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Vegetation and Substrate on Aeolian Landscapes in the Colorado River Corridor, Cataract Canyon, Utah

Open-File Report 2010-1273

U.S. Department of the Interior

U.S. Geological Survey

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By Amy E. Draut and Elizabeth R. Gillette

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Suggested citation:
Draut, A.E., and Gillette, E.R., 2010, Vegetation and substrate on aeolian landscapes in the Colorado River corridor, Cataract Canyon, Utah: U.S. Geological Survey Open-File Report 2010-1273, 61 p. and 14 spreadsheets [http://pub.usgs.gov/of/2010/1273/].

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Vegetation and Substrate on Aeolian Landscapes in the Colorado River Corridor, Cataract Canyon, Utah

By Amy E. Draut[1] and Elizabeth R. Gillette[2]

Abstract

Vegetation and substrate data presented in this report characterize ground cover on aeolian landscapes of the Colorado River corridor through Cataract Canyon, Utah, in Canyonlands National Park. The 27-km-long Cataract Canyon reach has undergone less anthropogenic alteration than other reaches of the mainstem Colorado River. Characterizing ecosystem parameters there provides a basis against which to evaluate future changes, such as those that could result from the further spread of nonnative plant species or increased visitor use. Upstream dams have less effect on the hydrology and sediment supply in Cataract Canyon compared with downstream reaches in Grand Canyon National Park. For this reason, comparison of these vegetation and substrate measurements with similar data from aeolian landscapes of Grand Canyon will help to resolve the effects of Glen Canyon Dam operations on the Colorado River corridor ecosystem.

Introduction

Most areas of the Colorado River corridor, in the southwestern United States, are affected by human-caused alteration, whether from changes in river flow and sediment supply caused by upstream dams, from introduced plant and animal species, or from land use in the watershed that includes

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agricultural and rangeland practices. The 27-km reach of the Colorado River corridor through Cataract Canyon, Utah (fig. 1), represents the least altered region along the mainstem Colorado River below its confluence with the major Green River tributary. Because its hydrology and sediment supply are less affected by upstream dams than are any reaches of the Colorado River farther downstream, and because the immediately surrounding watershed is nearly undeveloped as part of Canyonlands National Park, Cataract Canyon provides an opportunity to study natural resources in an ecosystem less disturbed than in many other parts of the Colorado River corridor. This field study quantified ground cover (vegetation and substrate) on landscapes of Cataract Canyon that are characterized by aeolian (wind-blown) sand.

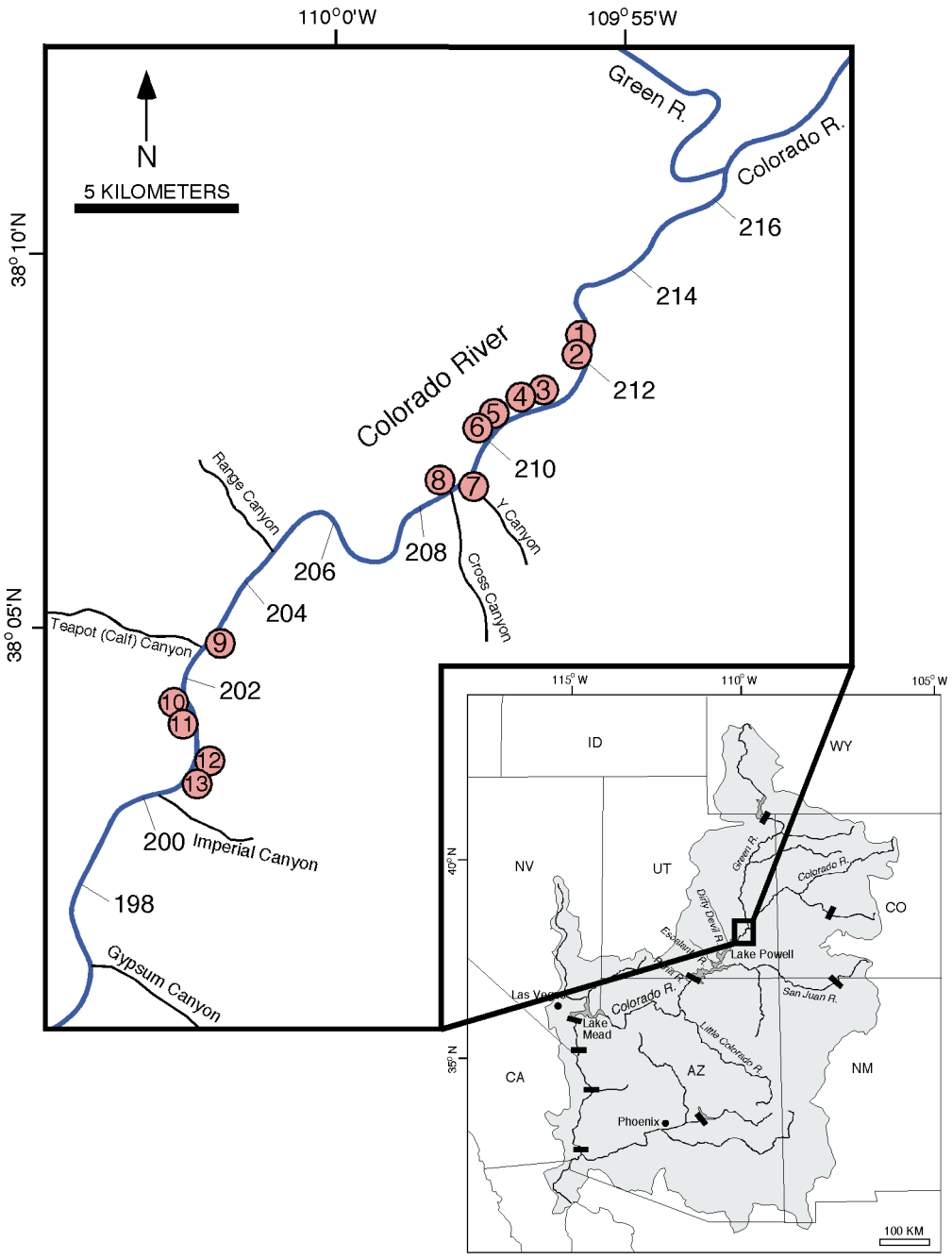

Figure 1. Study sites (numbered circles) in the Colorado River corridor through Cataract Canyon, Utah. Site descriptions are given in table 1. River miles of Belknap and others (2008) are shown. Inset map shows Cataract Canyon (box) in the context of the Colorado River basin (shaded region). Major dams of the Colorado River and its tributaries are shown as black bars on the inset map.

Project Objectives

The objective of this field study was to measure vegetation and substrate properties in aeolian dune fields within the Colorado River corridor through Cataract Canyon, Canyonlands National Park. Vegetative cover, native and nonnative species assemblages, and substrate composition including biologic crust extent are described in this report to further the ecosystem-monitoring efforts undertaken by Canyonlands National Park. These data will also be compared, in a separate publication, with ground-cover measurements made on aeolian landscapes of the Colorado River corridor in Grand Canyon National Park, a reach of the river affected substantially by flow regulation and sediment-supply limitations owing to Glen Canyon Dam operations.

This work in Cataract Canyon, upstream of Glen Canyon Dam and its reservoir, Lake Powell, constitutes part of a larger study of the effects of Glen Canyon Dam on the Colorado River corridor. Previous studies have shown that Glen Canyon Dam operations substantially reduced the size and number of fluvial sand deposits in Grand Canyon (Kearsley and others, 1994; Rubin and others, 2002; Wright and others, 2005; Hazel and others, 2006). Because fluvial sandbars are the primary source for sand that moves inland by wind and forms aeolian dune fields, the loss of fluvial sand, in turn, can reduce the supply of wind-blown sediment to aeolian dune fields downwind (Neal and others, 2000; Draut and Rubin, 2008; Draut and others, 2008, 2010) with possible consequences for ecosystems in those aeolian landscapes. To assess the degree to which sediment-supply limitation in Grand Canyon has affected conditions in aeolian landscapes there, it will therefore be informative to compare vegetation and substrate in aeolian dunes of Grand Canyon with those of Cataract Canyon, where hydrology and sediment supply more closely resemble natural conditions (see, for example, an earlier comparative geomorphic study by Thompson and Potochnik, 2000).

Methods

This study focused on the Cataract Canyon reach of the Colorado River corridor in Canyonlands National Park, between the confluence of the Green and Colorado Rivers and the recent upstream extent of Lake Powell in the area of Imperial Canyon (fig. 1). Vegetation cover (percent cover and vegetation type) and substrate were measured at 13 sites during July 2010. Study sites were chosen within landscapes dominated by aeolian geomorphology, above and within 100 m of the highest elevation of recent fluvial sand deposition. The peak stage of the spring flood in June 2010 (1,530 m^3/s) was readily identifiable by the presence of driftwood, vegetation debris in wrack lines, and sandbar morphology that commonly formed separation and reattachment bars associated with eddies (Schmidt, 1990). On the basis of aeolian landforms (sand dunes, coppice dunes, and sand shadows behind rocks and vegetation), erosion, transport, and deposition by wind appeared to have been the dominant sedimentary processes recently affecting the study sites. The source of aeolian sediment at the study sites was inferred to have been a combination of new sand recently transported inland from spring flood deposits situated at lower elevation and upwind of the sites and wind reworking of sediment from older, larger flood deposits that underlie the sites (known from the presence of old driftwood logs and flood debris inland of most study sites).

Table 1 lists site numbers, names, locations, and descriptions. At Sites 1, 3, 5, and 12, ground cover appeared to be affected somewhat by camping activity, such as the presence of tent sites (Sites 1, 3, and 5) or a trail (Site 12). Sites 3 and 4 were established in the same dune field, one (Site 3) in an area affected by camp activity and the other (Site 4) apparently unaffected. Sites 5 and 6, similarly, represent camp and noncamp areas within one dune field. Although areas affected by camping activity cannot be

considered to have entirely natural conditions, they were included in this study in order to represent the range of ground cover in Cataract Canyon's aeolian landscapes as completely as possible.

Vegetation and substrate were measured at each site by establishing a layout of circles and linear transects referred to here as a "pod." As shown in figure 2, each pod consisted of two orthogonal transects marked out with a tape reel (one oriented upstream-to-downstream and the other oriented inland-to-riverward) and five circles outlined in the sand (one in the center of the pod and one at the end of each of the four transects). At study sites within small dune fields, the pods used transects 20 m long, whereas in larger dune fields the pods used transects 40 m long (table 1). For both the smaller (20 x 20 m) and larger (40 x 40 m) pod size, the five circles were always the same size, having a 3-m radius (fig. 2).

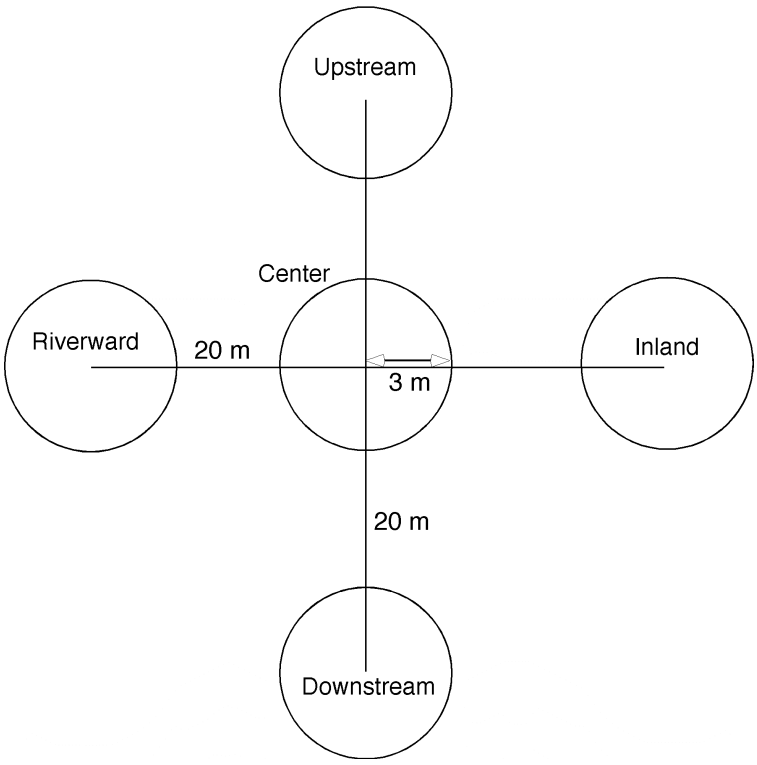

Figure 2. Scale diagram of "pod" configuration used to map vegetation and substrate in Cataract Canyon. Two transects of length 20 m and five circles of radius 3 m were used in small dune fields (as shown here). In study

sites with larger dune fields, the pod configuration included two transects of length 40 m and five circles of radius 3 m.

Along each of the transects within a pod, we measured the lengths of all gaps where the measuring tape crossed bare, open sand without rocks, biologic crust, leaf litter, or overhanging plant canopy. This method was modified from Herrick and others (2005), using their criteria to define plant canopy gaps, as a means to measure the spacing and abundance of roughness elements, vegetation, and patches of biologic crust that affect aeolian sediment mobility (Ash and Wasson, 1983; Buckley, 1987; Leys and Eldridge, 1998; Belnap, 2003; Goossens, 2004). The proportion of bare, open sand in the dune field can thus be estimated by adding all of the measured gap lengths from each transect to compile a cumulative gap length measurement and representing that total gap length as a percentage of the total transect length.

Within each of the five circles per pod, we measured the proportion of space occupied by vegetation (categorized at the species level wherever possible) and various types of substrate in which vegetation was growing. Substrate was considered in four categories: open sand, biologic soil crust, leaf litter (including driftwood, at some sites), and rock (fig. 3). We did not distinguish among the different species of biologic crust known to occur in Cataract Canyon (Webb and others, 2004). To estimate percent coverage, we compared a disc of known size with the area covered by a plant, rock, patch of soil crust, or other object of interest. The disc (radius 20 cm) has an area (0.13 m^2) approximately half of one percent of the circle size studied (28.3 m^2). By holding a disc of known radius above plants or crust cover to gage their size and percent coverage, we avoided disturbing the ground surface unnecessarily as would happen from handling plants or placing measuring devices (such as plastic grids) directly on sensitive, soil-encrusted ground. Field sites were photographed, transect orientations were measured

with a compass, and recent dominant wind directions were estimated by using compass measurements of dune slipface and sand-shadow orientations (table 1). All equipment was removed when the work was completed at each site.

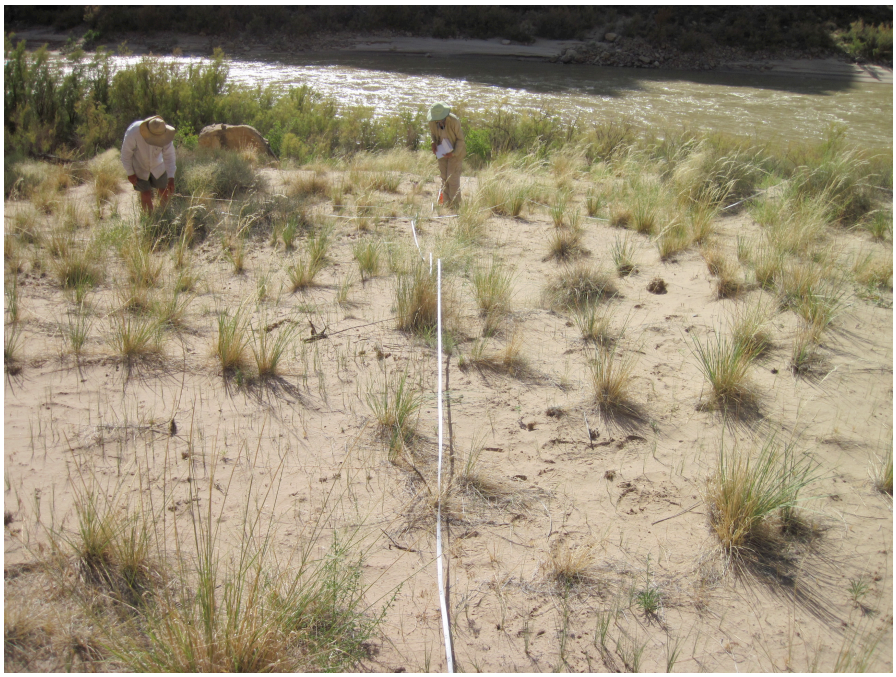

Figure 3. Measuring vegetation and substrate properties on an aeolian landscape in Cataract Canyon (Site 13), summer 2010.

Results and Discussion

Tables 2–14 list vegetation and substrate properties measured at the 13 Cataract Canyon study sites. Vegetation was identified to species level wherever possible, using names and descriptions given by Taylor (1992), Williams (2000), and Huisinga and others (2006). In cases where species

identification was unclear, plants were identified by their family or genus, or by designation as annual or perennial grass, forb, or shrub.

Figure 4 summarizes vegetation cover. Sites where camping activity was apparent did not have substantially different vegetation coverage from study sites without camping activity (median vegetation coverage was 20.2 percent among the 4 sites with camp activity, compared with a median value of 23.1 percent for the noncamp sites and 22.4 percent for all 13 sites). The sites with camp activity had more open, bare sand than was characteristic of most noncamp study sites, judging from differences in total gap length (fig. 5). Median total gap length among the 4 sites with evidence of camp use was 78.7 percent, compared with 66.0 percent among the 9 noncamp sites and 68.8 percent for all 13 sites. Differences in the amount of open sand between sites with and without camp activity are largely attributable to differences in biologic crust coverage. As a group, the sites used as camps had less biologic crust than noncamp areas (fig. 6), with lower median values (1.53 percent for the sites with camp activity compared to 2.80 percent for sites without camp activity) and a much lower maximum extent (4.00 percent among the sites with camp activity compared to 37.4 percent among the noncamp sites; fig. 6). Notably, the site with the most biologic crust (Site 6) is only a short distance away from an area used as a camp, with the center of the Site 6 pod being 50 m inland of the recent spring high-water line near a large camp. Apart from one prominent trail (not near the study pod), visitor use apparently had not disturbed areas with abundant biologic soil crust a short distance away from the camp at Site 6. Substrate composition at all 13 study sites is shown in figure 7.

Diverse vegetation assemblages were recorded at the study sites, with most aeolian landscapes containing between 10 and 20 different species. Among the native plant varieties, perennial bunch-grasses such as rice grass (*Oryzopsis hymenoides*, also known as genus *Achnatherum* or *Stipa*) and several species of dropseed (*Sporobolus*) were common, as were *Ephedra* shrubs, wire lettuce

(*Stephanomeria pauciflora*), snakeweed (*Gutierrezzia* sp.), forbs such as sand verbena (*Abronia elliptica*), dicoria (*Dicoria canescens*), and globemallow (*Sphaeralcea* sp.), and several members of the *Asteraceae/Compositae* family.

Every site contained at least one nonnative plant variety within the study pod. The three nonnative plants most commonly identified were Russian thistle (tumbleweed, *Salsola*), brome grasses (genus *Bromus*; we did not distinguish among varieties such as cheat grass, ripgut brome, and brown brome), and tamarisk trees (*Tamarix*). Each of these is able to spread rapidly and is considered an invasive plant in southwest desert ecosystems. *Salsola* and *Bromus* are especially adept at colonizing disturbed ground surfaces (D'Antonio and Vitousek, 1992; Belnap and others, 2009). Tamarisk and brome grasses were commonly associated with one another at the Cataract Canyon study sites, with the nonnative brome growing abundantly under tamarisk trees. Nearly all tamarisk had brown leaves and many tamarisk beetles (*Diorhabda elongata*), which land-management agencies introduced between 2005 and 2010 in an effort to curb the spread of tamarisk. Figures 8, 9, and 10 show the total area covered by *Salsola*, *Bromus*, and *Tamarix*, respectively, at the study sites. There do not appear to be substantial differences among sites with camp activity and those without, though the maximum coverage of *Salsola* and *Bromus* was highest at a noncamp site (Site 6). The apparently greater coverage of tamarisk at sites with camp activity (fig. 10) is likely due to both tamarisk and human visitors preferring locations near the river. The smaller number of study sites with camp activity may make it difficult to resolve other patterns in nonnative species prevalence that might exist between camp and noncamp areas. Figure 11 illustrates the proportions of *Salsola*, *Bromus*, and *Tamarix* at each study site relative to all other types of vegetation. In several places those plant varieties account for a substantial proportion of the vegetation community; notably, at Sites 3, 5, and 6, invasive *Salsola*, *Bromus*, and *Tamarix* together make up well over half of the total vegetation (fig. 11).

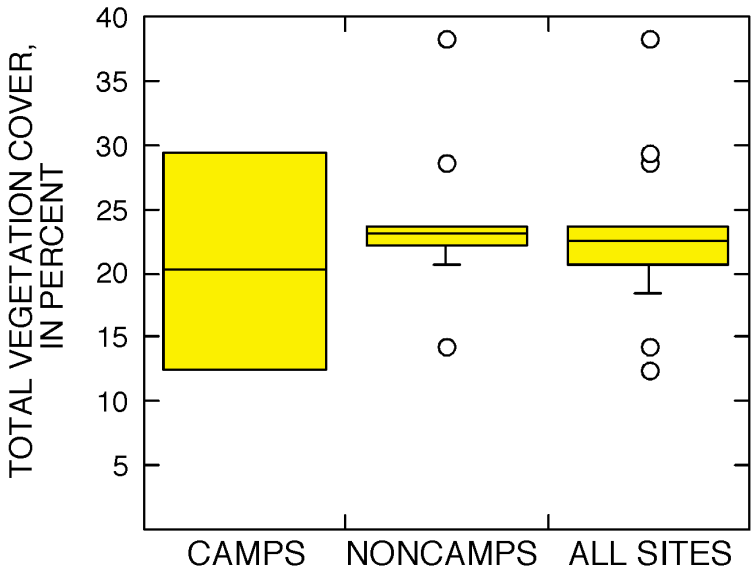

Figure 4. Box-and-whisker plots showing total area of vegetation cover, in percent, for the 4 study sites affected by camping activity (Sites 1, 3, 5, and 12), the 9 noncamp study sites, and all 13 sites combined. Length of each box spans the interquartile range (first quartile to third quartile) of the data; horizontal line through each box represents the median value. Circles mark outlier data points (those more than 1.5 times the interquartile range). Whiskers mark highest and lowest non-outlier data points.

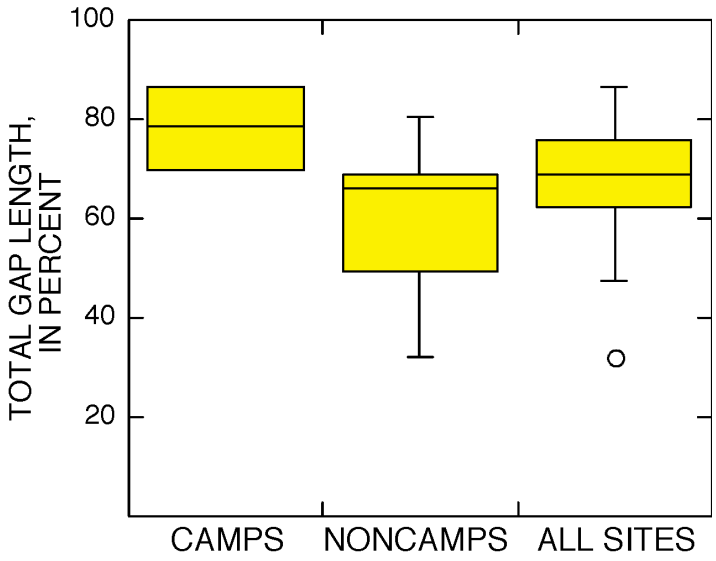

Figure 5. Box-and-whisker plots showing total gap length, as a percent of total transect length, for the 4 study sites affected by camping activity (Sites 1, 3, 5, and 12), the 9 noncamp study sites, and all 13 sites combined.

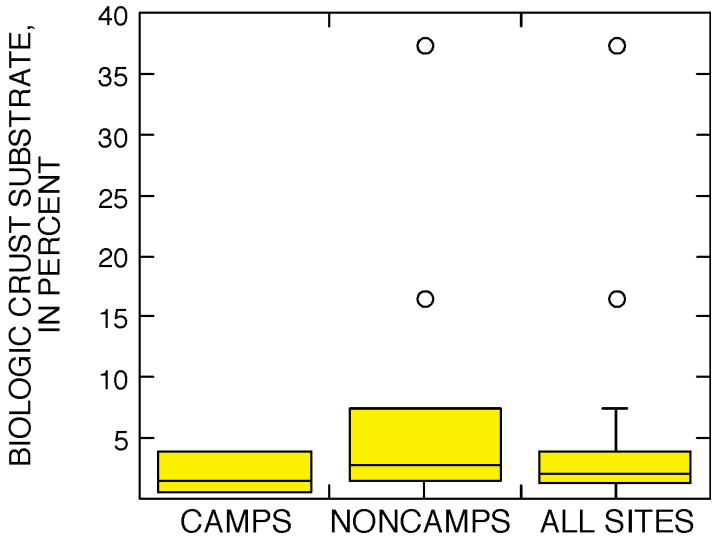

Figure 6. Box-and-whisker plots showing biologic soil crust abundance, as a percent of total substrate, for the 4 study sites affected by camping activity (Sites 1, 3, 5, and 12), the 9 noncamp study sites, and all 13 sites combined.

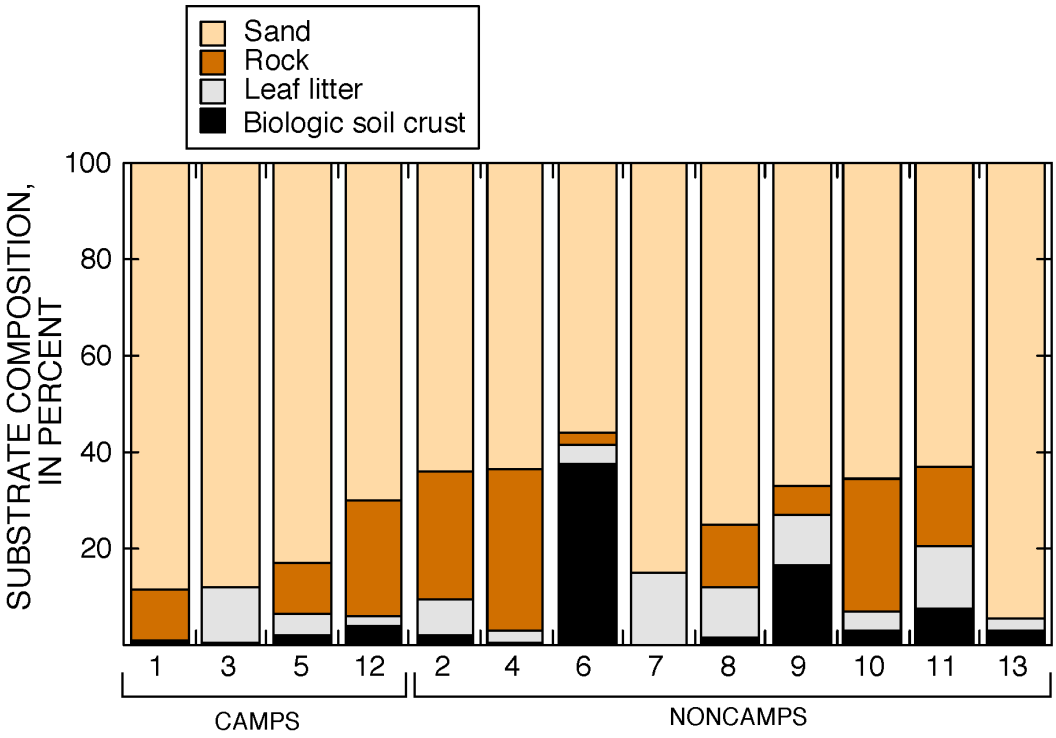

Figure 7. Substrate composition at each of the 13 study sites. Site numbers are listed below columns.

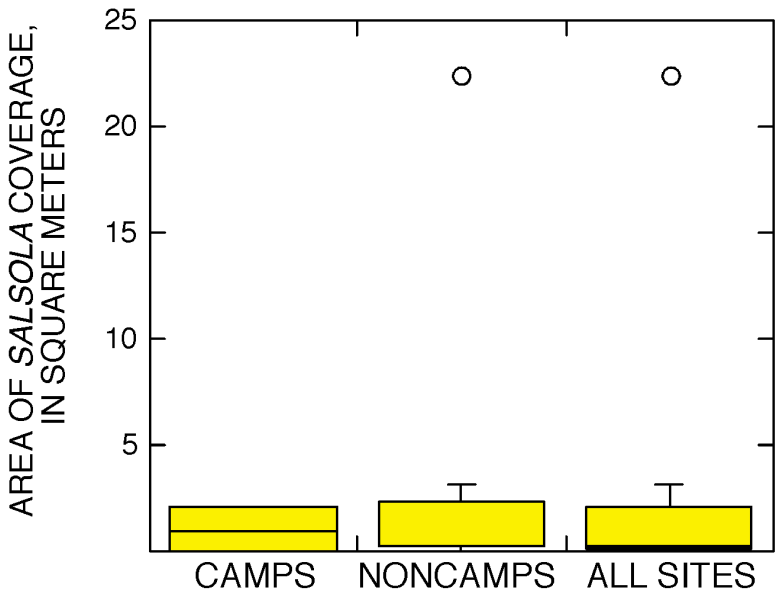

Figure 8. Box-and-whisker plots showing coverage of invasive Russian thistle (*Salsola* sp.) at the 4 study sites affected by camping activity (Sites 1, 3, 5, and 12), the 9 noncamp study sites, and all 13 sites combined.

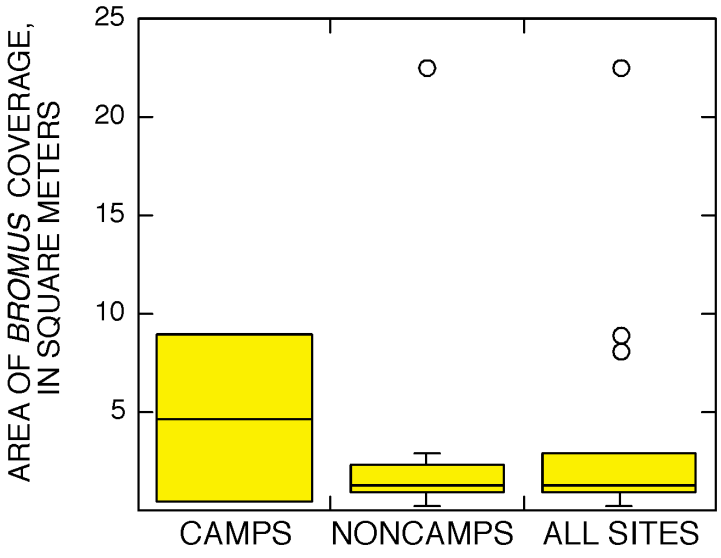

Figure 9. Box-and-whisker plots showing coverage of invasive brome grasses (*Bromus* sp.) at the 4 study sites affected by camping activity (Sites 1, 3, 5, and 12), the 9 noncamp study sites, and all 13 sites combined.

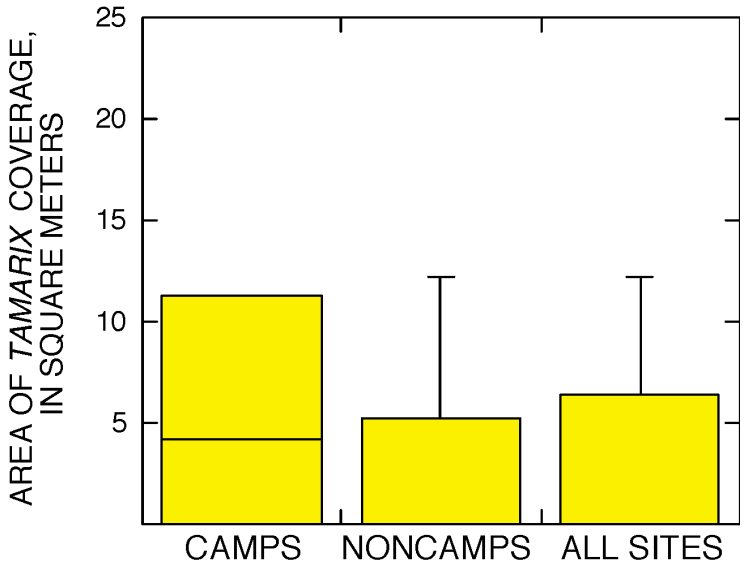

Figure 10. Box-and-whisker plots showing coverage of invasive tamarisk (*Tamarix* sp.) at the 4 study sites affected by camping activity (Sites 1, 3, 5, and 12), the 9 noncamp study sites, and all 13 sites combined.

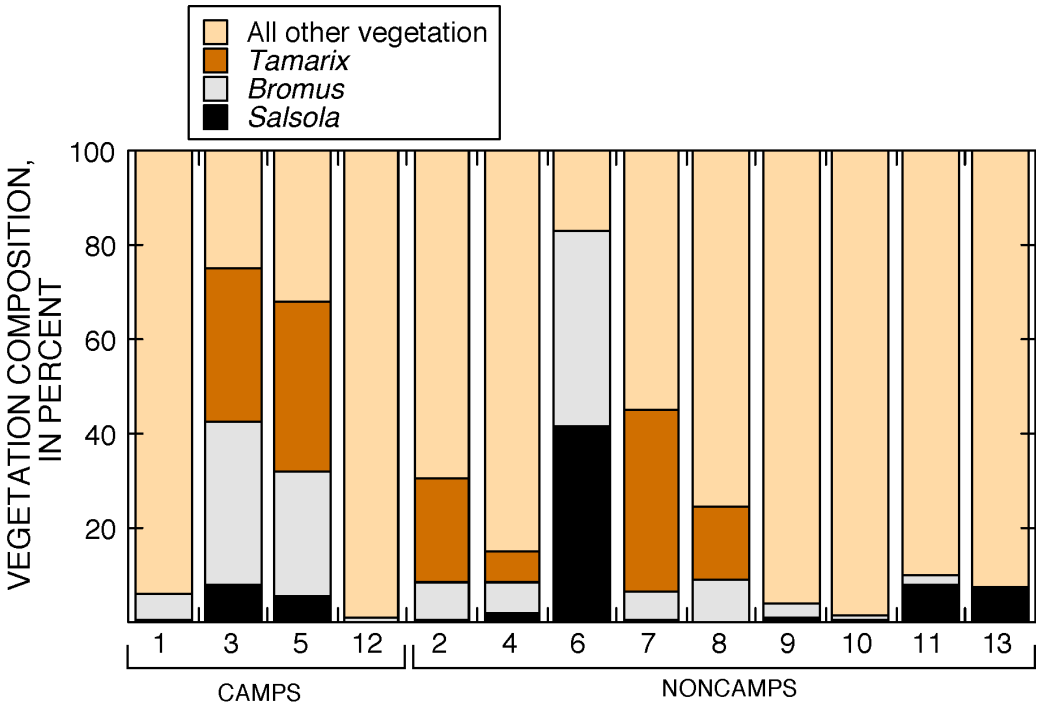

Figure 11. Vegetation composition, in percent areal coverage, at each of the 13 study sites, identifying the proportions of three prominent invasive plant types (*Tamarix*, *Bromus*, and *Salsola*).

Conclusions

Vegetation and substrate data presented here characterize ground cover on aeolian landscapes of the Colorado River corridor through Cataract Canyon, Utah. Some changes to the natural ecosystem likely have resulted from human camping use, notably the lower abundance of biologic soil crust and correspondingly more open, bare sand in dune fields that sustain some camp activity compared to those that do not. Nonnative vegetation was present among the plant communities at each of the 13 study sites. Invasive *Salsola*, *Bromus*, and *Tamarix* now compose a substantial proportion of the plant community in Cataract Canyon's aeolian landscapes.

These data can form a basis against which to evaluate future changes in the Cataract Canyon ecosystem, the least disturbed region of the Colorado River corridor below the confluence with its largest tributary, the Green River. Upstream dams have less effect on the hydrology and sediment supply in Cataract Canyon compared to downstream reaches in Grand Canyon National Park. For this reason, comparison of these vegetation and substrate measurements with similar data from aeolian landscapes of Grand Canyon will help to resolve the effects of Glen Canyon Dam operations on the Colorado River corridor ecosystem.

Acknowledgments

This work was conducted under National Park Service Research and Collecting permit CANY-2010-SCI-0003. The authors thank John Weisheit for providing logistical field support and sharing his greatly detailed knowledge of Cataract Canyon's natural and human history. R.L. Reynolds and C.D. Storlazzi provided constructive review comments that improved this report.

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Table 1. Details of Cataract Canyon study sites.

[Site names refer to the name of the rapid, camp, or side canyon nearest them, and to whether the site is on the left or right side of the river when viewed facing downstream. Wind direction is interpreted to be the recent dominant direction from which the wind came, estimated by measuring azimuth orientations of dune slipfaces and sand shadows behind rocks, vegetation, or other obstacles.]

Site Number	Site Name	Latitude	Longitude	Pod Size	Camp Activity?	Wind Direction
1	Brown Betty, Right	38˚08'52.43"N	109˚55'40.38"W	40 x 40 m	Yes	190–220˚
2	Lower 2, Right	38˚08'40.36"N	109˚55'44.52"W	40 x 40 m	No	149–183˚
3	Rapid 5, Right (camp pod)	38˚08'06.28"N	109˚56'44.99"W	40 x 40 m	Yes	205–224˚
4	Rapid 5, Right (noncamp pod)	38˚08'07.47"N	109˚56'41.25"W	20 x 20 m	No	205–224˚
5	Lower 5, Right (camp pod)	38˚07'56.61"N	109˚57'08.47"W	40 x 40 m	Yes	200–235˚
6	Lower 5, Right (noncamp pod)	38˚07'57.34"N	109˚57'07.75"W	40 x 40 m	No	200–235˚
7	Upper Tilted Park, Left	38˚06'46.23"N	109˚57'53.06"W	40 x 40 m	No	265–274˚
8	Lower Y, Right	38˚06'47.60"N	109˚58'08.96"W	40 x 40 m	No	265–274˚
9	Big Drop Beach, Left	38˚05'00.52"N	110˚02'12.23"W	20 x 20 m	No	240–250˚
10	Upper 25, Right	38˚03'55.84"N	110˚02'40.53"W	20 x 20 m	No	101–165˚
11	Lower 25, Right	38˚03'51.47"N	110˚02'41.78"W	40 x 40 m	No	130–159˚
12	Ten Cent Camp, Left	38˚03'22.50"N	110˚02'33.69"W	20 x 20 m	Yes	175–208˚
13	Lower Ten Cent, Left	38˚03'09.81"N	110˚02'35.80"W	20 x 20 m	No	194–230˚

Table 2. Vegetation cover and substrate measured at Site 1 (Brown Betty, Right).

Center Circle	Vegetation	Percent Cover
	None	
	Total	0

Substrate	Percent Cover
Sand	100
Rock	0
Leaf litter	0
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Netleaf hackberry (*Celtis laevigata*)	17.0
	Snakeweed (*Gutierrezzia* sp.)	3.75
	Broadleaf milkweed (*Asclepias latifolia*)	2.00
	Wire lettuce (*Stephanomeria pauciflora*)	1.75
	Rice grass (*Oryzopsis hymenoides*)	1.75
	Unidentified legume	1.00
	Unidentified annual forb	1.00
	Russian thistle (*Salsola* sp.)	0.13
	Total	28.4

Substrate	Percent Cover
Sand	87.3
Rock	12.5
Leaf litter	0
Biologic soil crust	0.25

Table 2. Vegetation cover and substrate measured at Site 1 (Brown Betty, Right)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Dropseed (*Sporobolus* sp.)	0.75
	Russian thistle (*Salsola* sp.)	0.18
	Brome grasses (*Bromus* sp.)	0.13
	Unidentified annual grass	0.05
	Total	1.10

Substrate	Percent Cover
Sand	90.9
Rock	9.00
Leaf litter	0.10
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Ephedra (*Ephedra* sp.)	25.0
	Brome grasses (*Bromus* sp.)	3.50
	Snakeweed (*Gutierrezzia* sp.)	2.75
	Prince's plume (*Stanleya pinnata*)	1.00
	Bladderpod (*Lesquerella* sp.)	1.00
	Prickly pear (*Opuntia* sp.)	0.10
	Total	33.4

Substrate	Percent Cover
Sand	64.0
Rock	30.0
Leaf litter	0
Biologic soil crust	6.00

Table 2. Vegetation cover and substrate measured at Site 1 (Brown Betty, Right)—Continued.

Riverward Circle	Vegetation	Percent Cover
	None	
	Total	0

Substrate	Percent Cover
Sand	100
Rock	0
Leaf litter	0
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 4,000 cm):	3,283 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	3,240 cm

Summary	
Total vegetation cover, in percent	12.6
Total sand substrate, in percent	88.4
Total rock substrate, in percent	10.3
Total leaf litter substrate, in percent	0.02
Total biologic crust substrate, in percent	1.25
Total gap length, in percent	81.5

Table 3. Vegetation cover and substrate measured at Site 2 (Lower 2, Right).

Center Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	6.63
	Unidentified perennial forb	4.50
	Wire lettuce (*Stephanomeria pauciflora*)	2.90
	Baccharis (*Baccharis salicifolia*)	1.00
	Long-leaf brickellbush (*Brickellia longifolia*)	1.00
	Rice grass (*Oryzopsis hymenoides*), dead	1.00
	Unidentified aster/composite	0.25
	Total	17.3

Substrate	Percent Cover
Sand	90.8
Rock	9.25
Leaf litter	0
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Brome grasses (*Bromus* sp.)	5.00
	Snakeweed (*Gutierrezzia* sp.)	4.50
	Ephedra (*Ephedra* sp.)	3.00
	Unidentified perennial forb	1.50
	Russian thistle (*Salsola* sp.)	0.75
	Rice grass (*Oryzopsis hymenoides*)	0.25
	Unidentified perennial grass	0.06
	Total	15.1

Substrate	Percent Cover
Sand	79.0
Rock	20.0
Leaf litter	1.00
Biologic soil crust	0

Table 3. Vegetation cover and substrate measured at Site 2 (Lower 2, Right)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Alfalfa (*Medicago sativa*)	0.15
	Total	0.15
	Substrate	**Percent Cover**
	Sand	53.0
	Rock	47.0
	Leaf litter	0
	Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Ephedra (*Ephedra* sp.)	22.0
	Unidentified aster/composite	5.00
	Snakeweed (*Gutierrezzia* sp.)	2.00
	Brome grasses (*Bromus* sp.)	1.50
	Bladderpod (*Lesquerella* sp.)	1.25
	Dropseed (*Sporobolus* sp.)	1.00
	Rice grass (*Oryzopsis hymenoides*)	0.75
	Claret cup cactus (*Echinocereus triglochidiatus*)	0.50
	Unidentified grass	0.25
	Netleaf hackberry (*Celtis laevigata*)	0.25
	Total	34.5
	Substrate	**Percent Cover**
	Sand	35.0
	Rock	40.0
	Leaf litter	15.0
	Biologic soil crust	10.0

Table 3. Vegetation cover and substrate measured at Site 2 (Lower 2, Right)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	22.5
	Prince's plume (*Stanleya pinnata*)	7.50
	Snakeweed (*Gutierrezzia* sp.)	4.63
	Brome grasses (*Bromus* sp.)	1.75
	Total	36.4

Substrate	Percent Cover
Sand	61.9
Rock	16.1
Leaf litter	22.0
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 4,000 cm):	2,314 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	1,626 cm

Summary	
Total vegetation cover, in percent	20.7
Total sand substrate, in percent	63.9
Total rock substrate, in percent	26.5
Total leaf litter substrate, in percent	7.60
Total biologic crust substrate, in percent	2.00
Total gap length, in percent	49.3

Table 4. Vegetation cover and substrate measured at Site 3 (Rapid 5, Right, camp pod).

Center Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	18.0
	Russian thistle (*Salsola* sp.)	2.50
	Rice grass (*Oryzopsis hymenoides*)	2.00
	Sand verbena (*Abronia elliptica*)	1.60
	Unidentified aster/composite	0.80
	Brome grasses (*Bromus* sp.)	0.75
	Total	25.7

Substrate	Percent Cover
Sand	78.0
Rock	0
Leaf litter	22.0
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	2.00
	Unidentified aster/composite	1.50
	Sand verbena (*Abronia elliptica*)	1.50
	Brome grasses (*Bromus* sp.)	0.75
	Unidentified perennial forb, dead	0.40
	Russian thistle (*Salsola* sp.)	0.25
	Unidentified perennial forb	0.25
	Total	6.15

Substrate	Percent Cover
Sand	96.8
Rock	0
Leaf litter	0.50
Biologic soil crust	2.75

Table 4. Vegetation cover and substrate measured at Site 3 (Rapid 5, Right, camp pod)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	3.25
	Sand verbena (*Abronia elliptica*)	2.25
	Unidentified aster/composite	2.00
	Dropseed (*Sporobolus* sp.)	1.50
	Spike dropseed (*Sporobolus contractus*)	0.90
	Russian thistle (*Salsola* sp.)	0.75
	Needle-and-thread (*Stipa comata*)	0.75
	Brome grasses (*Bromus* sp.)	0.15
	Total	11.6

Substrate	Percent Cover
Sand	100
Rock	0
Leaf litter	0
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Brome grasses (*Bromus* sp.)	30.0
	Tamarisk (*Tamarix* sp.)	12.0
	Russian thistle (*Salsola* sp.)	3.75
	Rice grass (*Oryzopsis hymenoides*)	0.60
	Unidentified aster/composite	0.50
	Dropseed (*Sporobolus* sp.)	0.25
	Pale evening primrose (*Oenothera pallida*)	0.05
	Total	47.2

Substrate	Percent Cover
Sand	65.0
Rock	0
Leaf litter	35.0
Biologic soil crust	0

Table 4. Vegetation cover and substrate measured at Site 3 (Rapid 5, Right, camp pod)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Willow (*Salix exigua*)	0.75
	Total	0.75

Substrate	Percent Cover
Sand	100
Rock	0
Leaf litter	0
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 4,000 cm):	2,934 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	2,636 cm

Summary	
Total vegetation cover, in percent	18.4
Total sand substrate, in percent	88.0
Total rock substrate, in percent	0
Total leaf litter substrate, in percent	11.5
Total biologic crust substrate, in percent	0.55
Total gap length, in percent	69.6

Table 5. Vegetation cover and substrate measured at Site 4 (Rapid 5, Right, noncamp pod).

Center Circle	Vegetation	Percent Cover
	Unidentified aster/composite	6.13
	Rice grass (*Oryzopsis hymenoides*)	5.88
	Dropseed (*Sporobolus* sp.)	1.00
	Wire lettuce (*Stephanomeria pauciflora*)	0.50
	Unidentified forbs	0.30
	Ephedra (*Ephedra* sp.)	0.25
	Pale evening primrose (*Oenothera pallida*)	0.25
	Russian thistle (*Salsola* sp.)	0.05
	Milkvetch (*Astralagus* sp.)	0.05
	Brome grasses (*Bromus* sp.)	0.05
	Total	14.5

Substrate	Percent Cover
Sand	59.0
Rock	41.0
Leaf litter	0
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Unidentified aster/composite	6.00
	Rice grass (*Oryzopsis hymenoides*)	3.88
	Brome grasses (*Bromus* sp.)	2.65
	Dropseed (*Sporobolus* sp.)	1.25
	Long-leaf brickellbush (*Brickellia longifolia*)	1.00
	Ephedra (*Ephedra* sp.)	0.50
	Milkvetch (*Astralagus* sp.)	0.38
	Wire lettuce (*Stephanomeria pauciflora*)	0.38
	Unidentified forbs	0.25
	Snakeweed (*Gutierrezzia* sp.)	0.25
	Pale evening primrose (*Oenothera pallida*)	0.05
	Total	16.6

Substrate	Percent Cover
Sand	47.0
Rock	52.0
Leaf litter	0
Biologic soil crust	1.00

Table 5. Vegetation cover and substrate measured at Site 4 (Rapid 5, Right, noncamp pod)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	5.00
	Dropseed (*Sporobolus* sp.)	2.50
	Rice grass (*Oryzopsis hymenoides*)	2.00
	Unidentified legume	1.20
	Brome grasses (*Bromus* sp.)	1.00
	Globemallow (*Sphaeralcea* sp.)	0.80
	Russian thistle (*Salsola* sp.)	0.75
	Grama grass (*Bouteloua* sp.)	0.50
	Pale evening primrose (*Oenothera pallida*)	0.15
	Unidentified forb	0.10
	Total	14.0

Substrate	Percent Cover
Sand	67.5
Rock	20.0
Leaf litter	12.0
Biologic soil crust	0.50

Table 5. Vegetation cover and substrate measured at Site 4 (Rapid 5, Right, noncamp pod)—Continued.

Inland Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	3.13
	Unidentified aster/composite	2.75
	Snakeweed (*Gutierrezzia* sp.)	2.75
	Wire lettuce (*Stephanomeria pauciflora*)	2.25
	Dropseed (*Sporobolus* sp.)	1.00
	Unidentified forb	1.00
	Brome grasses (*Bromus* sp.)	0.75
	Long-leaf brickellbush (*Brickellia longifolia*)	0.50
	Pale evening primrose (*Oenothera pallida*)	0.38
	Sand verbena (*Abronia elliptica*)	0.35
	Unidentified perennial grass, dead	0.25
	Milkvetch (*Astralagus* sp.)	0.05
	Total	15.2

Substrate	Percent Cover
Sand	55.3
Rock	42.5
Leaf litter	0
Biologic soil crust	2.25

Table 5. Vegetation cover and substrate measured at Site 4 (Rapid 5, Right, noncamp pod)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Unidentified annual grass	5.13
	Pale evening primrose (*Oenothera pallida*)	2.15
	Dropseed (*Sporobolus* sp.)	2.13
	Rice grass (*Oryzopsis hymenoides*)	1.60
	Russian thistle (*Salsola* sp.)	0.63
	Unidentified forb	0.18
	Brome grasses (*Bromus* sp.)	0.13
	Total	11.9

Substrate	Percent Cover
Sand	89.5
Rock	10.5
Leaf litter	0
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 2,000 cm):	1,062 cm
Total gap length on inland/riverward transect (out of 2,000 cm):	1,439 cm

Summary	
Total vegetation cover, in percent	14.4
Total sand substrate, in percent	63.7
Total rock substrate, in percent	33.2
Total leaf litter substrate, in percent	2.40
Total biologic crust substrate, in percent	0.75
Total gap length, in percent	62.5

Table 6. Vegetation cover and substrate measured at Site 5 (Lower 5, Right, camp pod).

Center Circle	Vegetation	Percent Cover
	Dicoria (*Dicoria canescens*)	9.00
	Russian thistle (*Salsola* sp.)	4.13
	Sand verbena (*Abronia elliptica*)	3.50
	Rice grass (*Oryzopsis hymenoides*)	2.00
	Dropseed (*Sporobolus* sp.)	0.50
	Total	19.1
	Substrate	**Percent Cover**
	Sand	97.0
	Rock	0
	Leaf litter	3.00
	Biologic soil crust	0
Upstream Circle	**Vegetation**	**Percent Cover**
	Tamarisk (*Tamarix* sp.)	25.0
	Brome grasses (*Bromus* sp.)	20.0
	Russian thistle (*Salsola* sp.)	1.50
	Sand verbena (*Abronia elliptica*)	1.00
	Rice grass (*Oryzopsis hymenoides*)	1.00
	Unidentified aster/composite	0.75
	Unidentified perennial grass	0.50
	Needle-and-thread (*Stipa comata*)	0.50
	Dicoria (*Dicoria canescens*)	0.10
	Total	50.4
	Substrate	**Percent Cover**
	Sand	76.5
	Rock	2.50
	Leaf litter	21.0
	Biologic soil crust	0

Table 6. Vegetation cover and substrate measured at Site 5 (Lower 5, Right, camp pod)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	1.13
	Netleaf hackberry (*Celtis laevigata*)	1.00
	Russian thistle (*Salsola* sp.)	0.50
	Unidentified perennial grass	0.50
	Unidentified forb	0.18
	Total	3.30

Substrate	Percent Cover
Sand	65.0
Rock	35.0
Leaf litter	0
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Brome grasses (*Bromus* sp.)	9.00
	Netleaf hackberry (*Celtis laevigata*)	2.75
	Dropseed (*Sporobolus* sp.)	2.50
	Wire lettuce (*Stephanomeria pauciflora*)	1.90
	Desert trumpet (*Eriogonum inflatum)*	1.50
	Globemallow (*Sphaeralcea* sp.)	1.25
	Rice grass (*Oryzopsis hymenoides*)	1.00
	Snakeweed (*Gutierrezzia* sp.)	0.90
	Unidentified aster/composite	0.10
	Russian thistle (*Salsola* sp.)	0.10
	Sand verbena (*Abronia elliptica*)	0.10
	Total	21.1

Substrate	Percent Cover
Sand	78.0
Rock	13.0
Leaf litter	0
Biologic soil crust	9.00

Table 6. Vegetation cover and substrate measured at Site 5 (Lower 5, Right, camp pod)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	15.0
	Unidentified forb	1.00
	Willow (*Salix exigua*)	0.50
	Total	16.5

Substrate	Percent Cover
Sand	99.5
Rock	0
Leaf litter	0.50
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 4,000 cm):	3,488 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	3,447 cm

Summary	
Total vegetation cover, in percent	22.1
Total sand substrate, in percent	83.2
Total rock substrate, in percent	10.1
Total leaf litter substrate, in percent	4.90
Total biologic crust substrate, in percent	1.80
Total gap length, in percent	86.7

Table 7. Vegetation cover and substrate measured at Site 6 (Lower 5, Right, noncamp pod).

Center Circle	Vegetation	Percent Cover
	Brome grasses (*Bromus* sp.)	60.0
	Russian thistle (*Salsola* sp.)	7.00
	Unidentified aster/composite	1.00
	Unidentified perennial forb	1.00
	Needle-and-thread (*Stipa comata*)	1.00
	Total	70.0

Substrate	Percent Cover
Sand	23.6
Rock	0.88
Leaf litter	10.5
Biologic soil crust	65.0

Upstream Circle	Vegetation	Percent Cover
	Russian thistle (*Salsola* sp.)	6.50
	Brome grasses (*Bromus* sp.)	5.50
	Unidentified perennial grass	4.50
	Dropseed (*Sporobolus* sp.)	3.50
	Unidentified perennial forb	1.70
	Unidentified aster/composite	1.00
	Sand verbena (*Abronia elliptica*)	1.00
	Total	23.7

Substrate	Percent Cover
Sand	87.0
Rock	0
Leaf litter	6.00
Biologic soil crust	7.00

Table 7. Vegetation cover and substrate measured at Site 6 (Lower 5, Right, noncamp pod)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Russian thistle (*Salsola* sp.)	4.50
	Spike dropseed (*Sporobolus contractus*)	3.00
	Unidentified aster/composite	2.00
	Brome grasses (*Bromus* sp.)	1.75
	Sand verbena (*Abronia elliptica*)	1.75
	Dropseed (*Sporobolus* sp.)	1.10
	Pale evening primrose (*Oenothera pallida*)	0.75
	Dicoria (*Dicoria canescens*)	0.75
	Unidentified perennial grass	0.50
	Total	16.1

Substrate	Percent Cover
Sand	99.9
Rock	0.10
Leaf litter	0
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Russian thistle (*Salsola* sp.)	16.5
	Brome grasses (*Bromus* sp.)	2.50
	Dropseed (*Sporobolus* sp.)	1.00
	Unidentified aster/composite	0.50
	Total	20.5

Substrate	Percent Cover
Sand	20.0
Rock	10.0
Leaf litter	0
Biologic soil crust	70.0

Table 7. Vegetation cover and substrate measured at Site 6 (Lower 5, Right, noncamp pod)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Russian thistle (*Salsola* sp.)	45.0
	Brome grasses (*Bromus* sp.)	10.0
	Unidentified aster/composite	2.50
	Unidentified perennial grass	2.00
	Dropseed (*Sporobolus* sp.)	1.00
	Needle-and-thread (*Stipa comata*)	1.00
	Unidentified forb	0.10
	Total	61.6

Substrate	Percent Cover
Sand	48.5
Rock	1.50
Leaf litter	5.00
Biologic soil crust	45.0

Total gap length on upstream/downstream transect (out of 4,000 cm):	1,799 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	782 cm

Summary	
Total vegetation cover, in percent	38.4
Total sand substrate, in percent	55.8
Total rock substrate, in percent	2.50
Total leaf litter substrate, in percent	4.30
Total biologic crust substrate, in percent	37.4
Total gap length, in percent	32.3

Table 8. Vegetation cover and substrate measured at Site 7 (Upper Tilted Park, Left).

Center Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	12.5
	Inland saltgrass (*Distichlis spicata*)	3.25
	Unidentified aster/composite	1.25
	Unidentified aster/composite, dead	1.00
	Total	18.0

Substrate	Percent Cover
Sand	98.0
Rock	0
Leaf litter	2.00
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Sand verbena (*Abronia elliptica*)	4.25
	Tamarisk (*Tamarix* sp.)	3.00
	Rice grass (*Oryzopsis hymenoides*)	2.25
	Unidentified forb	2.06
	Brome grasses (*Bromus* sp.)	1.50
	Inland saltgrass (*Distichlis spicata*)	0.25
	Total	13.3

Substrate	Percent Cover
Sand	91.3
Rock	0
Leaf litter	8.75
Biologic soil crust	0

Table 8. Vegetation cover and substrate measured at Site 7 (Upper Tilted Park, Left)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	20.0
	Inland saltgrass (*Distichlis spicata*)	11.8
	Unidentified forb	3.30
	Rice grass (*Oryzopsis hymenoides*)	0.50
	Russian thistle (*Salsola* sp.)	0.50
	Total	36.1

Substrate	Percent Cover
Sand	97.3
Rock	0
Leaf litter	2.75
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	20.0
	Inland saltgrass (*Distichlis spicata*)	8.00
	Brome grasses (*Bromus* sp.)	5.00
	Spike dropseed (*Sporobolus contractus*)	3.50
	Unidentified aster/composite	0.20
	Total	36.7

Substrate	Percent Cover
Sand	40.0
Rock	0
Leaf litter	60.0
Biologic soil crust	0

Table 8. Vegetation cover and substrate measured at Site 7 (Upper Tilted Park, Left)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Willow (*Salix exigua*)	6.50
	Total	6.50

Substrate	Percent Cover
Sand	98.8
Rock	0
Leaf litter	1.25
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 4,000 cm):	3,469 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	2,226 cm

Summary	
Total vegetation cover, in percent	22.1
Total sand substrate, in percent	85.1
Total rock substrate, in percent	0
Total leaf litter substrate, in percent	15.0
Total biologic crust substrate, in percent	0
Total gap length, in percent	71.2

Table 9. Vegetation cover and substrate measured at Site 8 (Lower Y, Right).

Center Circle	Vegetation	Percent Cover
	Willow (*Salix exigua*)	10.0
	Brome grasses (*Bromus* sp.)	6.50
	Snakeweed (*Gutierrezzia* sp.)	4.25
	Unidentified perennial grass	4.00
	Rice grass (*Oryzopsis hymenoides*)	1.75
	Unidentified aster/composite	1.58
	Dropseed (*Sporobolus* sp.)	0.50
	Unidentified forb	0.10
	Total	26.5

Substrate	Percent Cover
Sand	90.3
Rock	1.00
Leaf litter	8.75
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Unidentified perennial grass	10.0
	Rice grass (*Oryzopsis hymenoides*)	4.50
	Tamarisk (*Tamarix* sp.)	3.50
	Dropseed (*Sporobolus* sp.)	2.00
	Cottonwood (*Populus* sp.), dead	1.50
	Unidentified aster/composite	0.25
	Total	21.8

Substrate	Percent Cover
Sand	86.5
Rock	0
Leaf litter	13.5
Biologic soil crust	0

Table 9. Vegetation cover and substrate measured at Site 8 (Lower Y, Right)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Snakeweed (*Gutierrezzia* sp.)	5.50
	Brome grasses (*Bromus* sp.)	2.50
	Unidentified perennial grass, dead	2.00
	Wire lettuce (*Stephanomeria pauciflora*)	1.75
	Unidentified aster/composite	1.00
	Willow (*Salix exigua*)	0.20
	Unidentified perennial grass	0.10
	Total	13.1

Substrate	Percent Cover
Sand	68.5
Rock	30.0
Leaf litter	1.00
Biologic soil crust	0.50

Inland Circle	Vegetation	Percent Cover
	Tamarisk (*Tamarix* sp.)	15.0
	Unidentified perennial grasses	7.50
	Sand verbena (*Abronia elliptica*)	5.50
	Saltbush (*Atriplex* sp.)	4.50
	Rice grass (*Oryzopsis hymenoides*)	2.25
	Brome grasses (*Bromus* sp.)	1.50
	Wire lettuce (*Stephanomeria pauciflora*)	0.70
	Total	37.0

Substrate	Percent Cover
Sand	65.0
Rock	0
Leaf litter	28.0
Biologic soil crust	7.00

Table 9. Vegetation cover and substrate measured at Site 8 (Lower Y, Right)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Unidentified perennial grasses	12.5
	Willow (*Salix exigua*)	5.50
	Unidentified aster/composite	0.50
	Total	18.5

Substrate	Percent Cover
Sand	64.5
Rock	35.0
Leaf litter	0.50
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 4,000 cm):	2,351 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	1,435 cm

Summary	
Total vegetation cover, in percent	23.6
Total sand substrate, in percent	75.0
Total rock substrate, in percent	13.2
Total leaf litter substrate, in percent	10.4
Total biologic crust substrate, in percent	1.50
Total gap length, in percent	47.3

Table 10. Vegetation cover and substrate measured at Site 9 (Big Drop Beach, Left).

Center Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	6.88
	Sand verbena (*Abronia elliptica*)	6.50
	Wire lettuce (*Stephanomeria pauciflora*)	6.50
	Long-leaf brickellbush (*Brickellia longifolia*)	2.00
	Brome grasses (*Bromus* sp.)	0.50
	Russian thistle (*Salsola* sp.)	0.38
	Total	22.8
	Substrate	**Percent Cover**
	Sand	98.5
	Rock	0
	Leaf litter	1.50
	Biologic soil crust	0
Upstream Circle	**Vegetation**	**Percent Cover**
	Rabbitbrush (*Chrysothamnus* sp.)	9.00
	Netleaf hackberry (*Celtis laevigata*)	5.50
	Saltbush (*Atriplex* sp.)	3.00
	Sand verbena (*Abronia elliptica*)	1.70
	Brome grasses (*Bromus* sp.)	1.50
	Dropseed (*Sporobolus* sp.)	0.75
	Total	21.5
	Substrate	**Percent Cover**
	Sand	64.3
	Rock	0.50
	Leaf litter	3.00
	Biologic soil crust	32.2

Table 10. Vegetation cover and substrate measured at Site 9 (Big Drop Beach, Left)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	3.20
	Prince's plume (*Stanleya pinnata*)	2.00
	Wire lettuce (*Stephanomeria pauciflora*)	1.00
	Russian thistle (*Salsola* sp.)	0.55
	Sand verbena (*Abronia elliptica*)	0.15
	Unidentified annual grass	0.10
	Total	7.00

Substrate	Percent Cover
Sand	92.0
Rock	6.00
Leaf litter	2.00
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Rabbitbrush (*Chrysothamnus* sp.)	17.5
	Ephedra (*Ephedra* sp.)	12.5
	Prince's plume (*Stanleya pinnata*)	3.00
	Saltbush (*Atriplex* sp.)	2.50
	Rabbitbrush (*Chrysothamnus* sp.), dead	1.75
	Total	37.3

Substrate	Percent Cover
Sand	3.00
Rock	6.50
Leaf litter	40.0
Biologic soil crust	50.5

Table 10. Vegetation cover and substrate measured at Site 9 (Big Drop Beach, Left)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Long-leaf brickellbush (*Brickellia longifolia*)	16.5
	Wire lettuce (*Stephanomeria pauciflora*)	4.50
	Rice grass (*Oryzopsis hymenoides*)	3.50
	Brome grasses (*Bromus* sp.)	1.50
	Dropseed (*Sporobolus* sp.)	1.00
	Total	27.0

Substrate	Percent Cover
Sand	77.5
Rock	15.5
Leaf litter	7.00
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 2,000 cm):	1,569 cm
Total gap length on inland/riverward transect (out of 2,000 cm):	1,072 cm

Summary	
Total vegetation cover, in percent	23.1
Total sand substrate, in percent	67.1
Total rock substrate, in percent	5.70
Total leaf litter substrate, in percent	10.7
Total biologic crust substrate, in percent	16.5
Total gap length, in percent	66.0

Table 11. Vegetation cover and substrate measured at Site 10 (Upper 25, Right).

Center Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	13.0
	Long-leaf brickellbush (*Brickellia longifolia*)	6.00
	Squawbush (*Rhus* sp.)	5.00
	Snakeweed (*Gutierrezzia* sp.)	3.50
	Wire lettuce (*Stephanomeria pauciflora*)	2.50
	Total	30.0

Substrate	Percent Cover
Sand	84.8
Rock	14.8
Leaf litter	0.50
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Long-leaf brickellbush (*Brickellia longifolia*)	9.00
	Netleaf hackberry (*Celtis laevigata*)	5.00
	Rice grass (*Oryzopsis hymenoides*)	3.50
	Snakeweed (*Gutierrezzia* sp.)	2.75
	Needle-and-thread (*Stipa comata*)	2.00
	Russian thistle (*Salsola* sp.)	0.50
	Total	22.8

Substrate	Percent Cover
Sand	59.9
Rock	40.0
Leaf litter	0.10
Biologic soil crust	0

Table 11. Vegetation cover and substrate measured at Site 10 (Upper 25, Right)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Netleaf hackberry (*Celtis laevigata*)	6.50
	Wire lettuce (*Stephanomeria pauciflora*)	6.00
	Unidenfied perennial forb	5.00
	Rice grass (*Oryzopsis hymenoides*)	3.50
	Needle-and-thread (*Stipa comata*)	1.75
	Snakeweed (*Gutierrezzia* sp.)	1.00
	Unidentified aster/composite	0.50
	Russian thistle (*Salsola* sp.)	0.25
	Total	24.5

Substrate	Percent Cover
Sand	82.4
Rock	11.5
Leaf litter	6.00
Biologic soil crust	0.10

Inland Circle	Vegetation	Percent Cover
	Squawbush (*Rhus* sp.)	18.0
	Needle-and-thread (*Stipa comata*)	13.5
	Brome grasses (*Bromus* sp.)	1.00
	Snakeweed (*Gutierrezzia* sp.)	0.75
	Wire lettuce (*Stephanomeria pauciflora*)	0.40
	Rice grass (*Oryzopsis hymenoides*)	0.30
	Total	34.0

Substrate	Percent Cover
Sand	50.0
Rock	25.0
Leaf litter	10.0
Biologic soil crust	15.0

Table 11. Vegetation cover and substrate measured at Site 10 (Upper 25, Right)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	1.00
	Total	1.00

Substrate	Percent Cover
Sand	51.5
Rock	45.0
Leaf litter	3.50
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 2,000 cm):	1,678 cm
Total gap length on inland/riverward transect (out of 2,000 cm):	1,072 cm

Summary	
Total vegetation cover, in percent	22.4
Total sand substrate, in percent	65.7
Total rock substrate, in percent	27.3
Total leaf litter substrate, in percent	4.02
Total biologic crust substrate, in percent	3.02
Total gap length, in percent	68.8

Table 12. Vegetation cover and substrate measured at Site 11 (Lower 25, Right).

Center Circle	Vegetation	Percent Cover
	Russian thistle (*Salsola sp.*)	6.00
	Sand verbena (*Abronia elliptica*)	4.50
	Unidentified perennial forb	4.00
	Rice grass (*Oryzopsis hymenoides*)	3.50
	Unidentified perennial forb, dead	3.50
	Brome grasses (*Bromus* sp.)	1.50
	Needle-and-thread (*Stipa comata*)	1.50
	Pale evening primrose (*Oenothera pallida*)	0.75
	Total	25.3

Substrate	Percent Cover
Sand	92.9
Rock	0
Leaf litter	7.00
Biologic soil crust	0.10

Upstream Circle	Vegetation	Percent Cover
	Needle-and-thread (*Stipa comata*)	7.50
	Unidentified perennial forb	6.75
	Unidentified shrub, dead	3.00
	Unidentified legume	1.25
	Wire lettuce (*Stephanomeria pauciflora*)	1.00
	Russian thistle (*Salsola* sp.)	0.75
	Rice grass (*Oryzopsis hymenoides*)	0.50
	Unidentified annual grass	0.50
	Dropseed (*Sporobolus* sp.)	0.50
	Sand verbena (*Abronia elliptica*)	0.25
	Unidentified aster/composite	0.10
	Total	14.6

Substrate	Percent Cover
Sand	83.5
Rock	6.50
Leaf litter	0
Biologic soil crust	10.0

Table 12. Vegetation cover and substrate measured at Site 11 (Lower 25, Right)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Unidentified forbs	16.3
	Unidentified perennial forb, dead	7.00
	Russian thistle (*Salsola* sp.)	3.50
	Rice grass (*Oryzopsis hymenoides*)	1.00
	Sand verbena (*Abronia elliptica*)	0.50
	Dropseed (*Sporobolus* sp.)	0.50
	Globemallow (*Sphaeralcea* sp.)	0.25
	Total	29.0

Substrate	Percent Cover
Sand	92.0
Rock	0
Leaf litter	5.50
Biologic soil crust	2.50

Inland Circle	Vegetation	Percent Cover
	Ephedra (*Ephedra* sp.)	55.0
	Rice grass (*Oryzopsis hymenoides*)	1.25
	Brome grasses (*Bromus* sp.)	0.25
	Total	56.5

Substrate	Percent Cover
Sand	10.0
Rock	20.0
Leaf litter	50.0
Biologic soil crust	20.0

Table 12. Vegetation cover and substrate measured at Site 11 (Lower 25, Right)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	3.00
	Unidentified perennial grass	2.50
	Wire lettuce (*Stephanomeria pauciflora*)	1.75
	Brome grasses (*Bromus* sp.)	1.50
	Russian thistle (*Salsola* sp.)	1.00
	Ephedra (*Ephedra* sp.)	0.50
	Globemallow (*Sphaeralcea* sp.)	0.50
	Total	10.8

Substrate	Percent Cover
Sand	37.5
Rock	55.0
Leaf litter	3.00
Biologic soil crust	4.50

Total gap length on upstream/downstream transect (out of 4,000 cm):	2,618 cm
Total gap length on inland/riverward transect (out of 4,000 cm):	2,829 cm

Summary	
Total vegetation cover, in percent	28.7
Total sand substrate, in percent	63.2
Total rock substrate, in percent	16.3
Total leaf litter substrate, in percent	13.1
Total biologic crust substrate, in percent	7.42
Total gap length, in percent	68.1

Table 13. Vegetation cover and substrate measured at Site 12 (Ten Cent Camp, Left).

Center Circle	Vegetation	Percent Cover
	Netleaf hackberry (*Celtis laevigata*)	8.00
	Unidentified perennial forb	7.50
	Wire lettuce (*Stephanomeria pauciflora*)	3.50
	Apache plume (*Fallugia paradoxa*)	2.50
	Rice grass (*Oryzopsis hymenoides*)	1.50
	Unidentified perennial grass	0.50
	Total	23.5

Substrate	Percent Cover
Sand	51.5
Rock	46.0
Leaf litter	2.50
Biologic soil crust	0

Upstream Circle	Vegetation	Percent Cover
	Unidentified perennial forb	10.0
	Apache plume (*Fallugia paradoxa*)	6.00
	Unidentified legume	1.00
	Unidentified aster/composite	0.75
	Rice grass (*Oryzopsis hymenoides*)	0.75
	Netleaf hackberry (*Celtis laevigata*)	0.50
	Wire lettuce (*Stephanomeria pauciflora*)	0.25
	Brome grasses (*Bromus* sp.)	0.25
	Needle-and-thread (*Stipa comata*)	0.20
	Total	19.7

Substrate	Percent Cover
Sand	84.0
Rock	15.0
Leaf litter	1.00
Biologic soil crust	0

Table 13. Vegetation cover and substrate measured at Site 12 (Ten Cent Camp, Left)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Apache plume (*Fallugia paradoxa*)	8.50
	Unidentified shrub	7.00
	Rice grass (*Oryzopsis hymenoides*)	5.00
	Wire lettuce (*Stephanomeria pauciflora*)	5.00
	Unidentified legume	4.00
	Netleaf hackberry (*Celtis laevigata*)	2.75
	Total	32.3

Substrate	Percent Cover
Sand	89.3
Rock	10.0
Leaf litter	0.75
Biologic soil crust	0

Inland Circle	Vegetation	Percent Cover
	Apache plume (*Fallugia paradoxa*)	35.0
	Netleaf hackberry (*Celtis laevigata*)	1.50
	Brome grasses (*Bromus* sp.)	0.50
	Unidentified aster/composite	0.10
	Total	37.1

Substrate	Percent Cover
Sand	71.0
Rock	4.00
Leaf litter	5.00
Biologic soil crust	20.0

Table 13. Vegetation cover and substrate measured at Site 12 (Ten Cent Camp, Left)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Netleaf hackberry (*Celtis laevigata*)	30.0
	Wire lettuce (*Stephanomeria pauciflora*)	5.50
	Rice grass (*Oryzopsis hymenoides*)	1.00
	Brome grasses (*Bromus* sp.)	1.00
	Unidentified perennial grass	0.50
	Total	38.0

Substrate	Percent Cover
Sand	54.0
Rock	45.0
Leaf litter	1.00
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 2,000 cm):	1,606 cm
Total gap length on inland/riverward transect (out of 2,000 cm):	1,426 cm

Summary	
Total vegetation cover, in percent	30.1
Total sand substrate, in percent	70.0
Total rock substrate, in percent	24.0
Total leaf litter substrate, in percent	2.05
Total biologic crust substrate, in percent	4.00
Total gap length, in percent	75.8

Table 14. Vegetation cover and substrate measured at Site 13 (Lower Ten Cent, Left).

Center Circle	Vegetation	Percent Cover
	Unidentified perennial grass	10.5
	Ephedra (*Ephedra* sp.)	5.50
	Needle-and-thread (*Stipa comata*)	2.00
	Russian thistle (*Salsola* sp.)	1.00
	Unidentified forbs	0.70
	Sand verbena (*Abronia elliptica*)	0.50
	Rice grass (*Oryzopsis hymenoides*)	0.50
	Brome grasses (*Bromus* sp.)	0.50
	Bindweed heliotrope (*Heliotropium convolvulaceum*)	0.10
	Total	21.3

Substrate	Percent Cover
Sand	86.5
Rock	0
Leaf litter	3.50
Biologic soil crust	10.0

Upstream Circle	Vegetation	Percent Cover
	Ephedra (*Ephedra* sp.)	7.25
	Needle-and-thread (*Stipa comata*)	2.75
	Rice grass (*Oryzopsis hymenoides*)	2.25
	Dicoria (*Dicoria canescens*)	1.50
	Spike dropseed (*Sporobolus contractus*)	0.90
	Dropseed (*Sporobolus* sp.)	0.60
	Unidentified perennial grass, dead	0.50
	Sand verbena (*Abronia elliptica*)	0.40
	Bindweed heliotrope (*Heliotropium convolvulaceum*)	0.20
	Total	16.4

Substrate	Percent Cover
Sand	100
Rock	0
Leaf litter	0
Biologic soil crust	0

Table 14. Vegetation cover and substrate measured at Site 13 (Lower Ten Cent, Left)—Continued.

Downstream Circle	Vegetation	Percent Cover
	Ephedra (*Ephedra* sp.)	9.00
	Unidentified perennial grasses	8.50
	Wire lettuce (*Stephanomeria pauciflora*)	6.50
	Needle-and-thread (*Stipa comata*)	4.25
	Russian thistle (*Salsola* sp.)	0.75
	Sand verbena (*Abronia elliptica*)	0.50
	Unidentified annual grass	0.25
	Brome grasses (*Bromus* sp.)	0.13
	Bindweed heliotrope (*Heliotropium convolvulaceum*)	0.10
	Total	30.0

Substrate	Percent Cover
Sand	93.5
Rock	0
Leaf litter	5.50
Biologic soil crust	1.00

Inland Circle	Vegetation	Percent Cover
	Ephedra (*Ephedra* sp.)	10.0
	Unidentified perennial grass	7.00
	Unidentified annual grass	4.00
	Unidentified perennial grass, dead	3.25
	Russian thistle (*Salsola* sp.)	2.88
	Needle-and-thread (*Stipa comata*)	2.50
	Wire lettuce (*Stephanomeria pauciflora*)	2.50
	Rice grass (*Oryzopsis hymenoides*)	1.75
	Sand verbena (*Abronia elliptica*)	0.50
	Unidentified forb	0.20
	Brome grasses (*Bromus* sp.)	0.10
	Total	34.7

Substrate	Percent Cover
Sand	92.5
Rock	0
Leaf litter	4.50
Biologic soil crust	3.00

Table 14. Vegetation cover and substrate measured at Site 13 (Lower Ten Cent, Left)—Continued.

Riverward Circle	Vegetation	Percent Cover
	Rice grass (*Oryzopsis hymenoides*)	5.50
	Russian thistle (*Salsola* sp.)	3.50
	Sand verbena (*Abronia elliptica*)	1.50
	Needle-and-thread (*Stipa comata*)	1.00
	Unidentified perennial grass	1.00
	Bindweed heliotrope (*Heliotropium convolvulaceum*)	0.38
	Brome grasses (*Bromus* sp.)	0.10
	Unidentified legume	0.10
	Total	13.1

Substrate	Percent Cover
Sand	98.9
Rock	0.10
Leaf litter	1.00
Biologic soil crust	0

Total gap length on upstream/downstream transect (out of 2,000 cm):	1,547 cm
Total gap length on inland/riverward transect (out of 2,000 cm):	1,671 cm

Summary	
Total vegetation cover, in percent	23.1
Total sand substrate, in percent	94.3
Total rock substrate, in percent	0
Total leaf litter substrate, in percent	2.90
Total biologic crust substrate, in percent	2.80
Total gap length, in percent	80.5