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Table 1. Summary of vegetation and substrate measurements on aeolian dune fields in the Colorado River corridor, Grand Canyon, Arizona. A, 15 sites in modern-fluvial-sourced (MFS) aeolian dune fields; B, 12 sites in relict-fluvial-sourced (RFS) aeolian dune fields.

[Sites are labeled on figure 1. River mile and bank (L, left; R, right) are identified for each site. Vegetation and substrate properties were measured once at each site during 2009 and 2010. Weather stations operated at 14 of the sites between 2003 and 2011 with record lengths ranging from 21 to 69 months (Draut and Rubin, 2005, 2006; Draut and others, 2009a, b, 2010a). Wind direction at those sites was measured directly. At all other sites, dominant local wind direction was estimated by measuring azimuth orientations of dune slipfaces and sand shadows behind rocks and vegetation.]

A. Modern-fluvial-sourced (MFS) dune fields studied in Grand Canyon.

River mile and bank	Wind direction	Total gap length (%)	Biologic crust (%)	Vegetation cover (%)	Number of species	Weather station site?	Visitor use?
24.7 L, lower site	169–244°	61.4	1.20	10.0	10	Yes	No
24.7 L, upper site	211–244°	56.1	3.00	10.0	14	Yes	No
44.0 L	274–303°	79.3	1.05	23.3	12	No	Yes
50.1 R	74–94°	90.8	0	25.1	10	No	No
57.9 R, lower site	132–154°	83.0	0	24.7	10	Yes	No
57.9 R, upper site	138–156°	65.6	14.0	32.6	12	Yes	No
60.1 R	121–127°	70.4	2.45	13.3	16	No	Yes
69.0 R	205–225°	79.3	4.50	12.5	8	No	Yes
69.5 R	175–200°	82.2	0	30.0	14	Yes	No
93.3 L	284–349°	81.3	0.60	15.5	13	No	No
109.0 R	250–270°	92.6	3.00	11.8	14	No	Yes
122.5 L	21–26°	69.5	15.8	29.5	16	No	No
123.0 L	21–26°	85.9	0.20	4.62	13	Yes	No
134.5 L	76–91°	85.8	0.30	11.3	14	No	Yes
223.0 R	176–199°	49.4	6.02	49.2	11	Yes	No

B. Relict-fluvial-sourced (RFS) dune fields studied in Grand Canyon.

River mile and bank	Wind direction	Total gap length (%)	Biologic crust (%)	Vegetation cover (%)	Number of species	Weather station site?	Visitor use?
60.0 R	121–127°	14.9	34.9	51.2	21	Yes	No
65.5 L	132–155°	42.8	51.0	18.5	15	Yes	No
68.0 L	98–153°	54.9	18.0	14.8	8	Yes	No
68.1 L	98–153°	34.9	16.1	19.2	8	No	Yes
70.0 L, lower site	244–254°	42.6	18.0	34.6	7	Yes	No
70.0 L, upper site	233–237°	44.8	13.6	18.1	6	Yes	No
72.3 L	267–289°	37.0	6.50	16.4	7	No	No
135.0 L	84–97°	64.5	43.0	13.0	15	Yes	No
171.5 L	229–271°	27.6	27.1	18.2	13	No	Yes
202.9 R	194–283°	20.9	26.6	63.4	10	Yes	No
207.0 L	105–130°	0	69.8	58.8	5	No	No
209.0 L	190–240°	0.71	95.3	30.6	15	No	No

Table 2. Vegetation cover and substrate measured at river mile 24.7 L, lower site, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Long-leaf brickellbush (<i>Brickellia longifolia</i>)	6.25	4.42	130
Wire lettuce (<i>Stephanomeria pauciflora</i>)	3.68	2.60	98
Dropseed grass (<i>Sporobolus</i> sp.)	1.63	1.15	86
Indian rice grass (<i>Achnatherum hymenoides</i>)	1.05	0.74	90
Prickly pear (<i>Opuntia</i> sp.)	0.85	0.60	76
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	0.28	0.20	24
Globemallow (<i>Sphaeralcea</i> sp.)	0.14	0.10	62
Russian thistle (<i>Salsola tragus</i>)	0.14	0.10	44
Dicoria (<i>Dicoria canescens</i>)	0.06	0.04	33
Total vegetation cover	14.1	10.0	
Other species observed:			
Spiny aster (<i>Chloracantha spinosa</i>)			
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Substrate	Area, in square meters	Percentage	
Sand	99.0	70.0	
Rock	40.7	28.8	
Leaf litter	0	0	
Biologic soil crust	1.70	1.20	
Total gap length		61.4	

Table 3. Vegetation cover and substrate measured at river mile 24.7 L, upper site, Grand Canyon, Arizona. [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Ephedra (<i>Ephedra</i> sp.)	4.67	3.30	99
Beavertail (<i>Opuntia basilaris</i>)	3.53	2.50	48
Dropseed grass (<i>Sporobolus</i> sp.)	3.05	2.16	92
Unidentified shrub, dead	0.85	0.60	71
Prickly pear (<i>Opuntia</i> sp.)	0.85	0.60	38
Unidentified aster (<i>Asteraceae</i> family)	0.71	0.50	64
Indian rice grass (<i>Achnatherum hymenoides</i>)	0.42	0.30	84
Dicoria (<i>Dicoria canescens</i>)	0.06	0.04	36
Russian thistle (<i>Salsola tragus</i>)	0.03	0.02	13
Total vegetation cover	14.2	10.0	
Other species observed:			
Twining milkweed (<i>Sarcostemma cynanchoides</i>)			
Globemallow (<i>Sphaeralcea</i> sp.)			
Wire lettuce (<i>Stephanomeria pauciflora</i>)			
Brome grasses, undifferentiated (<i>Bromus</i> sp.)			
Unidentified forb			
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Substrate	Area, in square meters	Percentage	
Sand	109	77.2	
Rock	28.0	19.8	
Leaf litter	0	0	
Biologic soil crust	4.24	3.00	
Total gap length		56.1	

Table 4. Vegetation cover and substrate measured at river mile 44.0 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Tamarisk (<i>Tamarix ramosissima</i>)	14.8	10.5
Russian thistle (<i>Salsola tragus</i>)	6.43	4.55
Dropseed grass (<i>Sporobolus</i> sp.)	3.75	2.65
Indian rice grass (<i>Achnatherum hymenoides</i>)	1.98	1.40
Spiny aster (<i>Chloracantha spinosa</i>)	1.98	1.40
Spike dropseed (<i>Sporobolus contractus</i>)	1.20	0.85
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	0.85	0.60
Dicoria (<i>Dicoria canescens</i>)	0.74	0.53
Inland saltgrass (<i>Distichlis</i> sp.)	0.71	0.50
Unidentified aster (<i>Asteraceae</i> family)	0.21	0.15
Saltbush (<i>Atriplex</i> sp.)	0.21	0.15
Unidentified perennial forb	0.01	0.01
Total vegetation cover	32.9	23.3

Substrate	Area, in square meters	Percentage
Sand	123	87.1
Rock	0.07	0.05
Leaf litter	16.7	11.8
Biologic soil crust	1.48	1.05
Total gap length		79.3

Table 5. Vegetation cover and substrate measured at river mile 50.1 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Arrowweed (<i>Pluchea sericea</i>)	13.0	9.20
Tamarisk (<i>Tamarix ramosissima</i>)	7.07	5.00
Spike dropseed (<i>Sporobolus contractus</i>)	5.51	3.90
Coyote willow (<i>Salix exigua</i>)	2.97	2.10
Indian rice grass (<i>Achnatherum hymenoides</i>)	2.76	1.95
Dicoria (<i>Dicoria canescens</i>)	1.85	1.31
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	1.13	0.80
Dropseed grass (<i>Sporobolus</i> sp.)	0.71	0.50
Unidentified aster (<i>Asteraceae</i> family)	0.28	0.20
Spiny aster (<i>Chloracantha spinosa</i>)	0.14	0.10
Total vegetation cover	35.4	25.1

Substrate	Area, in square meters	Percentage
Sand	138	97.9
Rock	0	0
Leaf litter	2.97	2.10
Biologic soil crust	0	0
Total gap length		90.8

Table 6. Vegetation cover and substrate measured at river mile 57.9 R, lower site, Grand Canyon, Arizona. [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Dropseed grass (<i>Sporobolus</i> sp.)	12.4	8.80	80
Coyote willow (<i>Salix exigua</i>)	9.61	6.80	180
Indian rice grass (<i>Achnatherum hymenoides</i>)	6.08	4.30	118
Tamarisk (<i>Tamarix ramosissima</i>)	2.83	2.00	250
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	2.83	2.00	40
Dicoria (<i>Dicoria canescens</i>)	0.99	0.70	46
Russian thistle (<i>Salsola tragus</i>)	0.06	0.04	38
Wire lettuce (<i>Stephanomeria pauciflora</i>)	0.03	0.02	64
Total vegetation cover	34.9	24.7	
Other species observed:			
Seepweed (<i>Suaeda moquinii</i>)			
Unidentified annual grass			
Substrate	Area, in square meters	Percentage	
Sand	141	100	
Rock	0	0	
Leaf litter	0	0	
Biologic soil crust	0	0	
Total gap length		83.0	

Table 7. Vegetation cover and substrate measured at river mile 57.9 R, upper site, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Mesquite (<i>Prosopis glandulosa</i>)	18.7	13.2	140
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	17.0	12.0	8
Acacia (<i>Acacia greggii</i>)	3.39	2.40	150
Dicoria (<i>Dicoria canescens</i>)	2.01	1.42	70
Grama grass (<i>Bouteloua</i> sp.)	1.41	1.00	15
Saltbush (<i>Atriplex</i> sp.)	0.99	0.70	70
Unidentified annual grass	0.99	0.70	50
Desert pepperweed (<i>Lepidium fremontii</i>)	0.57	0.40	11
Grizzly bear prickly pear (<i>Opuntia polycantha</i> var. <i>erinacea</i>)	0.42	0.30	58
Russian thistle (<i>Salsola tragus</i>)	0.31	0.22	53
Brittlebush (<i>Encelia farinosa</i>)	0.28	0.20	82
Sand verbena (<i>Abronia elliptica</i>)	0.03	0.02	9
Total vegetation cover	46.0	32.6	
Other species observed: None			
Substrate	Area, in square meters	Percentage	
Sand	122	86.0	
Rock	0	0	
Leaf litter	0	0	
Biologic soil crust	19.8	14.0	
Total gap length		65.6	

Table 8. Vegetation cover and substrate measured at river mile 60.0 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3. N/R, not recorded.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Acacia (<i>Acacia greggii</i>)	23.8	16.8	350
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	16.4	11.6	N/R
Mesquite (<i>Prosopis glandulosa</i>)	14.1	10.0	N/R
Desert pepperweed (<i>Lepidium fremontii</i>)	11.3	8.02	N/R
Brittlebush (<i>Encelia farinosa</i>)	1.58	1.12	N/R
Unidentified aster (<i>Asteraceae</i> family)	1.41	1.00	N/R
Saltbush (<i>Atriplex</i> sp.)	0.85	0.60	70
Snakeweed (<i>Gutierrezia</i> sp.)	0.71	0.50	N/R
Dropseed grass (<i>Sporobolus</i> sp.)	0.59	0.42	71
Grizzly bear prickly pear (<i>Opuntia polyacantha</i> var. <i>erinacea</i>)	0.42	0.30	N/R
Ephedra (<i>Ephedra</i> sp.)	0.28	0.20	N/R
Sand verbena (<i>Abronia elliptica</i>)	0.28	0.20	N/R
Wire lettuce (<i>Stephanomeria pauciflora</i>)	0.17	0.12	38
Big bluestem (<i>Andropogon gerardii</i>)	0.14	0.10	N/R
Rabbitbrush (<i>Chrysothamnus</i> sp.)	0.14	0.10	N/R
Globemallow (<i>Sphaeralcea</i> sp.)	0.14	0.10	N/R
Twining milkweed (<i>Sarcostemma cynanchoides</i>)	0.06	0.04	N/R
Total vegetation cover	72.4	51.2	
Other species observed:			
Hedgehog cactus (<i>Echinocereus engelmannii</i>)			
Grama grass (<i>Bouteloua</i> sp.)			
Plantain (<i>Plantago</i> sp.)			
Unidentified forb			
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Substrate	Area, in square meters	Percentage	
Sand	32.0	22.7	
Rock	26.4	18.7	
Leaf litter	33.6	23.8	
Biologic soil crust	49.3	34.9	
Total gap length		14.9	

Table 9. Vegetation cover and substrate measured at river mile 60.1 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Indian rice grass (<i>Achnatherum hymenoides</i>)	3.11	2.20
Sand verbena (<i>Abronia elliptica</i>)	2.26	1.60
Wire lettuce (<i>Stephanomeria pauciflora</i>)	2.12	1.50
Dropseed grass (<i>Sporobolus</i> sp.)	2.05	1.45
Arizona three-awn (<i>Aristida arizonica</i>)	1.84	1.30
Red brome (<i>Bromus rubens</i>)	1.84	1.30
Rabbitbrush (<i>Chrysothamnus</i> sp.)	1.27	0.90
Snakeweed (<i>Gutierrezia</i> sp.)	0.99	0.70
Tamarisk (<i>Tamarix ramosissima</i>)	0.71	0.50
Goldenbush (<i>Isocoma acradenia</i>)	0.57	0.40
Long-leaf brickellbush (<i>Brickellia longifolia</i>)	0.57	0.40
Brittlebush (<i>Encelia farinosa</i>)	0.57	0.40
Fetid marigold (<i>Thymophylla pentachaeta</i>)	0.42	0.30
Milkvetch (<i>Astragalus</i> sp.)	0.14	0.10
Matted tiquilia (<i>Tiquilia latior</i>)	0.14	0.10
Stinking milkvetch (<i>Astragalus praelongus</i>)	0.14	0.10
Total vegetation cover	18.7	13.3

Substrate	Area, in square meters	Percentage
Sand	138	90.6
Rock	0	6.10
Leaf litter	2.97	0.90
Biologic soil crust	0	2.45
Total gap length		70.4

Table 10. Vegetation cover and substrate measured at river mile 65.5 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3. NR, not recorded.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Six weeks grama (<i>Bouteloua barbata</i>)	12.7	9.00	26
Seepweed (<i>Suaeda moquinii</i>)	3.25	2.30	100
Beavertail (<i>Opuntia basilaris</i>)	3.11	2.20	30
Mesquite (<i>Prosopis glandulosa</i>)	2.26	1.60	165
Fendler's sandmat (<i>Chamaesyce fendleri</i>)	1.16	0.82	20
Six weeks needle grama (<i>Bouteloua aristidoides</i>)	1.16	0.82	14
Mesquite (<i>Prosopis glandulosa</i>), dead	0.57	0.40	Long branches near ground
Grama grasses, undifferentiated (<i>Bouteloua</i> sp.)	0.57	0.40	N/R
Big bluestem (<i>Andropogon gerardii</i>)	0.42	0.30	86
Desert pepperweed (<i>Lepidium fremontii</i>)	0.31	0.22	30
Dropseed grass (<i>Sporobolus</i> sp.)	0.28	0.20	N/R
Globemallow (<i>Sphaeralcea</i> sp.)	0.28	0.20	70
Russian thistle (<i>Salsola tragus</i>)	0.11	0.08	38
Total vegetation cover	26.2	18.5	
Other species observed:			
Four o' clock (<i>Allonia</i> sp.)			
Unidentified shrub			
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Substrate	Area, in square meters	Percentage	
Sand	69.3	49.0	
Rock	0	0	
Leaf litter	0	0	
Biologic soil crust	72.1	51.0	
Total gap length		42.8	

Table 11. Vegetation cover and substrate measured at river mile 68.0 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Mesquite (<i>Prosopis glandulosa</i>)	7.35	5.20	160
Saltbush (<i>Atriplex</i> sp.)	5.09	3.60	90
Seepweed (<i>Suaeda moquinii</i>)	3.25	2.30	74
Unidentified annual grass	2.29	1.62	31
Unidentified perennial forb	1.44	1.02	60
Globemallow (<i>Sphaeralcea</i> sp.)	0.88	0.62	48
Russian thistle (<i>Salsola tragus</i>)	0.59	0.42	20
Big bluestem (<i>Andropogon gerardii</i>)	0.06	0.04	30
Total vegetation cover	21.0	14.8	

Other species observed:
 None

Substrate	Area, in square meters	Percentage
Sand	116	82.0
Rock	0	0
Leaf litter	0	0
Biologic soil crust	25.4	18.0
Total gap length		54.9

Table 12. Vegetation cover and substrate measured at river mile 68.1 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Seepweed (<i>Suaeda moquinii</i>)	16.3	11.5
Six weeks fescue (<i>Vulpia octoflora</i>)	3.82	2.70
Annual mustard (<i>Streptanthella</i> sp.)	2.47	1.75
Desert pepperweed (<i>Lepidium fremontii</i>)	1.48	1.05
Mediterranean grass (<i>Schismus</i> sp.)	1.41	1.00
Mesquite (<i>Prosopis glandulosa</i>)	1.41	1.00
Dropseed grass (<i>Sporobolus</i> sp.)	0.14	0.10
Saltbush (<i>Atriplex</i> sp.)	0.07	0.05
Total vegetation cover	27.1	19.2

Substrate	Area, in square meters	Percentage
Sand	107	75.6
Rock	8.48	6.00
Leaf litter	3.25	2.30
Biologic soil crust	22.8	16.1
Total gap length		34.9

Table 13. Vegetation cover and substrate measured at river mile 69.0 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Arrowweed (<i>Pluchea sericea</i>)	8.06	5.70
Mesquite (<i>Prosopis glandulosa</i>)	4.24	3.00
Spike dropseed (<i>Sporobolus contractus</i>)	3.53	2.50
Dropseed grass (<i>Sporobolus</i> sp.)	0.71	0.50
Indian rice grass (<i>Achnatherum hymenoides</i>)	0.71	0.50
Small flowered milkvetch (<i>Astragalus nuttallianus</i>)	0.14	0.10
Wire lettuce (<i>Stephanomeria pauciflora</i>)	0.14	0.10
Red brome (<i>Bromus rubens</i>)	0.07	0.05
Total vegetation cover	17.6	12.5

Substrate	Area, in square meters	Percentage
Sand	130	92.3
Rock	2.26	1.60
Leaf litter	2.26	1.60
Biologic soil crust	6.36	4.50
Total gap length		79.3

Table 14. Vegetation cover and substrate measured at river mile 69.5 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Mesquite (<i>Prosopis glandulosa</i>)	35.3	25.0	>400
Arrowweed (<i>Pluchea sericea</i>)	3.68	2.60	130
Unidentified aster (<i>Asteraceae</i> family)	0.85	0.60	80
Unidentified perennial forb	0.74	0.52	27
Saltbush (<i>Atriplex</i> sp.)	0.57	0.40	76
Dropseed grass (<i>Sporobolus</i> sp.)	0.57	0.40	77
Acacia (<i>Acacia greggii</i>)	0.28	0.20	68
Unidentified annual grass	0.28	0.20	40
Globemallow (<i>Sphaeralcea</i> sp.)	0.14	0.10	40
Total vegetation cover	42.4	30.0	
Other species observed:			
Big bluestem (<i>Andropogon gerardii</i>)			
Brittlebush (<i>Encelia farinosa</i>)			
Prickly pear (<i>Opuntia</i> sp.)			
Wire lettuce (<i>Stephanomeria pauciflora</i>)			
Sand verbena (<i>Abronia elliptica</i>)			
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Substrate	Area, in square meters	Percentage	
Sand	124	87.7	
Rock	3.25	2.30	
Leaf litter	14.1	10.0	
Biologic soil crust	0	0	
Total gap length		82.2	

Table 15. Vegetation cover and substrate measured at river mile 70.0 L, lower site, Grand Canyon, Arizona. [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Russian thistle (<i>Salsola tragus</i>)	26.0	18.4	50
Mesquite (<i>Prosopis glandulosa</i>)	16.7	11.8	>200
Seepweed (<i>Suaeda moquinii</i>)	2.83	2.00	120
Saltbush (<i>Atriplex</i> sp.)	1.84	1.30	84
Unidentified perennial forb	0.99	0.70	53
Globemallow (<i>Sphaeralcea</i> sp.)	0.28	0.20	85
Big bluestem (<i>Andropogon gerardii</i>)	0.28	0.20	73
Total vegetation cover	48.9	34.6	
Other species observed:			
None			

Substrate	Area, in square meters	Percentage
Sand	116	82.0
Rock	0	0
Leaf litter	0	0
Biologic soil crust	25.4	18.0
Total gap length		42.6

Table 16. Vegetation cover and substrate measured at river mile 70.0 L, upper site, Grand Canyon, Arizona. [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Mesquite (<i>Prosopis glandulosa</i>)	15.8	11.2	200
Seepweed (<i>Suaeda moquinii</i>)	6.64	4.70	88
Unidentified annual grass	1.41	1.00	11
Russian thistle (<i>Salsola tragus</i>)	0.88	0.62	45
Unidentified perennial forb	0.57	0.40	40
Saltbush (<i>Atriplex</i> sp.)	0.28	0.20	30
Total vegetation cover	25.6	18.1	
Other species observed: None			
Substrate	Area, in square meters	Percentage	
Sand	121	85.4	
Rock	1.41	1.00	
Leaf litter	0	0	
Biologic soil crust	19.2	13.6	
Total gap length		44.8	

Table 17. Vegetation cover and substrate measured at river mile 72.3 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Six weeks fescue (<i>Vulpia octoflora</i>)	8.69	6.15
Seepweed (<i>Suaeda moquinii</i>)	7.92	5.60
Annual mustard (<i>Streptanthella</i> sp.)	3.18	2.25
Saltbush (<i>Atriplex</i> sp.)	1.56	1.10
Mesquite (<i>Prosopis glandulosa</i>)	1.56	1.10
Spike dropseed (<i>Sporobolus contractus</i>)	0.14	0.10
Dropseed grass (<i>Sporobolus</i> sp.)	0.07	0.05
Total vegetation cover	23.1	16.4

Substrate	Area, in square meters	Percentage
Sand	124	87.8
Rock	1.56	1.10
Leaf litter	6.50	4.60
Biologic soil crust	9.19	6.50
Total gap length		37.0

Table 18. Vegetation cover and substrate measured at river mile 93.3 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Goldenbush (<i>Isocoma acradenia</i>)	6.08	4.30
Ephedra (<i>Ephedra</i> sp.)	3.39	2.40
Spike dropseed (<i>Sporobolus contractus</i>)	2.54	1.80
Dropseed grass (<i>Sporobolus</i> sp.)	2.12	1.50
Indian rice grass (<i>Achnatherum hymenoides</i>)	1.98	1.40
Sand verbena (<i>Abronia elliptica</i>)	1.41	1.00
Ripgut brome (<i>Bromus diandrus</i>)	1.20	0.85
Dicoria (<i>Dicoria canescens</i>)	1.20	0.85
Acacia (<i>Acacia greggii</i>)	0.85	0.60
Dune broom (<i>Parryella filifolia</i>)	0.57	0.40
Red brome (<i>Bromus rubens</i>)	0.21	0.15
Pale evening primrose (<i>Oenothera</i> sp.)	0.14	0.10
Six weeks fescue (<i>Vulpia octoflora</i>)	0.14	0.10
Total vegetation cover	21.8	15.5

Substrate	Area, in square meters	Percentage
Sand	134	95.1
Rock	1.48	1.05
Leaf litter	4.81	3.40
Biologic soil crust	0.85	0.60
Total gap length		81.3

Table 19. Vegetation cover and substrate measured at river mile 109.0 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters Percentage	
Dropseed grass (<i>Sporobolus</i> sp.)	5.51	3.90
Chuckwalla's delight (<i>Bebbia juncea</i>)	2.97	2.10
Dicoria (<i>Dicoria canescens</i>)	2.47	1.75
Brittlebush (<i>Encelia farinosa</i>)	1.84	1.30
Acacia (<i>Acacia greggii</i>)	1.70	1.20
Ripgut brome (<i>Bromus diandrus</i>)	0.64	0.45
Red brome (<i>Bromus rubens</i>)	0.57	0.40
Goldenbush (<i>Isocoma acradenia</i>)	0.28	0.20
Borage (<i>Cryptantha</i> sp.)	0.14	0.10
Annual mustard (<i>Descuriana</i> sp.)	0.14	0.10
Bigelow's linanthus (<i>Linanthus bigelovii</i>)	0.14	0.10
Grizzly bear prickly pear (<i>Opuntia polykantha</i> var. <i>erinacea</i>)	0.14	0.10
Small flowered milkvetch (<i>Astragalus nuttallianus</i>)	0.07	0.05
Six weeks fescue (<i>Vulpia octoflora</i>)	0.03	0.02
Total vegetation cover	16.6	11.8

Substrate	Area, in square meters Percentage	
Sand	128	90.2
Rock	8.55	6.05
Leaf litter	1.06	0.75
Biologic soil crust	4.24	3.00
Total gap length		92.6

Table 20. Vegetation cover and substrate measured at river mile 122.5 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square	
	meters	Percentage
Cheatgrass (<i>Bromus tectorum</i>)	21.6	15.3
Goldenbush (<i>Isocoma acradenia</i>)	5.09	3.60
Tamarisk (<i>Tamarix ramosissima</i>)	4.24	3.00
Spike dropseed (<i>Sporobolus contractus</i>)	3.82	2.70
Sand verbena (<i>Abronia elliptica</i>)	2.05	1.45
Russian thistle (<i>Salsola tragus</i>)	1.41	1.00
Indian rice grass (<i>Achnatherum hymenoides</i>)	1.27	0.90
Red brome (<i>Bromus rubens</i>)	0.99	0.70
Dicoria (<i>Dicoria canescens</i>)	0.28	0.20
Pale evening primrose (<i>Oenothera</i> sp.)	0.28	0.20
Arizona three-awn (<i>Aristida arizonica</i>)	0.28	0.20
Brittlebush (<i>Encelia farinosa</i>)	0.14	0.10
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	0.07	0.05
Globemallow (<i>Sphaeralcea</i> sp.)	0.07	0.05
Annual mustard (<i>Descuriana</i> sp.)	0.07	0.05
Total vegetation cover	41.7	29.5
Other species observed:		
Bindweed heliotrope (<i>Heliotropium convolvulaceum</i>)		
Substrate	Area, in square	
	meters	Percentage
Sand	108	76.4
Rock	0.28	0.20
Leaf litter	10.7	7.60
Biologic soil crust	22.3	15.8
Total gap length		69.5

Table 21. Vegetation cover and substrate measured at river mile 123.0 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Spike dropseed (<i>Sporobolus contractus</i>)	1.87	1.32	102
Indian rice grass (<i>Achnatherum hymenoides</i>)	1.56	1.10	100
Unidentified aster (<i>Asteraceae</i> family)	1.30	0.92	130
Acacia (<i>Acacia greggii</i>)	0.71	0.50	26
Dropseed grass (<i>Sporobolus</i> sp.)	0.57	0.40	45
Wire lettuce (<i>Stephanomeria pauciflora</i>)	0.17	0.12	43
Unidentified shrub, dead	0.14	0.10	45
Snakeweed (<i>Gutierrezia</i> sp.)	0.08	0.06	20
Sand verbena (<i>Abronia elliptica</i>)	0.06	0.04	2
Dicoria (<i>Dicoria canescens</i>)	0.06	0.04	20
Brittlebush (<i>Encelia farinosa</i>)	0.03	0.02	5
Total vegetation cover	6.53	4.62	
Other species observed:			
Big bluestem (<i>Andropogon gerardii</i>)			
Goldenbush (<i>Isocoma acradenia</i>)			
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Substrate	Area, in square meters	Percentage	
Sand	128	90.2	
Rock	13.6	9.60	
Leaf litter	0.00	0.00	
Biologic soil crust	0.28	0.20	
Total gap length		85.9	

Table 22. Vegetation cover and substrate measured at river mile 134.5 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Desert baccharis (<i>Baccharis sergiloides</i>)	2.83	2.00
Spike dropseed (<i>Sporobolus contractus</i>)	2.69	1.90
Tamarisk (<i>Tamarix ramosissima</i>)	1.98	1.40
Brittlebush (<i>Encelia farinosa</i>)	1.98	1.40
Sand verbena (<i>Abronia elliptica</i>)	1.20	0.85
Goldenbush (<i>Isocoma acradenia</i>)	0.99	0.70
Indian rice grass (<i>Achnatherum hymenoides</i>)	0.99	0.70
Snakeweed (<i>Gutierrezia</i> sp.)	0.85	0.60
Dicoria (<i>Dicoria canescens</i>)	0.78	0.55
Long-leaf brickellbush (<i>Brickellia longifolia</i>)	0.71	0.50
Dropseed grass (<i>Sporobolus</i> sp.)	0.42	0.30
Arizona three-awn (<i>Aristida arizonica</i>)	0.28	0.20
Wire lettuce (<i>Stephanomeria pauciflora</i>)	0.21	0.15
Red brome (<i>Bromus rubens</i>)	0.07	0.05
Total vegetation cover	16.0	11.3

Substrate	Area, in square meters	Percentage
Sand	126	89.0
Rock	12.7	9.00
Leaf litter	2.40	1.70
Biologic soil crust	0.42	0.30
Total gap length		85.8

Table 23. Vegetation cover and substrate measured at river mile 135.0 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3. N/R, not recorded.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Dropseed grass (<i>Sporobolus</i> sp.)	3.96	2.80	120
Goldenbush (<i>Isocoma acradenia</i>)	2.97	2.10	89
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	2.83	2.00	20
Spike dropseed (<i>Sporobolus contractus</i>)	1.98	1.40	150
Beavertail (<i>Opuntia basilaris</i>)	1.56	1.10	50
Pale evening primrose (<i>Oenothera</i> sp.)	1.41	1.00	35
Wire lettuce (<i>Stephanomeria pauciflora</i>)	1.19	0.84	100
Snakeweed (<i>Gutierrezia</i> sp.)	1.13	0.80	55
Unidentified annual grass	0.57	0.40	N/R
Indian rice grass (<i>Achnatherum hymenoides</i>)	0.28	0.20	30
Arrowweed (<i>Pluchea sericea</i>)	0.25	0.18	90
Milkvetch (<i>Astragalus</i> sp.)	0.17	0.12	28
Sand verbena (<i>Abronia elliptica</i>)	0.08	0.06	12
Dicoria (<i>Dicoria canescens</i>)	0.03	0.02	20
Total vegetation cover	18.4	13.0	

Other species observed:

Globemallow (*Sphaeralcea* sp.)

Substrate	Area, in square meters	Percentage
Sand	46.8	52.4
Rock	3.68	2.60
Leaf litter	2.83	2.00
Biologic soil crust	60.8	43.0
Total gap length		64.5

Table 24. Vegetation cover and substrate measured at river mile 171.5 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Arrowweed (<i>Pluchea sericea</i>)	4.95	3.50
Red brome (<i>Bromus rubens</i>)	3.82	2.70
Mesquite (<i>Prosopis glandulosa</i>)	2.83	2.00
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	2.54	1.80
Dropseed grass (<i>Sporobolus</i> sp.)	2.26	1.60
Indian rice grass (<i>Achnatherum hymenoides</i>)	2.12	1.50
Pale evening primrose (<i>Oenothera</i> sp.)	1.70	1.20
Dicoria (<i>Dicoria canescens</i>)	1.44	1.02
Spike dropseed (<i>Sporobolus contractus</i>)	1.41	1.00
Wire lettuce (<i>Stephanomeria pauciflora</i>)	1.27	0.90
Unidentified perennial grass	0.71	0.50
Brittlebush (<i>Encelia farinosa</i>)	0.57	0.40
Unidentified perennial forb	0.06	0.04
Total vegetation cover	25.7	18.2

Substrate	Area, in square meters	Percentage
Sand	89.8	63.6
Rock	0.64	0.45
Leaf litter	12.6	8.90
Biologic soil crust	38.3	27.1
Total gap length		27.6

Table 25. Vegetation cover and substrate measured at river mile 202.9 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3. N/R, not recorded.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Arrowweed (<i>Pluchea sericea</i>)	73.5	52.0	100
Indian rice grass (<i>Achnatherum hymenoides</i>)	11.0	7.8	90
Unidentified grass	2.83	2.00	2
Beavertail (<i>Opuntia basilaris</i>)	1.44	1.02	N/R
Dropseed grass (<i>Sporobolus</i> sp.)	0.85	0.60	70
Brittlebush (<i>Encelia farinosa</i>)	0.03	0.02	7
Total vegetation cover	89.7	63.4	
Other species observed:			
Mesquite (<i>Prosopis glandulosa</i>)			
Creosote (<i>Larrea tridentata</i>)			
Cocklebur (<i>Xanthium strumarium</i>)			
Six weeks fescue (<i>Vulpia octoflora</i>)			
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Substrate	Area, in square meters	Percentage	
Sand	49.8	35.2	
Rock	0	0	
Leaf litter	54.0	38.2	
Biologic soil crust	37.6	26.6	
Total gap length		20.9	

Table 26. Vegetation cover and substrate measured at river mile 207.0 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Unidentified annual grasses	60.8	43.0	4
Mesquite (<i>Prosopis glandulosa</i>)	13.6	9.60	160
Creosote (<i>Larrea tridentata</i>)	4.52	3.20	150
Blackbrush (<i>Coleogyne ramosissima</i>)	2.26	1.60	73
Unidentified aster (<i>Asteraceae</i> family)	1.98	1.40	70
Total vegetation cover	83.1	58.8	
Other species observed: None			

Substrate	Area, in square meters	Percentage
Sand	1.41	1.00
Rock	17.5	12.4
Leaf litter	23.8	16.8
Biologic soil crust	98.7	69.8
Total gap length		0

Table 27. Vegetation cover and substrate measured at river mile 209.0 L, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage
Creosote (<i>Larrea tridentata</i>)	11.3	8.00
Annual grasses, undifferentiated	10.7	7.60
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	6.79	4.80
Bigelow's linanthus (<i>Linanthus bigelovii</i>)	5.94	4.20
Prickly pear (<i>Opuntia</i> sp.)	2.62	1.85
Six weeks fescue (<i>Vulpia octoflora</i>)	1.48	1.05
Ratany (<i>Krameria</i> sp.)	1.34	0.95
Woolly plantain (<i>Plantago patagonica</i>)	1.27	0.90
Cholla (<i>Cylindropuntia</i> sp.)	0.57	0.40
Unidentified aster (<i>Asteraceae</i> family)	0.42	0.30
Borage (<i>Cryptantha</i> sp.)	0.28	0.20
Desert pepperweed (<i>Lepidium fremontii</i>)	0.14	0.10
Beavertail (<i>Opuntia basilaris</i>)	0.14	0.10
Red brome (<i>Bromus rubens</i>)	0.07	0.05
Annual mustard (<i>Descuriana</i> sp.)	0.07	0.05
Total vegetation cover	43.2	30.6

Substrate	Area, in square meters	Percentage
Sand	4.24	3.00
Rock	0.00	0.00
Leaf litter	2.40	1.70
Biologic soil crust	135	95.3
Total gap length		0.71

Table 28. Vegetation cover and substrate measured at river mile 223.0 R, Grand Canyon, Arizona.
 [Coverage is given in terms of area and percentage within five circles of radius 3 m, as shown in figure 3.]

Vegetation	Area, in square meters	Percentage	Maximum height, in centimeters
Mesquite (<i>Prosopis glandulosa</i>)	30.5	21.6	200
Unidentified annual grasses	27.7	19.6	30
Creosote (<i>Larrea tridentata</i>)	8.20	5.80	160
Beavertail (<i>Opuntia basilaris</i>)	1.44	1.02	38
Brome grasses, undifferentiated (<i>Bromus</i> sp.)	1.13	0.80	32
Unidentified aster (<i>Asteraceae</i> family)	0.28	0.20	40
Unidentified shrub	0.14	0.10	22
Brittlebush (<i>Encelia farinosa</i>)	0.03	0.02	50
Total vegetation cover	69.5	49.2	
Other species observed:			
Prickly pear (<i>Opuntia</i> sp.)			
Desert pepperweed (<i>Lepidium fremontii</i>)			
Dropseed grass (<i>Sporobolus</i> sp.)			
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Substrate	Area, in square meters	Percentage	
Sand	77.2	54.6	
Rock	0.03	0.02	
Leaf litter	55.6	39.4	
Biologic soil crust	8.51	6.02	
Total gap length		49.4	