TRANSITIONAL MONITORING OF RIPARIAN VEGETATION IN LOWER GRAND CANYON - 1997

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TRANSITIONAL MONITORING OF RIPARIAN VEGETATION IN LOWER GRAND CANYON - 1997

INTRODUCTION

Riparian vegetation in lower Grand Canyon/upper Lake Mead represents some of the most abundant wildlife habitats in the American Southwest (Carothers et al. 1974, Carothers and Aitchison 1976). It has been estimated that over 1,200 hectares of this valuable resource is available for nesting and foraging to approximately 15,000 breeding birds between Spencer Creek and Pearce Ferry (Christensen et al. 1996). Operation of Glen and Hoover dams can have important implications to the extent and health of these important habitats. Because of the potential for loss of these habitats and to better understand the natural dynamics of riparian vegetation in lower Grand Canyon, we have been monitoring vegetation characteristics in lower Grand Canyon since 1992 as part of the Glen Canyon Environmental Studies.

In 1996, we initiated new methodologies for examining plant community structure and dynamics in lower Grand Canyon. The new method used is called the Releve' method where habitat polygons are delineated on aerial photographs and percent cover of each plant species present is estimated in circular plots of varying radii. In addition, at each circular plot, the number of vertical vegetation hits (intersections with a vertical rod) is recorded at five elevations above the grounds surface. Previously, we monitored long-term plots (LTP's), marsh transects (MT's) and silt terrace transects (STT's) at nine sites between Diamond Creek and Pearce Ferry.

Until recently, we have seen a steady increase in vegetation density and abundance as low Lake Mead levels and interim flows have favored establishment of native and exotic species on large silt terraces on upper Lake Mead. Lake Mead elevation, however, increased in late 1995 and continues to do so today to inundate significant areas of these terraces (Christensen et al. 1996). Because of this inundation, it was necessary to abandon the two lowest sites on upper Lake Mead (River Mile 269.6L and 273.1R). In addition, several polygons at site 254.0R and 249.4L are submerged.

Historically, vegetation surveys were conducted in Grand Canyon by the Museum of Northern Arizona in the 1970s and 1980s, and by the National Park Service between 1987 and 1994 (Carothers and Aitchison 1976, Phillips et al. 1977, Carothers and Dolan 1982, Phillips et al. 1987, Carothers and Brown 1991, Stevens and Ayers 1993). These surveys included the reach from Lees Ferry to Diamond Creek, and with few exceptions did not include the 51-mile reach from Diamond Creek to the Grand Wash Cliffs due to logistical and political considerations.

Carothers and Aitchison (1976) conducted an overview study that included lower Grand Canyon; Phillips et al. (1977) mapped vegetation in the Grand Canyon to the Grand Wash Cliffs; and Phillips et al. (1987) produced an annotated checklist of vascular plants in all of Grand Canyon. In-depth vegetation surveys of lower Grand Canyon were not begun, however, until 1992, when the Hualapai Tribe became involved in Grand Canyon decision-making and began to support vegetation studies downstream of Diamond Creek.

Study Sites

In 1997, we continued to monitor vegetation at four sites in lower Grand Canyon (river mile (RM) 241.5L, 246.0L, 249.4L and 254.0R; Figure 1). These sites were chosen because they had been monitored since 1992. Here, we describe the general characteristics of these sites.

241.5L

This site has three distinct characters. The upstream side is largely open sand with a dense *Tamarix* thicket in the middle. This area is used frequently as a camping beach. Downstream and near the shore, is a dense patch of horsetail *(Equisetum hiemale)* and bermuda grass (*Cynodon dactylon*) that was regularly inundated prior to interim flows. This patch seems to persist without further inundation, but is being eroded away due to high flows and high lake levels. Behind the horsetail, there is dense saltcedar (*Tamarix chinensis)* and seep willow (*Baccharis salicifolia)*.

246.0L

This site is at the confluence of the Colorado River and Spencer Creek. At the upstream side and at a fairly high elevation, there is a dense stand of saltcedar with a dense canopy and little understory. Along the edge of this plateau and the creek delta, there is a more mesic community of cattail (*Typha latifolia*) and coyote willow (*Salix exigua*). On the delta itself, there is a very dynamic assemblage that is typically very diverse, but often lacking density. This is due to the level of disturbance that this habitat receives due to scouring from Spencer Creek and inundation from Lake Mead. Goodding's willow (*Salix gooddingii*) and Fremont cottonwood (*Populus fremontii*) are often found in good numbers on the delta.

249.4L

This site has distinct lateral layers of vegetation types. The near-shore habitats are dominated by seep willow, coyote willow and saltcedar. Cattails were historically abundant here, but have declined under interim flows. On a level behind the near-shore vegetation, there is a patch of bermuda grass, seep willow and coyote willow. Farther back, saltcedar dominates.

254.0R

Near-shore vegetation at this site is dominated by coyote willow and seep willow that are extremely dense. Farther back, saltcedar and seep willow also form an incredibly dense thicket. Near the back of the vegetation, and up a small side canyon, there is a fairly large opening (approximately 20 meters by 30 meters) that has relatively little vegetation, but that supports a high diversity of plants.

METHODS

On enlarged (400%) May, 1995 aerial photographs of these sites, we delineated vegetation polygons. These polygons were numbered and digitized into our GIS (Geographic Information System) system (Figures 2-5). The photographs were rectified by establishing ground control using standard survey techniques.

As mentioned above, in 1996 and 1997, we used the Releve' method (Mueller-Dombois and Ellenberg 1974) of vegetation characterization to describe vegegetation structure and community composition in lower Grand Canyon. Fourteen vegetation polygons were delineated at RM241.5L, 12 at RM 246.0L, 16 at RM 249.4L and six at RM 254.0R. Within each of the polygons, two to eight circular plots were randomly selected for examination. The number varied according to polygon size. The diameter of the circular plots varied from two meters to six meters depending on the location of the plot (those close to the polygon's edge were necessarily smaller). All polygons were sampled in October.

At each circular plot, percent cover of each plant species present was visually estimated. A species list was also prepared that included species that were not present within the circular plots. At each plot, duff depth and the number of vertical vegetation hits was recorded at 0-0.3 meter, 0.3-1.0 meter, 1.0-2.0 meters, 2.0-4.0 meters and above four meter intervals. We calculated mean percent cover for each species for each polygon and mean number of vertical hits per polygon.

For each species that was found to exhibit the greatest percent cover for any polygon at each site, we provided the lowest and highest percent cover values along with mean percent

cover and the number of polygons where that species occurred of all the polygons at each site. Additionally, for each polygon at the four study sites, we provide a species list and mean percent cover for each species.

RESULTS AND DISCUSSION

The greatest change in vegetation characteristics between 1996 and 1997 was due to higher Lake Mead elevations and higher discharges from Glen Canyon Dam (Table 1). In 1996, Lake Mead's elevation ranged from a low of 1190.02 feet in August to a high of 1194.4 feet in December. In 1997, Lake Mead elevation rose from 1195.6 feet in January to 1212.0 feet in December. Discharge from Glen Canyon Dam varied from an average of 11,540 cfs in October, 1996 to an average of 21,790 cfs in August of 1997 (U.S. Geological Survey, 1997). The combination of high lake levels and high discharges from Glen Canyon Dam caused inundation and submergence of near shore polygons (Table 1) which we assume will be recolonized once lake levels and dam discharge rates subside. Although it appears that lake and dam influences diminish at site 254.0R because only two polygons were lost, loss of these two polygons represents a loss of over 50% of the vegetation there.

If dam discharges decline in the near future, we may be able to assess the relative effects of lake levels and dam discharges on riparian vegetation in lower Grand Canyon by determining whether any of the polygons are re-exposed following this decline. We do know, however, that during the 45,000 cfs flood in 1996 when lake elevations were relatively low, Site 254.0R was substantially inundated (Christensen 1996). This showed direct effects of the dam on vegetation even at the furthest downstream site. It is possible, however, that dam discharges have less influence on the vegetation at higher lake levels.

Table 1. Identification of vegetation polygons that were inundated or eroded between 1996 and 1997.0

SITE	POLYGONS LOST	PROPORTION OF POLYGONS LOST
241.5L	1,2	2 of 13
246.0L	1,5,9,10,15a,15b, 15c	7 of 14
249.4L	1,2,4,10,11,19,22	7 of 14
254.0R	2,3	2 of 6

Below, we examine patterns of species' abundances for each site in general. A species list and their associated mean percent cover for each polygon is also presented.

River Mile 241.5L:

At river mile 241.5, although *Cynodon dactylon* was the most dominant species at four of the eleven polygons (Table 2), it only averaged less than one percent cover across polygons (Table 3). *Tamarix chinensis* and *Equisetum hiemale* were both dominant at two of the eleven polygons (Table 2) and provided the greatest percent cover at this site (Table 3). *Dicoria brandegei*, *Sporobolus flexuosus* and *Bromus rubens* were dominant at one polygon each and provided little to moderate amounts of cover overall (Table 3). The complete species lists for each polygon at RM 241.5 and their mean percent cover are given in Tables 4 to 14.

Table 2. For site 241.5L, a list of plant species that provided the most percent cover in at least one polygon and the number of polygons in which it provided the greatest cover.

SPECIES	# OF POLYGONS DOMINANT	SAMPLE SIZE
Cynodon dactylon	4	11
Tamarix chinensis	2	11
Equisetum hiemale	2	11
Dicoria brandegei	1	11
Sporobolus flexuosus	1	11
Bromus rubens	1	11

Table 3. The low, high and mean percent cover for the dominant plants at site 241.5 in 1997 along with the number of polygons in which the species were found of the eleven examined.

SPECIES	LOW % COVER	HIGH % COVER	MEAN % COVER	# OF POLYGONS PRESENT
Cynodon dactylon	0.0	2.5	0.23	1
Tamrix chinensis	0.0	70.0	18.3	8
Equisetum hiemale	0.0	62.5	21.1	9
Dicoria brandegei	0.0	2.5	0.5	5
Sporobolus flexuosus	0.0	56.3	10.0	5
Bromus rubens	0.0	27.5	3.9	8

Table 4. Percent cover of the species present in polygon #3 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Dicoria brandegei	2.5 ± 2.5	4
Oenothera pallida	0.03 ± 0.02	4
Bromus rubens	0.0003 ± 0.0003	4
Lactuca serriola	0.0	4
Conyza canadensis	0.0	4
Aristida purpura	0.0	4
Brickellia atractyloides	0.0	4
Tamarix chinensis	0.0	4

Table 5. Percent cover of the species present in polygon #4 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	67.5 ± 10.3	4
Cynodon dactylon	31.3 ± 18.8	4
Baccharis salicifolia	10.0 ± 10.0	4
Sporobolus flexuosus	0.5 ± 0.5	4
Bromus rubens	0.03 ± 0.03	4
Lactuca serriola	0.003 ± 0.003	4
Opuntia acanthocarpa	0.003 ± 0.003	4

Table 6. Percent cover of the species present in polygon #5/8 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	36.3 ± 17.8	4
Bromus rubens	2.5 ± 2.5	4
Lactuca serriola	0.01 ± 0.01	4
Watermelon	0.001 ± 0.001	4
Equisetum laevigatum	0.0	4
Oenothera pallida	0.0	4
Sporobolus contractus	0.0	4

Table 7. Percent cover of the species present in polygon #6 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	30.0 ± 7.1	2
Bromus rubens	7.0 ± 3.0	2
Tamarix chinensis	1.6 ± 1.5	2
Perityle emoryi	0.01 ± 0.01	2
Acacia greggii	0.0	2
Lactuca serriola	0.0	2
Dicoria brandegei	0.0	2
Erigeron lobatus	0.0	2
Mirabilis bigelovii	0.0	2
Larrea tridenta	0.0	2
Conyza canadensis	0.0	2
Viguiera deltoides	0.0	2

Table 8. Percent cover of the species present in polygon #7 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Sporobolus flexuosus	0.5 ± 0.3	4
Cynodon dactylon	0.5 ± 0.5	4
Oenothera pallida	0.01 ± 0.01	4
Bromus rubens	0.003 ± 0.003	4

Table 9. Percent cover of the species present in polygon #9 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	70.0 ± 7.4	4
Sporobolus flexuosus	0.3 ± 0.3	4
Acacia greggii	0.03 ± 0.03	4
Tessaria sericea	0.03 ± 0.03	4

Table 10. Percent cover of the species present in polygon #11 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	50.0 ± 6.5	4
Tamarix chinensis	32.5 ± 4.8	4
Equisetum hiemale	23.8 ± 15.5	4
Sporobolus flexuosus	1.5 ± 1.2	4
Bromus rubens	0.3 ± 0.3	4
Lactuca serriola	0.01 ± 0.01	4
Equisetum laevigatum	0.0	4

Table 11. Percent cover of the species present in polygon #12 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Equisetum hiemale	30 ± 30.0	2
Baccharis salicifolia	25.0 ± 20.0	2
Tamarix chinensis	22.5 ± 2.5	2
Cynodon dactylon	12.5 ± 2.5	2

Table 12. Percent cover of the species present in polygon #13 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Equisetum hiemale	56.3 ± 9.9	4
Baccharis salicifolia	25.0 ± 8.7	4
Cynodon dactylon	8.5 ± 5.5	4
Tamarix chinensis	4.0 ± 2.3	4
Gnaphalium chilense	0.003 ± 0.003	4
Salix exigua	0.0	4

Table 13. Percent cover of the species present in polygon #14 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Bromus rubens	5.5 ± 4.5	2
Sporobolus flexuosus	2.5 ± 2.5	2
Cynodon dactylon	0.6 ± 0.5	2
Lactuca serriola	0.03 ± 0.03	2
Equisetum hiemale	0.03 ± 0.03	2

Table 14. Percent cover of the species present in polygon #15 at site 241.5L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	62.5 ± 12.5	2
Bromus rubens	27.5 ± 22.5	2
Baccharis salicifolia	3.5 ± 1.5	2
Tamarix chinensis	3.5 ± 1.5	2
Lactuca serriola	2.6 ± 2.5	2
Conyza canadensis	0.3 ± 0.3	2
Equisetum hiemale	0.03 ± 0.03	2
Bebbia juncea	0.03 ± 0.03	2
Gnaphalium chilense	0.003 ± 0.003	2

Vertical Vegetation Structure

Polygon twelve exhibited the greatest vertical structure at site 241.5 with a good number of hits at all elevations (Table 15). The understory in this polygon is dominated by *Equisetum hiemale* with a midstory of *Baccharis salicifolia* and an overstory of mature *Tamarix chinensis* (Table 10). Polygons four and thirteen also exhibited substantial vertical structure but not above the two meter elevation (Table 15). These polygons are dominated by *Tamarix chinensis* and *Equisetum hiemale* respectively (Tables 4 and 11 respectively). Duff depth was considerable at several of the polygons. Polygons four, twelve and thirteen also exhibited the greatest vertical structure in 1996 suggesting that this methodology produces repeatable results.

Table 15. Mean vertical vegetation hits across polygons at site 241.5L.

Polygn	Duff	<0.3m	0.3-1m	1-2m	2-4m	>4m	n
3	0.0	0.0	0.0	0.0	0.0	0.0	4
4	4.0 ± 0.7	2.3 ± 1.9	3.3 ± 1.4	2.5 ± 1.7	0.0	0.0	4
5/8	0.3 ± 0.3	1.0 ± 0.6	0.0	0.0	0.0	0.0	4
6	0.0	0.0	0.0	0.0	0.0	0.0	4
7	0.0	0.0	0.0	0.0	0.0	0.0	2
9	3.9 ± 1.3	0.8 ± 0.5	0.8 ± 0.3	0.5 ± 0.3	2.3 ± 0.8	0.0	4
11	2.5 ± 0.5	4.0 ± 0.0	0.0	0.0	4.5 ± 3.5	1.0 ± 1.0	2
12	3.5 ± 0.6	6.3 ± 4.7	2.5 ± 1.9	4.3 ± 0.5	4.0 ± 1.4	1.5 ± 1.2	4
13	3.5 ± 1.2	4.5 ± 2.2	1.3 ± 0.8	1.8 ± 0.8	0.0	0.0	4
14	0.0	0.0	0.0	0.0	0.0	0.0	2
15	2.0 ± 0.0	0.5 ± 0.5	2.0 ± 2.0	0.0	0.0	0.0	2

River Mile 246.0L:

At river mile 246.0L, *Cynodon dactylon* and *Tamarix chinensis* were the most dominant species at two of the seven polygons (Table 16) and also had the highest mean percent cover scores (Table 17). *Baccharis salicifolia, Prosopis glandulosa* and *Salix gooddingii* also exhibited the greatest amount of cover at one polygon each (Table 16). These species also provided a moderate amount of cover across polygons (Table 17). The complete species list for each polygon at RM 246.0 and their mean percent cover are given in Tables 18 to 24.

Table 16. For site 246.0L, a list of plant species that provided the most percent cover in at least one polygon and the number of polygons in which it provided the greatest cover.

SPECIES	# OF POLYGONS DOMINANT	SAMPLE SIZE
Cynodon dactylon	2	7
Tamarix chinensis	2	7
Baccharis salicifolia	1	7
Prosopis glandulosa	1	7
Salix gooddingii	1	7

Table 17. The low, high and mean percent cover for the dominant plants at site 246.0L in 1997 along with the number of polygons in which the species were found of the seven examined.

SPECIES	LOW % COVER	HIGH % COVER	MEAN % COVER	# OF POLYGONS PRESENT
Cynodon dactylon	0.0	100.0	18.9	3
Tamarix chinensis	0.0	78.8	22.8	5
Baccharis saliciflia	0.0	76.7	15.1	5
Prosopis glandulosa	0.0	70.0	10.0	2
Salix gooddingii	0.0	41.7	6.0	1

Table 18. Percent cover of the species present in polygon #2 at site 246.0L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	100.0	1

Table 19. Percent cover of the species present in polygon #3 at site 246.0L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	67.5 ± 6.0	4
Salix exigua	1.3 ± 1.3	4
Bromus rubens	0.3 ± 0.2	4
Tessaria sericea	0.5 ± 0.3	4
Acacia greggii	0.1 ± 0.1	4
Baccharis salicifolia	0.03 ± 0.03	4
Panicum capillare	0.0	4
Agrostis semiverticillata	0.0	4
Prosopis glandulosa	0.0	4
Sphaeralcea ambigua	0.0	4
Cynodon dactylon	0.0	4
Marrubium vulgare	0.0	4

Table 20. Percent cover of the species present in polygon #6 at site 246.0L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	78.8 ± 9.7	4
Baccharis salicifolia	9.3 ± 5.4	4

Table 21. Percent cover of the species present in polygon #11 at site 246.0L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	32.5 ± 17.1	6
Bromus rubens	10.8 ± 4.9	6
Conyza canadensis	8.4 ± 4.6	6
Baccharis salicifolia	6.7 ± 4.9	6
Tessaria sericea	3.3 ± 3.3	6
Lactuca serriola	1.7 ± 1.7	6
Marrubium vulgare	0.9 ± 0.8	6
Acacia greggii	0.02 ± 0.02	6
Gnaphalium chilense	0.02 ± 0.02	6
Solanum douglasii	0.02 ± 0.02	6
Taraxacum officinale	0.0	6
Rumex crispus	0.0	6
Trixis californica	0.0	6

Table 22. Percent cover of the species present in polygon #12 at site 246.0L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Baccharis salicifolia	76.7 ± 1.7	3
Tamarix chinensis	1.7 ± 1.7	3
Bromus rubens	1.0 ± 0.6	3
Tessaria sericea	0.4 ± 0.3	3
Lactuca serriola	0.3 ± 0.3	3
Solanum douglasii	0.3 ± 0.3	3

Table 26. For site 249.4L, a list of plant species that provided the most percent cover in at least one polygon and the number of polygons in which it provided the greatest cover.

SPECIES	# OF POLYGONS DOMINANT	SAMPLE SIZE
Tamarix chinensis	9	12
Cynodon dactylon	3	12

Table 27. The low, high and mean percent cover for the dominant plants at site 249.4L in 1997 along with the number of polygons in which the species were found of the twelve examined.

SPECIES	LOW % COVER	HIGH % COVER	MEAN % COVER	# OF POLYGONS PRESENT
Tamarix chinensis	0.0	95.0	53.7	11
Cynodon dactylon	0.0	83.3	10.6	7

Table 28. Percent cover of the species present in polygon #6 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	41.7 ± 19.6	3
Baccharis salicifolia	21.8 ± 11.5	3
Bromus rubens	3.7 ± 1.3	3
Tessaria sericea	1.7 ± 1.7	3
Bebbia juncea	0.02 ± 0.02	3
Mammilaria microcarpa	0.003 ± 0.003	3
Lactuca serriola	0.0003 ± 0.0003	3
Sphaeralcea ambigua	0.0	3
Happlopappus spinulosus	0.0	3
Acacia greggii	0.0	3
Bothriochloa barbinodis	0.0	3
Sonchus oleraceus	0.0	3
Mirabilis bigelovii	0.0	3

Table 29. Percent cover of the species present in polygon #7 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	45.0 ± 13.2	3
Bromus rubens	18.3 ± 13.6	3
Baccharis salicifolia	10.0 ± 5.0	3
Prosopis glandulosa	0.7 ± 0.7	3
Acacia greggii	0.4 ± 0.3	3
Encelia farinosa	0.3 ± 0.3	3
Tessaria sericea	0.01 ± 0.01	3
Mammilaria microcarpa	0.003 ± 0.003	3
Porophyllum gracile	0.003 ± 0.003	3
Trixix californica	0.0	3
Sphaeralcea ambigua	0.0	3
Mirabilis bigelovii	0.0	3

Table 30. Percent cover of the species present in polygon #8 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	85.0 ± 7.6	3
Baccharis salicifolia	5.0 ± 2.9	3
Cynodon dactylon	0.3 ± 0.3	3

Table 31. Percent cover of the species present in polygon #12 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	83.3 ± 8.3	3
Tamarix chinensis	21.7 ± 11.7	3
Baccharis salicifolia	16.7 ± 1.7	3
Baccharis emoryi	6.7 ± 6.7	3
Sonchus oleraceus	0.03 ± 0.03	3

Table 32. Percent cover of the species present in polygon #14 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	80.0 ± 3.5	4
Tessaria sericea	0.8 ± 0.5	4
Baccharis salicifolia	0.3 ± 0.3	4
Bromus rubens	0.3 ± 0.3	4
Acacia greggii	0.3 ± 0.3	4
Cynodon dactylon	0.03 ± 0.03	4

Table 33. Percent cover of the species present in polygon #15 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	95.0 ± 0.0	4

Table 34. Percent cover of the species present in polygon #16 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	58.3 ± 17.4	3
Baccharis salicifolia	25.0 ± 8.7	3
Bromus rubens	11.7 ± 6.0	3
Tessaria sericea	6.7 ± 4.4	3
Sphaeralcea ambigua	0.2 ± 0.2	3
Brickellia coulteri	0.0	3

Table 35. Percent cover of the species present in polygon #17 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	83.3 ± 6.7	3
Baccharis salicifolia	10.7 ± 9.7	3
Bromus rubens	8.3 ± 6.0	3
Trixix californica	1.0 ± 0.6	3
Lactuca serriola	0.003 ± 0.003	3
Acacia greggii	0.02 ± 0.02	3

Table 36. Percent cover of the species present in polygon #20 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	52.5 ± 9.5	4
Baccharis salicifolia	17.5 ± 7.5	4
Cynodon dactylon	1.0 ± 0.7	4
Acacia greggii	0.3 ± 0.2	4
Trixis californica	0.1 ± 0.1	4
Pleurocoronis pluriseta	0.03 ± 0.03	4
Galium stellatum	0.01 ± 0.01	4
Bromus rubens	0.01 ± 0.01	4
Lactuca serriola	0.003 ± 0.003	4

Table 37. Percent cover of the species present in polygon #21 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	38.5 ± 19.2	4
Tamarix chinensis	28.8 ± 12.6	4
Baccharis salicifolia	22.5 ± 6.0	4
Bromus rubens	10.0 ± 2.0	4
Sphaeralcea ambigua	2.5 ± 2.5	4
Viguiera deltoides	0.3 ± 0.3	4
Sonchus oleraceus	0.03 ± 0.03	4
Salix gooddingii	0.03 ± 0.03	4
Tessaria sericea	0.003 ± 0.003	4
Acacia greggii	0.003 ± 0.003	4
Lactuca serriola	0.0	4

Table 38. Percent cover of the species present in polygon #23 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	52.5 ± 21.7	4
Baccharis salicifolia	13.8 ± 8.5	4
Trixis californica	7.8 ± 7.4	4
Acacia greggii	0.0	4
Erigeron lobatus	0.0	4
Bernardia incana	0.0	4
Brickellia coulteri	0.0	4
Hoffmeisteria pluriseta	0.0	4
Sphaeralcea ambigua	0.0	4

Table 39. Percent cover of the species present in polygon #24 at site 249.4L in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Cynodon dactylon	3.7 ± 3.2	3
Bromus rubens	1.3 ± 0.9	3
Prosopis glandulosa	0.3 ± 0.3	3

Vertical Vegetation Structure

Vegetation at site 249.4 is quite tall and dense as is reflected by the vertical hits scores (Table 40). Of particular interest are polygons 15, 16, 17 and 20. Each is dominated by mature stands of *Tamarix chinensis* with little or no understory (Tables 33-36). Only two polygons lack substantial vertical structure. Polygon 12 is dominated by a thick mat of *Cynodon dactylon* bordered by tamarisk and seep willow (Table 31). Polygon 24 is a near barren opening in a dense stand of tamarisk with very little vegetation at all (Table 39).

Table 40. Mean vertical vegetation hits across polygons at site 249.4L.

Polygn	Duff	<0.3m	0.3-1m	1-2m	2-4m	>4m	n
6	4.0 ± 1.5	0.0	1.0 ± 0.6	2.0 ± 2.0	3.0 ± 3.0	0.0	3
7	6.3 ± 1.9	0.3 ± 0.3	3.0 ± 1.0	6.3 ± 4.3	1.3 ± 1.3	0.0	3
8	6.0 ± 0.6	0.0	1.7 ± 1.7	0.7 ± 0.7	4.3 ± 0.7	0.0	3
12	0.0	26.7 ± 3.3	0.0	0.0	0.0	0.0	3
14	7.8 ± 1.0	0.3 ± 0.3	0.0	1.5 ± 0.6	3.8 ± 0.9	0.0	4
15	6.8 ± 0.9	0.3 ± 0.3	0.8 ± 0.3	0.3 ± 0.3	7.0 ± 1.9	0.0	4
16	3.7 ± 0.7	0.0	1.0 ± 0.6	6.0 ± 1.2	4.7 ± 2.3	0.0	3
17	2.0 ± 0.6	0.0	2.0 ± 1.5	6.7 ± 3.7	3.3 ± 1.5	0.7 ± 0.7	3
20	3.8 ± 1.7	0.3 ± 0.3	2.5 ± 0.6	5.0 ± 0.7	3.5 ± 1.3	0.8 ± 0.8	4
21	5.5 ± 1.3	3.1 ± 2.3	1.3 ± 0.8	0.3 ± 0.3	2.5 ± 1.6	0.0	4
23	1.9 ± 1.1	0.8 ± 0.5	0.8 ± 0.5	1.5 ± 1.0	3.5 ± 2.1	0.0	4
24	0.8 ± 0.2	0.0	0.0	0.0	0.0	0.0	3

River Mile 254.0R:

At river mile 254.0R, *Tamarix chinensis* dominates at three of the four polygons while *Tessaria sericea* provided the most cover at an open polygon within a dense stand of tamarisk (Table 41). *Tamarix chinensis* by far provides the greatest cover across polygons while *Tessaria sericea* provides relatively little (Table 42). A dense stand of *Salix exigua* at the front of this site was completely inundated and submerged by Lake Mead waters in 1997. The complete species list for each polygon are given in Tables 43 to 46.

Table 41. For site 254.0R, a list of plant species that provided the most percent cover in at least one polygon and the number of polygons in which it provided the greatest cover.

SPECIES	# OF POLYGONS DOMINANT	SAMPLE SIZE
Tamarix chinensis	3	4
Tessaria sericea	1	4

Table 42. The low, high and mean percent cover for the dominant plants at site 254.0R in 1997 along with the number of polygons in which the species were found of the four examined.

SPECIES	LOW % COVER	HIGH % COVER	MEAN % COVER	# OF POLYGONS PRESENT
Tamarix chinensis	0.0	87.5	59.0	4
Tessaria sericea	0.0	17.5	4.4	2

Table 43. Percent cover of the species present in polygon #4 at site 254.0R in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	68.3 ± 6.0	3
Baccharis salicifolia	14.0 ± 6.0	3
Trixis californica	0.03 ± 0.03	3
Encelia farinosa	0.0	3

Table 44. Percent cover of the species present in polygon #5 at site 254.0R in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	87.5 ± 7.5	2
Tessaria sericea	0.05 ± 0.05	2

Table 45. Percent cover of the species present in polygon #6 at site 254.0R in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tessaria sericea	17.5 ± 7.5	2
Bromus rubens	5.3 ± 4.8	2
Encelia farinosa	5.1 ± 5.0	2
Acacia greggii	1.8 ± 1.3	2
Cucurbita palmata	1.5 ± 1.5	2
Physalis crassifolia	1.0 ± 1.0	2
Sphaeralcea grossulariaefolia	1.0 ± 1.0	2
Baccharis salicifolia	1.0 ± 1.0	2
Larrea tridentata	0.05 ± 0.05	2
Sonchus oleraceus	0.05 ± 0.05	2
Ditaxis neomexicana	0.05 ± 0.05	2
Perityle emoryi	0.005 ± 0.005	2
Nicotiana trigonophylla	0.005 ± 0.005	2
Cryptantha racemosa	0.005 ± 0.005	2
Brickellia longifolia	0.0	2
Brickellia coulteri	0.0	2
Tamarix chinensis	0.0	2

Table 46. Percent cover of the species present in polygon #7 at site 254.0R in 1997.

SPECIES	MEAN ± 1 S.E.	SAMPLE SIZE
Tamarix chinensis	80.0 ± 5.0	3
Trixis californica	0.03 ± 0.03	3
Perityle emoryi	0.0	3
Acacia greggii	0.0	3
Baccharis salicifolia	0.0	3
Bromus rubens	0.0	3
Encelia farinosa	0.0	3
Physalis crassifolia	0.0	3
Sphaeralcea grossulariaefolia	0.0	3

Vertical Vegetation Structure

Vertical vegetation structure was substantial at three of the four polygons each of which had hits above four meters (Table 47). These polygons, number four, five and seven are mature stands of *Tamarix chinensis* (Tables 43, 44 and 46 respectively). Polygon six is an opening in the tamarisk that supports a high diversity of plants, but with little percent cover or vertical structure (Table 45).

Table 47. Mean vertical vegetation hits across polygons at site 254.0R.

Polygn	Duff	<0.3m	0.3-1m	1-2m	2-4m	>4m	n
4	5.3 ± 0.9	0.0	1.3 ± 0.7	1.7 ± 0.7	4.3 ± 0.9	0.3 ± 0.3	3
5	5.5 ± 0.6	0.3 ± 0.3	1.0 ± 0.6	6.0 ± 0.6	6.8 ± 1.4	1.0 ± 0.7	4
6	0.3 ± 0.2	1.5 ± 0.5	1.5 ± 0.5	0.5 ± 0.5	0.0	0.0	2
7	4.3 ± 1.2	1.0 ± 1.0	1.3 ± 1.3	0.0	3.3 ± 1.2	0.7 ± 0.3	3

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