eriogonum</i> sp.	buckwheat	Polygonaceae	0	0	0	0	0.001	20
<i>Eriogonum cernuum</i>	nodding buckwheat	Polygonaceae	0	0	0.001	20	<0.001	10
<i>Eriogonum deflexum</i>	flatcrown buckwheat	Polygonaceae	0.007	40	0.015	30	0.008	10
<i>Eriogonum divaricatum</i>	divergent buckwheat	Polygonaceae	0.006	50	0.002	20	0.002	40
<i>Escobaria vivipara</i>	spiny star	Cactaceae	0	0	<0.001	10	0	0
<i>Gaillardia pinnaefida</i>	red dome blanketflower	Asteraceae	<0.001	10	0	0	0	0
<i>Gutierrezia sarothrae</i>	broom snakeweed	Asteraceae	0.089	40	0.057	50	0.060	50
<i>Hellomeris multiflora</i>	showy goldeneye	Asteraceae	<0.001	10	<0.001	10	0	0
<i>Hesperostipa comata</i>	needle and thread	Poaceae	0	0	0.009	30	0.012	10
<i>Hymenopappus flavescens</i>	college flower	Asteraceae	0.004	10	0	0	0	0
<i>Ipomopsis</i> sp.	Ipomopsis	Polemoniaceae	0.001	20	0	0	0	0
<i>Isocoma drummondii</i>	Drummond's goldenbush	Asteraceae	0.027	20	0.012	20	0.027	20
<i>Krascheninnikovia lanata</i>	winterfat	Chenopodiaceae	0.016	30	0.016	20	0.012	20
<i>Machaeranthera canescens</i>	hoary tansyaster	Asteraceae	0.002	20	<0.001	10	0	0
<i>Mentzelia albicaulis</i>	whitestem blazingstar	Loasaceae	0.002	30	0.002	10	0	0
<i>Monroa squarrosa</i>	false buffalograss	Poaceae	0.030	80	0.005	30	0	0
<i>Muhlenbergia pungens</i>	sandhill muhly	Poaceae	0.009	20	0.008	20	0.012	20
<i>Oenothera</i> sp.	evening primrose	Onagraceae	0.019	40	0.001	10	0	0

Appendix A continued

Species	Common name	Family	2007		2008		2009	
			Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)
<i>Opuntia</i> sp.	prickly pear	Cactaceae	0.011	30	0.006	30	0.009	40
<i>Opuntia whipplei</i>	Whipple's cholla	Cactaceae	0.007	20	0.012	20	0.004	30
<i>Panicum hirticaule</i>	Mexican panicgrass	Poaceae	0.001	10	0	0	0	0
<i>Parryella filifolia</i>	common dunebroom	Fabaceae	0.038	10	0.017	10	0.017	10
<i>Pascopyrum smithii</i>	western wheatgrass	Poaceae	0	0	0	0	0.005	10
<i>Pectis angustifolia</i>	lemonscent	Asteraceae	0.008	20	0.001	20	0	0
<i>Plantago patagonica</i>	woolly plantain	Plantaginaceae	0.030	80	0.002	20	0.001	20
<i>Pleuraphis jamesii</i>	James' galleta	Poaceae	1.266	100	1.713	100	1.237	100
<i>Portulaca oleracea</i> ^a	little hogweed	Portulacaceae	0.044	60	0	0	0	0
<i>Psilostrophe tagetina</i>	woolly paperflower	Asteraceae	0.001	10	<0.001	10	<0.001	10
<i>Salsola tragus</i> ^a	prickly Russian thistle	Chenopodiaceae	0.973	100	0.376	100	0.089	60
<i>Sanvitalia abertii</i>	Albert's creeping zinnia	Asteraceae	0.012	20	0.001	20	0	0
<i>Sarcobatus vermiculatus</i>	greasewood	Chenopodiaceae	0.293	10	0.173	10	0.155	10
<i>Schkuhria multiflora</i>	many-flower false threadleaf	Asteraceae	0.001	20	0	0	0	0
<i>Senecio flaccidus</i>	threadleaf ragwort	Asteraceae	0.004	10	0.004	10	0.002	10
<i>Senecio spartioides</i>	broomlike ragwort	Asteraceae	0	0	0	0	0.002	10
<i>Sphaeralcea hastulata</i>	spear globemallow	Malvaceae	0.069	90	0.027	80	0.007	50
<i>Sporobolus airoides</i>	alkali sacaton	Poaceae	6.181	100	3.902	100	3.895	100
<i>Sporobolus contractus</i>	spike dropseed	Poaceae	0.056	30	0.022	10	0	0
<i>Sporobolus coromandelianus</i>	Madagascar dropseed	Poaceae	1.251	80	0.039	50	0	0
<i>Sporobolus cryptandrus</i>	sand dropseed	Poaceae	0.008	40	0.014	50	0.062	10
<i>Sporobolus flexuosus</i>	mesa dropseed	Poaceae	0.020	20	0.222	30	0.029	10
<i>Thelesperma megapotamicum</i>	Hopi tea greenthread	Asteraceae	<0.001	10	0	0	0	0
<i>Vulpia octoflora</i>	sixweeks fescue	Poaceae	0.005	40	0	0	0.001	20
<i>Yucca angustissima</i>	narrowleaf yucca	Agavaceae	0.009	40	0.007	50	0.009	40

Appendix A continued

Species	Common name	Family	2007		2008		2009	
			Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)
Unknown 09172007-1			<0.001	10	0	0	0	0
Unknown 09272007-2			0.007	10	0	0	0	0
Unknown 10012007-1			0.000	10	0	0	0	0
Unknown 10022007-2			0.002	10	0	0	0	0
Unknown 10022007-3			0.000	10	0	0	0	0
Unknown 10042007-2			0.001	10	0	0	0	0
Unknown 10212008-1			0	0	0.003	10	0	0

^a Nonnative species

Appendix B

Complete species list at the Sandy Loam ecological site with mean foliar cover and frequency for species in 2007, 2008, and 2009. Annual *Chamaesyce* spp. that were not identifiable to species in the field are placed in one of two groups based on leaf morphology.

Species	Common name	Family	2007		2008		2009	
			Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)
<i>Achnatherum hymenoides</i>	Indian ricegrass	Poaceae	0.484	90	0.764	90	0.698	90
<i>Amaranthus</i> sp.	pigweed	Amaranthaceae	0.000	10	0	0	0	0
<i>Aristida purpurea</i>	Fendler's threeawn	Poaceae	0.040	40	0.052	50	0.054	50
<i>Artemisia bigelovii</i>	Bigelow sage	Asteraceae	0.363	30	0.364	40	0.405	30
<i>Artemisia filifolia</i>	sand sagebrush	Asteraceae	0.743	30	0.602	30	0.331	30
<i>Asclepias subverticillata</i>	western whorled milkweed	Asclepiadaceae	<0.001	10	<0.001	10	0	0
<i>Astragalus</i> sp.	milkvetch	Fabaceae	0.004	50	<0.001	10	0	0
<i>Atriplex canescens</i>	fourwing saltbush	Chenopodiaceae	1.085	90	0.686	90	0.524	90
<i>Atriplex confertifolia</i>	shadscale saltbush	Chenopodiaceae	0.096	20	0.194	20	0.074	20
<i>Atriplex obovata</i>	mound saltbush	Chenopodiaceae	0.224	10	0.144	10	0.232	10
<i>Bouteloua barbata</i>	sixweeks grama	Poaceae	0.005	20	0.001	20	0	0
<i>Bouteloua eriopoda</i>	black grama	Poaceae	0.714	60	0.536	60	0.572	60
<i>Bouteloua gracilis</i>	blue grama	Poaceae	3.712	80	3.815	80	3.248	90
<i>Bromus tectorum</i> ^a	cheatgrass	Poaceae	0.726	60	0.098	50	0.001	20
<i>Chaetopappa ericoides</i>	rose heath	Asteraceae	0.093	90	0.073	90	0.041	80
<i>Chamaesaracha coronopus</i>	greenleaf five eyes	Solanaceae	0.001	10	0	0	0	0
<i>Chamaesyce</i> spp. Group A	annual sandmats	Euphorbiaceae	0.042	80	0.001	20	0	0
<i>Chamaesyce</i> spp. Group B	annual sandmats	Euphorbiaceae	0.010	50	0.001	20	0	0
<i>Chamaesyce</i> sp.	sandmat	Euphorbiaceae	0	0	0	0	<0.001	10
<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot	Chenopodiaceae	0.002	10	0	0	0	0
<i>Chrysothamnus Greenei</i>	Greene's rabbitbrush	Asteraceae	0.776	50	0.980	60	0.639	60
<i>Cryptantha</i> sp.	cryptantha	Boraginaceae	0	0	0.001	20	<0.001	10
<i>Dasyochloa pulchella</i>	low woollygrass	Poaceae	0	0	<0.001	10	<0.001	10
<i>Echinocereus triglochidiatus</i>	kingcup cactus	Cactaceae	0	0	0	0	<0.001	10

Appendix B continued

Species	Common name	Family	2007		2008		2009	
			Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)
<i>Ephedra cutleri</i>	Cutler's jointfir	Ephedraceae	0.083	10	0.076	10	0.059	10
<i>Ephedra torreyana</i>	Torrey's jointfir	Ephedraceae	0.279	60	0.306	60	0.242	60
<i>Ericameria nauseosa</i>	rubber rabbitbrush	Asteraceae	0.028	20	0.060	20	0.033	20
<i>Erigeron divergens</i>	spreading fleabane	Asteraceae	0.005	10	<0.001	10	0	0
<i>Eriogonum corymbosum</i>	crispleaf buckwheat	Polygonaceae	0.000	10	0.002	10	0.002	10
<i>Eriogonum ericifolium</i>	Yavapai buckwheat	Polygonaceae	0.002	10	0.002	10	0.002	10
<i>Eriogonum jamesii</i>	James' buckwheat	Polygonaceae	0.002	10	0.002	10	0.002	10
<i>Eriogonum leptoclodon</i>	sand buckwheat	Polygonaceae	0	0	0.001	20	0	0
<i>Escobaria vivipara</i>	spiny star	Cactaceae	0.002	10	0.002	10	0	0
<i>Evolvulus nuttallianus</i>	shaggy dwarf morning-glory	Convolvulaceae	0.011	20	0.006	20	<0.001	10
<i>Gutierrezia sarothrae</i>	broom snakeweed	Asteraceae	1.495	90	1.225	90	0.839	90
<i>Hesperostipa comata</i>	needle and thread	Poaceae	0.256	60	0.323	60	0.377	60
<i>Hymenopappus flavescens</i>	college flower	Asteraceae'	0.003	20	0	0	0	0
<i>Ipomopsis longiflora</i>	whiteflower ipomopsis	Polemoniaceae	0.050	50	0.009	30	0	0
<i>Krascheninnikovia lanata</i>	winterfat	Chenopodiaceae	0.091	50	0.097	50	0.113	50
<i>Machaeranthera canescens</i>	hoary tansyaster	Asteraceae	0.015	20	0.003	30	<0.001	10
<i>Machaeranthera gracilis</i>	slender goldenweed	Asteraceae	<0.001	10	0	0	0	0
<i>Mentzelia albicaulis</i>	whitestem blazingstar	Loasaceae	0.002	10	0	0	0	0
<i>Monroa squarrosa</i>	false buffalograss	Poaceae	0.019	40	<0.001	10	0	0
<i>Muhlenbergia pungens</i>	sandhill muhly	Poaceae	0.038	20	0.032	20	0.035	20
<i>Muhlenbergia torreyi</i>	ring muhly	Poaceae	0.069	60	0.046	60	0.077	60
<i>Oenothera caespitosa</i>	tufted evening-primrose	Onagraceae	0.002	10	0	0	0	0
<i>Opuntia</i> sp.	prickly pear	Cactaceae	0.022	60	0.012	60	0.009	50
<i>Opuntia whipplei</i>	Whipple's cholla	Cactaceae	0.085	60	0.081	70	0.075	50
<i>Plantago patagonica</i>	woolly plantain	Plantaginaceae	0.035	80	0.004	30	0	0
<i>Pleuraphis jamesii</i>	James' galleta	Poaceae	2.589	100	2.444	100	2.889	100

Appendix B continued

Species	Common name	Family	2007		2008		2009	
			Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)	Foliar cover (%)	Plot frequency (%)
<i>Portulaca oleracea</i> ^a	little hogweed	Portulacaceae	0.002	10	0	0	0	0
<i>Salsola tragus</i> ^a	prickly Russian thistle	Chenopodiaceae	0.365	70	0.632	60	0.069	30
<i>Schkuhria multiflora</i>	many-flower false threadleaf	Asteraceae	<0.001	10	0	0	0	0
<i>Senecio flaccidus</i>	threadleaf ragwort	Asteraceae	<0.001	10	0	0	0	0
<i>Sisymbrium altissimum</i>	tumblemustard	Brassicaceae	0	0	<0.001	10	0	0
<i>Sphaeralcea hastulata</i>	spear globemallow	Malvaceae	0.142	70	0.073	80	0.006	40
<i>Sporobolus</i> spp.	dropseed	Poaceae	0	0	0	0	0.006	20
<i>Sporobolus airoides</i>	alkali sacaton	Poaceae	2.622	90	2.142	70	2.031	80
<i>Sporobolus contractus</i>	spike dropseed	Poaceae	0.039	10	0.033	20	0	0
<i>Sporobolus coromandelianus</i>	Madagascar dropseed	Poaceae	0.036	20	0.001	10	0	0
<i>Sporobolus cryptandrus</i>	sand dropseed	Poaceae	0.035	10	0.152	60	0	0
<i>Sporobolus flexuosus</i>	mesa dropseed	Poaceae	0.224	20	0.012	20	0	0
<i>Verbena bracteata</i>	bigbract verbena	Verbenaceae	0.023	10	0.002	10	0	0
<i>Vulpia octoflora</i>	sixweeks fescue	Poaceae	0.018	70	0	0	0	0
<i>Yucca angustissima</i>	narrowleaf yucca	Agavaceae	0.036	50	0.028	40	0.038	50
<i>Yucca baccata</i>	banana yucca	Agavaceae	0.002	10	0.002	10	0.005	10
<i>Zinnia grandiflora</i>	Rocky Mountain zinnia	Asteraceae	0.085	30	0.026	30	0.015	30
Unknown 09122007-2			0.000	10	0	0	0	0

^a Nonnative species