
Santa Fe River Riparian Vegetation Monitoring

Report 2010



Natural Heritage New Mexico Report – 11-GTR-352



Table of Contents

Introduction.....	1
Methods.....	1
Study area.....	1
Sampling design and analysis.....	2
Results.....	5
Vegetation zones.....	5
Utilization.....	11
Tree and shrub monitoring.....	11
Discussion.....	18
References.....	19
Appendix A	
Appendix B	
Appendix C	
Appendix D	

Tables

Table 1. List of plant name changes between 2005 and 2010.....	5
Table 2. Riparian vegetation zone and subzones along river cross-sections of the BLM Santa Fe River ACEC defined in 2005.....	6
Table 3. Tree and shrub species observed on woody monitoring quadrats with number of quadrats occupied by year.....	12

Figures

Figure 1. Study area for the Santa Fe River ACEC riparian monitoring program.....	3
Figure 2. Average total cover by life form, vegetation zone, origin and year.....	7
Figure 3. Average percent cover for selected species by vegetation zone and year.....	8
Figure 4. Average percent cover for selected species by vegetation zone and year.....	10
Figure 5. Average height in cm of herbaceous vegetation by year.....	11
Figure 6. Average number of individual rubber rabbitbrush per square meter by vegetation zone and year.....	13
Figure 7. Number of Russian olive individuals per meter square by size class, vegetation zone and year.....	14
Figure 8. Number of Russian olive stems per square meter by size class, vegetation zone and year.....	15
Figure 9. Number of saltcedar individuals per square meter by size class, vegetation zone and year.....	16
Figure 10. Number of saltcedar stems per square meter by size class, vegetation zone and year.....	17

Cover: Transect No. 03SF005 along the Santa Fe River.

Santa Fe River Riparian Vegetation Monitoring¹

Report 2010

Elizabeth Milford, Esteban Muldavin, Yvonne Chauvin, and Hugh Hulse

Natural Heritage New Mexico, Biology Department
University of New Mexico, Albuquerque, New Mexico 87131

March 2011

Introduction

The Taos Field Office of the Bureau of Land Management (BLM) initiated a riparian vegetation monitoring program for its lands along the lower Santa Fe River just west of La Cienega in 2003. The intent of this program is to monitor long-term changes in riparian plant communities due to changes in livestock management. Nine monitoring transects were established in September of 2003. Sampling was focused on riparian and wetland vegetation within the active floodplain. Transects average 26 meters in length, but vary depending on the width of the floodplain, and extend from the edge of the high terrace above the river channel across the active floodplain to the opposite terrace. Percent vegetation cover and height of all species was measured using 20 x 50-cm quadrat frames laid lengthwise end to end along the upstream side of each transect. Vegetation cover was measured in September of 2003 and 2004, and in late July 2005 (Milford et al 2006). In 2006 a protocol for assessing changes in number of individuals and stems for woody species was initiated using the same vegetation transects (Milford et al. 2007). Both vegetation cover and woody individuals and stems were measured in August 2010.

The sampling sites are located within a two-mile reach of the river that had been recently excluded from livestock grazing. Historically, the allotment was subject to livestock grazing year round. Starting in 2004 grazing within the allotment was limited, and in the summer of 2008 livestock had been removed from the allotment completely, with the exception of occasional trespass cattle. We report here on the 2010 data and on trends observed across the entire monitoring period.

Methods

Study area

The study area is located 26 km (16 mi) southwest of Santa Fe within the lower portion of the Santa Fe River Area of Critical Environmental Concern (ACEC) managed by the BLM (Figure 1). The study reach is approximately 3.5 km (2.2 mi) long with elevations that range

¹ Final report Cooperative Agreement Award No. L09AC15871.

from 1768 m (5800 ft) at the upper end to 1737 m (5700 ft) at the lower, resulting in a gentle stream gradient (approximately 1%). The floodplain averages only about 100 m in width and is constrained within a deep canyon that is bounded by mesas capped with ancient basalt lava flows. The river has a perennial flow sustained by a combination of natural discharge from a drainage basin of 45.5 km² (18.20 sq mi) and from the City of Santa Fe sewage treatment facility south of town.

The study area has a long history of human use as evidenced by numerous archeological sites within the canyon. Over the past century, livestock grazing has been the primary land use, typically on a year-round basis, and the site is part of an active BLM grazing allotment. At the time NHHM began vegetation sampling in 2003, cattle had been heavily using the site through the summer season since forage elsewhere in the allotment was in short supply due to drought conditions. An attempt was made to limit grazing within the allotment starting in 2004. However, for several months during the summers of 2004 to 2006 cattle were present on the allotment and there was grazing within the active floodplain, again because of limited forage elsewhere. Grazing was limited to only a few trespass cattle during the summers of 2008-2010.

Sampling design and analysis

Nine vegetation monitoring transects were established in September 2003 along the lower two-mile stretch of the Santa Fe River within the ACEC (Figure 1). During 2003 to 2010 sampling was focused on riparian and wetland vegetation within the active floodplain with the intent of detecting major changes in species composition and structure. Hence, transects were more or less evenly distributed along the reach and generally across straight reaches between river bends where the widest zones of riparian vegetation occurred.

Transects averaged 26 m (85 ft) in length, but varied, depending on the width of the floodplain, from 16.8 to 38.2 m (55 to 125 ft). All transects started on the right (northern) bank terrace above the river channel and the active floodplain, and extended perpendicularly across the river and up onto the left bank terrace. Three to five meters of terrace were included on either side of the active floodplain. Rebar stakes with aluminum tags were used to monument both ends of the transect on the terraces, with two additional tagged stakes located along the transect within the active floodplain to improve repeatability. The locations of the end-point stakes were recorded with a Garmin GPS with an accuracy of +/- 3 m (Appendix A). Each year four monitoring photographs were taken along each transect: one from the start stake to end stake and vice-versa, then two more photographs, one looking upstream and one looking downstream, were taken from a point upstream of the transect at a distance measured and recorded off the right bank floodplain stake. Appendix B contains a set of example monitoring photographs for each site, with a complete set of digital monitoring photographs provided on the CD included with this report. The location of major features along the transects were also recorded, including transitions between vegetations zones, and the left and right banks of the active channel (open water).

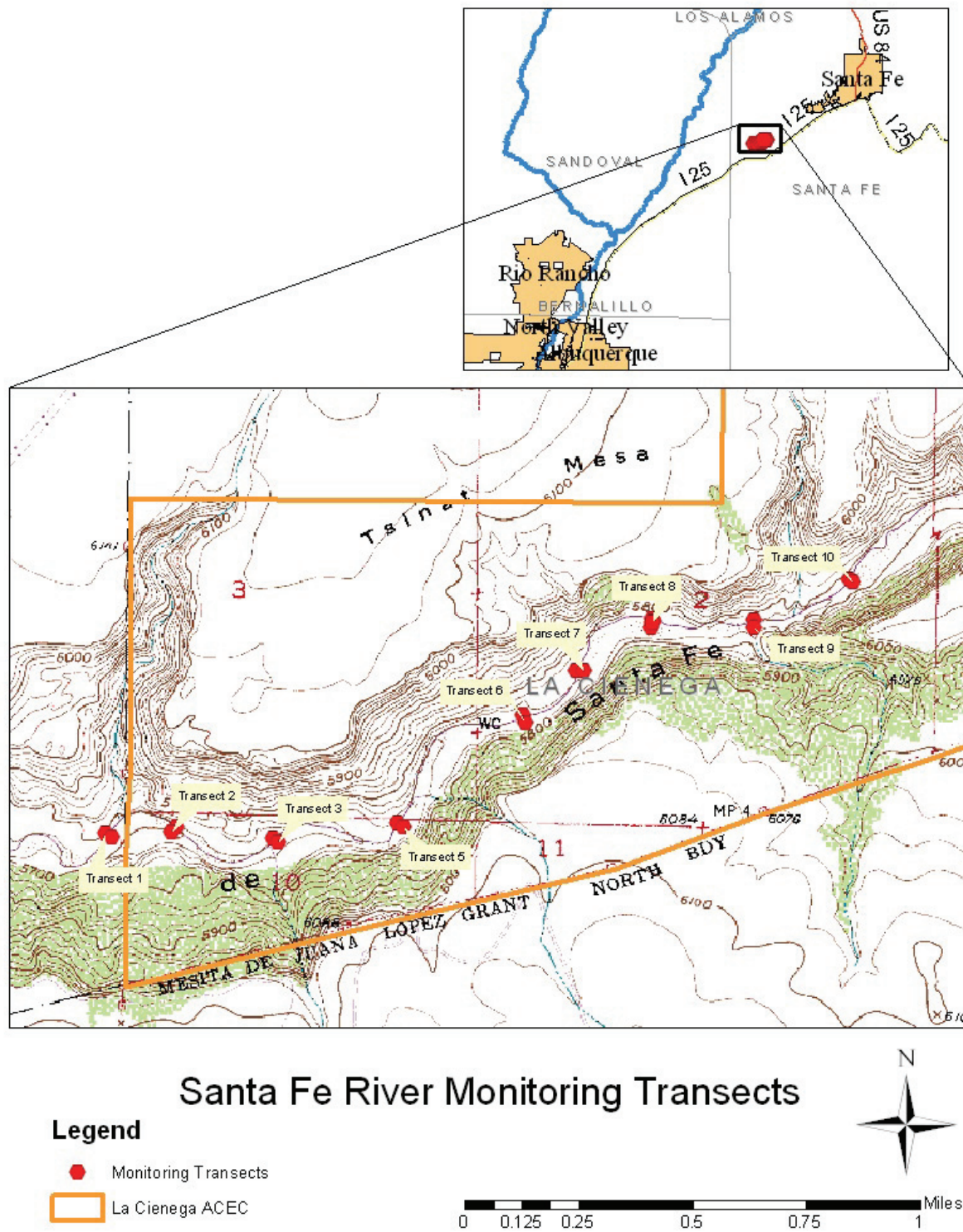


Figure 1. Study area for the Santa Fe River ACEC riparian monitoring program.

Vegetation cover was measured in 2003, 2004, 2005 and 2010, using 20 x 50-cm quadrat frames laid lengthwise end to end along the upstream side of each transect starting at the first stake (rebar 1, at 0 m) and continuing until there was no longer room for a complete quadrat along the line. (i.e., if the transect line ended at 23.4 m, the last quadrat was from 22.5 to 23 m.). In each quadrat, canopy cover of all species was evaluated to the nearest percent, and with some smaller-sized species, to one-tenth of a percent. In addition, average height for each species was measured to the nearest cm. Ground-cover components of litter, exposed soil, gravel, rock, water, cryptogams and total herbaceous canopy cover were also recorded to the nearest percent. Vascular aquatic vegetation was identified to species and measured as canopy cover whether it was submerged or emergent. However, algae, which was not identified to species, was measured as part of the ground cover components and was only measured when not submerged (i.e., submerged algae was not recorded and was simply part of the total area assigned to water for quadrats in which it occurred.). Additionally, the start and end points of the major vegetation zones were recorded for each transect.

In 2006 and 2010 a woody stem count was conducted along the nine transects. Four by half-meter quadrats were centered on the transect tape, such that each quadrat covered half a meter along the transect tape, with two meters of width extending upstream from the tape and two meters extending downstream. The quadrats started at 0 meters and were read consecutively every half meter, so that they overlapped with the vegetation cover quadrats. Counts within the woody quadrats included the total number of individual plants divided into five size classes: <2"/>4.5' (less than two inches diameter, less than four and a half feet tall), <2"/>4.5' (less than two inches diameter, greater than four and a half feet tall), 2-4" (two to four inches diameter, any height), 4-6" (four to six inches diameter any height), >6" (greater than six inches diameter). For individuals and stems >6" an exact measurement of diameter was obtained at the root crown using a DBH tape. These same size classes were also used to count individual stems within the quadrat.

Vouchers of all plant species were taken, identified, and have been archived at the herbarium of the University of New Mexico Museum of Southwest Biology. The vegetation data were entered using Microsoft Access into the NHNM's Ecology database with tables specifically designed for this project. Over the past decade the NHNM ecology database has been developed and populated with over 12,000 plot records from around the state and Southwest. Accordingly, there is a set of data-entry protocols that have been implemented that ensure data quality including independently proofreading the data for accuracy. The compact disk included with this report contains all of the raw data in MS Excel files, along with the photo files, and a PDF of this report.

Natural Heritage New Mexico periodically updates species lists to remain current with nationally accepted nomenclature. Since the 2005 vegetation monitoring report was published, names of some species have been changed. These names have all been updated in the database, and current names are being used in this report. For ease in comparing this report to prior ones, a list of synonymies is provided in Table 1.

Table 1. List of plant name changes between 2005 and 2010.

Current Name		Previous Name	
Common Name	Scientific Name	Common Name	Scientific Name
rubber rabbitbrush	<i>Ericameria nauseosa</i>	rubber rabbitbrush	<i>Chrysothamnus nauseosus</i>
Saltcedar	<i>Tamarix chinensis</i>	saltcedar	<i>Tamarix ramosissima</i>
red clover	<i>Trifolium pratense</i>	strawberry clover	<i>Trifolium fragiferum</i>

Using the quadrat data, vegetation zones were analytically defined along each transect using sliding-window boundary analysis in 2005 (Ludwig and Cornelius 1987). These preliminary zones were then grouped by similarity of vegetation using cluster analysis (SAS 2001) to generate a set of hierarchically arranged zones and subzones that form the foundation for the interpretation of changes across transects and throughout the study area. There are five zones and 10 subzones (excluding water) as defined by their dominant species or species complex (Table 2) (Milford et al. 2006). Appendix C provides summary vegetation cover data by species and year for each of the five major vegetation zones.

Results

Vegetation zones

A total of 121 plant species were identified along the transects during the four years of vegetation-cover surveys (Appendix D). The majority of woody cover was from exotic (non-native) species and over half of all herbaceous cover was also comprised of exotics (Fig. 2). With the reduction in grazing between 2003 and 2010 both woody and graminoid cover increased on the transects. In 2010, total average graminoid cover was 68%; over two times higher than in 2003 (Fig 2).

We focus here on trends and changes within the five major vegetation zones: 1) active channel, 2) mesic herbaceous wetland, 3) upper herbaceous wetland, 4) arroyo riparian, and 5) woody riparian. In the active channel zone, which comprised the area of open water and the surrounding aquatic vegetation dominated by rooted vascular aquatic species, graminoid cover nearly doubled between 2003 and 2010, while there was a dramatic decline in forb cover by 2010 (fig. 2b & 2c). Concurrently the average width of the open-water portion of the channel went from 2.65 m in 2003 to 1.36 m 2010. The increase in grass cover was due in part to large increases in cover of the native species knotgrass (*Paspalum distichum*) and common threesquare (*Schoenoplectus pungen*), and the exotic species tall fescue (*Festuca arundinaceae*) between 2005 and 2010 (fig 3a). The exotic creeping bentgrass (*Agrostis stolonifera*) showed a large increase in cover when grazing was first reduced between 2003 and 2004, but between 2004 and 2010 creeping bentgrass cover was in decline (Fig 3a). The exotic aquatic forb watercress (*Rorippa nasturtium-aquaticum*) was a dominant species within the channel vegetation zone when sampling began in 2003, and it increased with reduced grazing in 2004, but then dramatically dropped in cover by 2005, and was completely absent from the monitoring transects in 2010 (Fig 3a). The native aquatic forb water speedwell (*Veronica anagallis-aquatica*) was also completely absent in 2010 (Fig 3a). (Appendix C).

Table 2. Riparian vegetation zone and subzones along river cross-sections of the BLM Santa Fe River ACEC defined in 2005. Codes are NHNM acronyms for the scientific names or physical elements of the subzone name. Channel location refers to the primary landscape position of the subzones. Active Channel is the location of the current river and is usually filled with water; the Floodplain adjacent to the channel is typically flooded every one to two years up to ten; the Terrace is upper alluvial terraces that are only rarely flooded (> 10 years return interval).

Vegetation Zone	Sub-Vegetation Zone Name	Code	Channel Location
Active Channel	Open Water - little or no vegetation	OPEN WATER	Active Channel
	Watercress-Water Speedwell Aquatic Vegetation (<i>Rorippa nasturtium-aquaticum-Veronica anagallis-aquatica</i>)	RORAQU-VERANA	Active Channel
Mesic Herbaceous Wetland	Creeping Bentgrass-Knotgrass Mesic Herbaceous Vegetation (<i>Agrostis stolonifera-Paspalum distichum</i>)	AGRSTO-PASDIS	Active Floodplain
	Common Threesquare Sparse Herbaceous Wetland (<i>Schoenoplectus pungens</i>)	SCHPUN	Active Floodplain
Upper Herbaceous Wetland	Tall Fescue-Alkali Muhly Upper Herbaceous (<i>Festuca arundinaceae-Muhlenbergia asperifolia</i>)	FESARU-MUHASP	Terrace slope
	Yerba Mansa/Alkali Muhly Upper Herbaceous (<i>Anemopsis californica-Muhlenbergia asperifolia</i>)	ANECAL/MUHASP	Terrace slope
	Sparse Upper Herbaceous	SPARSE UPPER HERB	Terrace slope
Woody Riparian	Russian Olive Riparian Woodland (<i>Elaeagnus angustifolia</i>)	ELAANG	Terrace
	Russian Olive/Rubber Rabbitbush Riparian Woodland (<i>Elaeagnus angustifolia/Ericameria nauseosus</i>)	ELAANG/ERINAU	Terrace
	Saltcedar Riparian Shrubland (<i>Tamarix chinensis</i>)	TAMCHI	Terrace
Arroyo Riparian	Rubber Rabbitbush Riparian Shrubland (<i>Ericameria nauseosus</i>)	ERINAU	Terrace

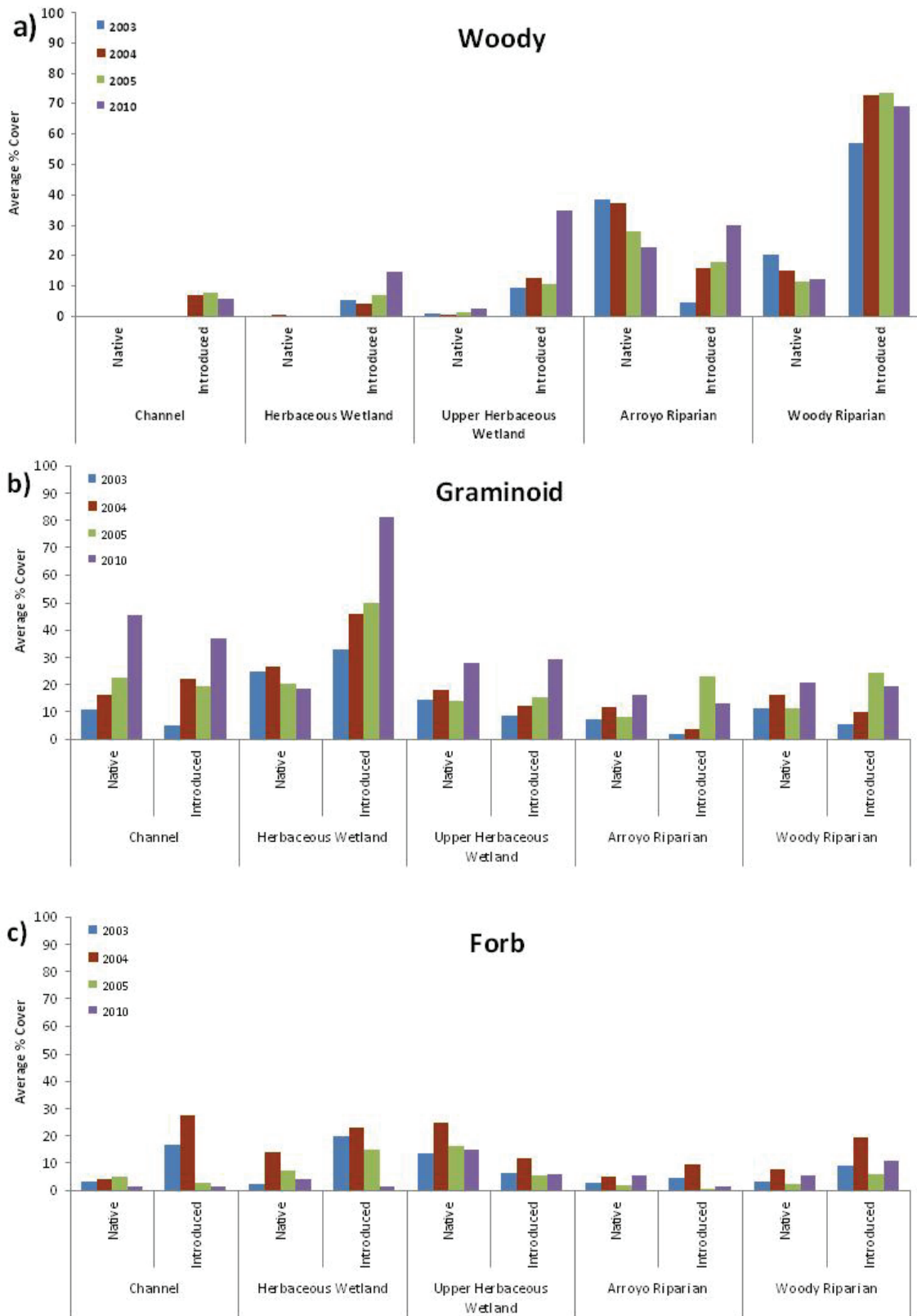


Figure 2. Average total cover by life form, vegetation zone, origin and year.

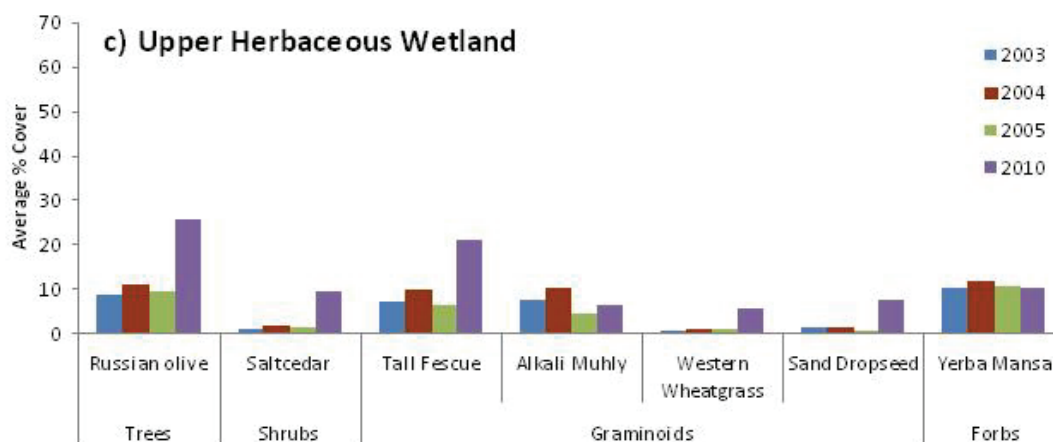
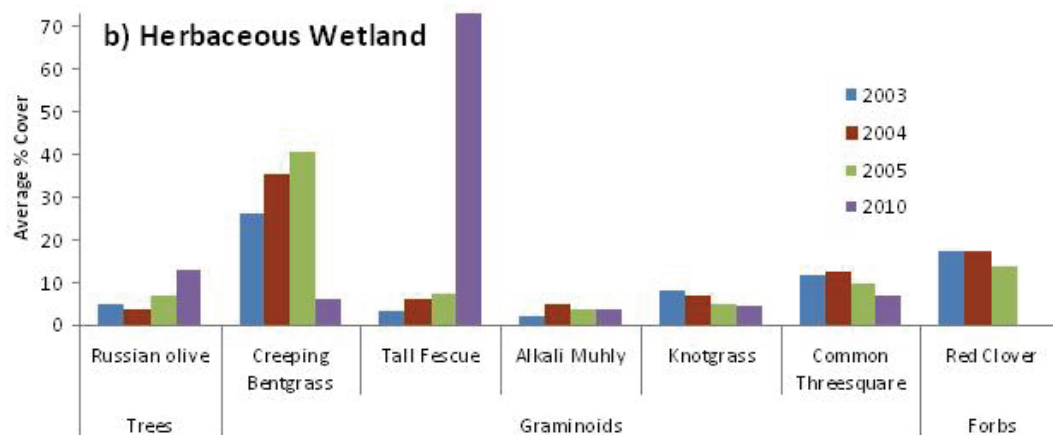
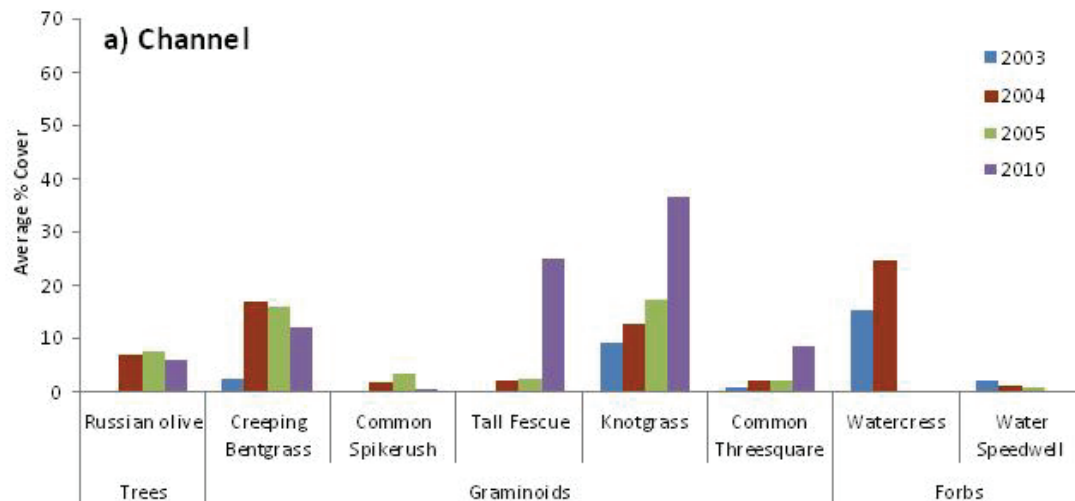


Figure 3. Average percent cover for selected species by vegetation zone and year.

The Mesic Herbaceous Wetland Zone occurs on frequently flooded alluvial bars adjacent to the active channel and is a complex of two vegetation subzones, defined as the Creeping Bentgrass-Knotgrass Mesic Herbaceous Wetland and Common Threesquare Sparse Herbaceous Wetland (Table 2). Between 2005 and 2010, exotic woody cover increased within the Herbaceous Wetland vegetation zone, due mostly to the doubling of Russian olive (*Elaeagnus angustifolia*) cover (Fig 2a, 3b). Overall graminoid cover also doubled during the period, however the increase was due to a large increase in exotic grass cover, while native species declined (Fig 2b). The exotic tall fescue became the overwhelming dominant across the entire Herbaceous Wetland Zone as it increased in cover over 1000% (Fig 3b). Other herbaceous species that were previously dominant in this zone showed a decline between 2005 and 2010 with the exotic creeping bentgrass showing the largest declines, while the native knotgrass, alkali muhly (*Muhlenbergia asperifolia*), and common threesquare were less reduced (Fig 3b). Forb cover also significantly declined between 2004 and 2010, mostly among exotics. For example, the previously dominant and abundant red clover (*Trifolium pratense*) was reduced to trace amounts from an average of 17% in 2004 (Fig 2c & 3b).

The Upper Herbaceous Wetland Zone was found on the slope between the active floodplain and upper terraces and is flooded infrequently relative to the active floodplain (soils may become saturated during high flows). It is comprised of three subzones: 1) Tall Fescue-Alkali Muhly, 2) Yerba Mansa (*Anemopsis californica*)/Alkali Muhly, and the 3) Sparse subzone. This zone can have an overhanging canopy of Russian olive shrubs and trees extending from the upper terrace. Overall, Upper Herbaceous Wetland saw an increase in both woody and graminoid cover between 2005 and 2010 (Fig 2a & b). The two dominant exotic woody species, Russian olive and saltcedar (*Tamarix chinensis*), showed large increases in cover (Fig 3c). As in the mesic herbaceous vegetation zone, tall fescue cover nearly tripled between 2005 and 2010, and it became the dominant grass (Fig 3c). However, the native species western wheatgrass (*Pascopyrum smithii*) and sand dropseed (*Sporobolus cryptandrus*), also showed large increases in cover, and went from very rare to co-dominants (Fig 3c). Other native herbaceous co-dominants such as alkali muhly and yerba mansa remained relatively stable in cover across the monitoring period (Fig 3c).

The rarely flooded terraces were characterized by the Woody Riparian Zone dominated by either Russian olive or saltcedar, and the Arroyo Riparian zone dominated by rubber rabbitbrush (*Ericameria nauseosa*). There are three subzones in the Woody Riparian: 1) Russian Olive, 2) Russian Olive/Rubber Rabbitbrush, and 3) Saltcedar. Overall, woody cover and Russian olive cover, after showing an initial uptick in cover between 2003 and 2004, remained more or less stable between 2004 and 2010 (Fig 2a & 4a). Rubber rabbitbrush showed a steady decline in cover across the monitoring period, with a 60% reduction in cover from 2003 to 2010 (Fig 4a). Saltcedar cover is relatively low and has remained more or less constant over the entire monitoring period (shifting a few percentage points either way) (Fig 4a). Overall, both native and exotic graminoid cover increased between 2003 and 2010 by 180-350% (Fig 2b). Among the herbaceous species, tall fescue again showed a significant increase in 2010. The cover of other herbaceous species was low through the monitoring period. Hence, trends were not easy to detect but there was a suggestion that western wheatgrass, sand dropseed, and yerba mansa may be increasing (Fig 4a).

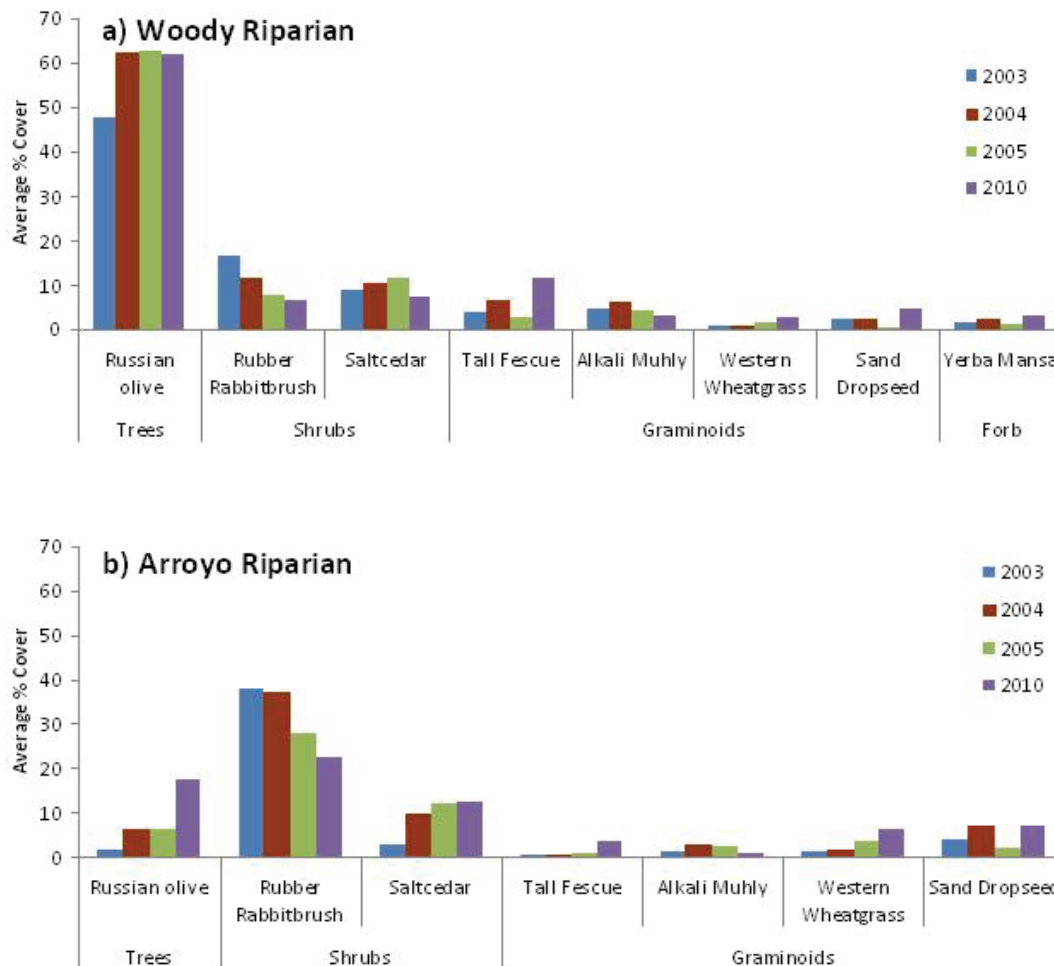


Figure 4. Average percent cover for selected species by vegetation zone and year.

The Rubber Rabbitbrush Riparian Shrubland is an arroyo riparian type present on drier terraces throughout the canyon. It occurs on dry, sandy soils that are likely only wetted during very high flows, particularly summer flash floods. Within the Arroyo riparian zone, native woody species were in decline, while exotic species increased over the monitoring period (Fig 2a). In particular, the native rubber rabbitbrush showed a large decline, while both Russian olive and saltcedar cover increased (Fig 4b). Saltcedar showed the largest increase between 2003 and 2004, while Russian olive's greatest increase was between 2005 and 2010. Herbaceous cover followed a similar pattern to that of the Woody Riparian zone, with native and exotic grass cover increasing 200-800% over the study period (Fig 2b). Tall fescue again showed a large increase in cover between 2005 and 2010, as did western wheatgrass and sand dropseed (Fig 4b). Alkali muhly again had a large decline in cover between 2005 and 2010 (Fig 4b).

Utilization

In all vegetation zones the average height of herbaceous vegetation (grasses and forbs) was less than eight centimeters in 2003 (Fig. 5). This likely reflected the high livestock utilization throughout the reach during that year, but the severe drought of 2003 may have also played a role (and perhaps indirectly as livestock gravitated to the riparian zone during the drought). The average height of herbaceous vegetation increased to about 12 cm in 2004 and 2005 as precipitation increased to near normal and livestock use declined somewhat based on on-site inspection (the exact grazing level was not measured). With nearly complete removal of livestock for two years starting in 2009, graminoids had reached an average height of 24 cm and forbs 14 cm in 2010. Many of the grasses and forbs observed on these monitoring transects have the capacity to reach anywhere from 30 to 100 cm under normal moisture conditions. Hence, by 2010 utilization had dropped from a high of around 80% to about 20%, and grazing appeared to be a less significant factor affecting standing crop biomass than in years prior.

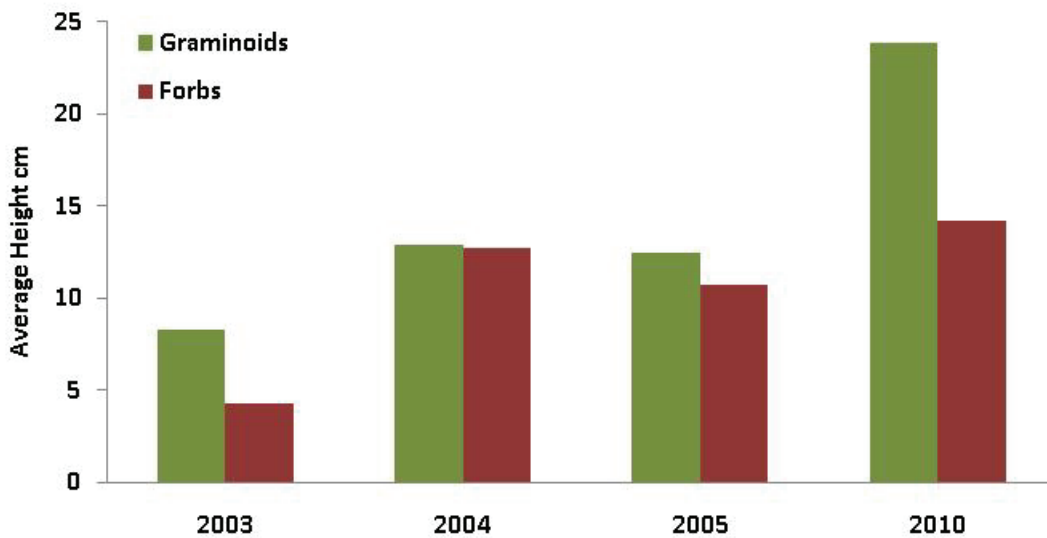


Figure 5. Average height in cm of herbaceous vegetation by year.

Tree and shrub monitoring

Eight woody species were encountered within the woody species monitoring quads, seven in 2006 and seven in 2010 (Table 3). Among these, five were native: rubber rabbitbrush, trumpet gooseberry (*Ribes leptanthum*), fourwing saltbush (*Atriplex canescens*), oneseed juniper (*Juniperus monosperma*), and Goodding's willow (*Salix gooddingii*). The other three were exotic: Russian olive (*Elaeagnus angustifolia*), saltcedar (*Tamarix ramosissima*), and Siberian elm (*Ulmus pumila*). While the native Rio Grande cottonwood (*Populus deltoides* ssp. *wislizeni*) and coyote willow (*Salix exigua*) were absent on the monitoring transects, they did occur within the canyon as scattered individuals. The most common woody species overall were rubber rabbitbrush, Russian olive, and saltcedar. As in the vegetation monitoring, rubber rabbitbrush

showed a decline in number of quadrats occupied, with 25% less in 2010 than in 2006 (Table 3). Russian olive showed an increase, occupying 30% more quadrats in 2010 than in 2006, while saltcedar remained relatively stable in the number of quadrats occupied (Table 3). Oneseed juniper, an upland species that was dominant on the canyon slopes and upper terraces, occurred only incidentally at the edge of the floodplain. Goodding's willow, like coyote willow and cottonwood, was rare, forming scattered patches of young individuals along with coyote willow; there was just one individual Goodding's willow sapling that occurred within our monitoring transects (Table 3) (Appendix C). Scattered Siberian elm are present on the floodplain terraces within the canyon, but have not yet become a major component of the woody riparian vegetation within the canyon. Fourwing saltbush was first observed within the monitoring transects in 2010, and although a common upland species, it also occurs in arroyos and terraces adjacent to rivers throughout the state.

Table 3. Tree and shrub species observed on woody monitoring quadrats with number of quadrats occupied by year.

Species Name	Common Name	2006	2010
Trees			
<i>Elaeagnus angustifolia</i>	Russian olive	22	32
<i>Juniperus monosperma</i>	oneseed juniper	2	2
<i>Salix gooddingii</i>	Goodding's willow	1	1
<i>Ulmus pumila</i>	Siberian elm	1	
Shrubs			
<i>Atriplex canescens</i>	fourwing saltbush		1
<i>Ericameria nauseosa</i>	rubber rabbitbrush	87	66
<i>Ribes leptanthum</i>	trumpet gooseberry	1	1
<i>Tamarix chinensis</i>	saltcedar	22	21

With respect to vegetation zones (Table 2), rubber rabbitbrush was most common within the Arroyo Riparian vegetation zone where it averaged approximately one individual/m², a drop from the 2006 average of 1.5 individuals/m² (Fig 7). It also occurred within the Woody Riparian zone and the Upper Herbaceous Wetland, but in these zones was considered a transitional species. It was very rare in the active floodplain in both years, and is expected to remain so as long as there is sufficient perennial flow in the river. The decline in individuals from 2006 to 2010 reflected the decline in cover that was observed in the vegetation- monitoring quadrats.

Russian olive was the dominant riparian tree species. Large, mature individuals grow in dense patches along the terrace edges just beyond the active floodplain. They occupied a narrow zone between the floodplain and the higher and drier terraces. Our count data indicated that the majority of individuals that were over two inches in diameter occurred within the Woody Riparian zone on the low terraces, and that there was recruitment to the larger stems classes from the smaller classes between 2006 and 2010 (Fig. 7). A few large individuals occurred in the Arroyo Riparian zone and the Upper Herbaceous Wetland as well, and these vegetation zones also showed an increase in large individuals between 2006 and 2010. There was a drop in the number of individuals smaller than two inches, presumably as they were recruited into the larger

size classes. There was some recruitment of small individuals in the Herbaceous Wetland and Arroyo Riparian zones, but whether this is a trend remains to be seen (Fig 7a & b).

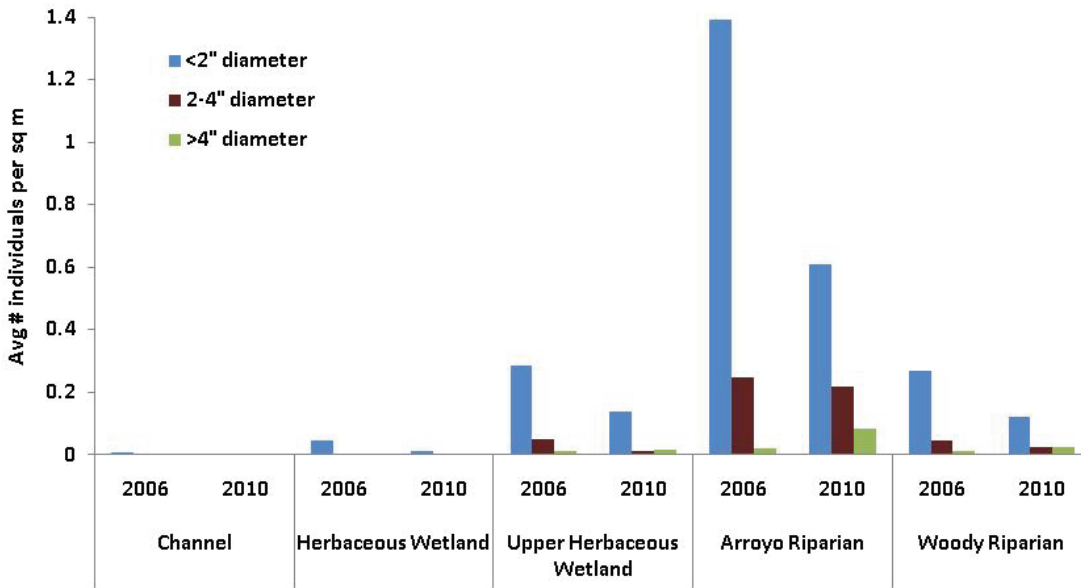


Figure 6. Average number of individual rubber rabbitbrush per square meter by vegetation zone and year.

With respect to stems (versus individuals), the majority of stems of all sizes also occurred within the Woody Riparian vegetation zone, with a number of small- and medium-sized stems also occurring in the Upper Herbaceous Wetland on the terrace slope (Fig. 8). Numbers of stems in all size classes remained stable or showed an increase between 2006 and 2010. The exception was less than two inch diameter and less than 4.5-foot tall class, which declined in both the Upper Herbaceous and Arroyo Riparian zones (Fig. 8).

Saltcedar formed dense patches along the terrace edges and was scattered throughout the reach (Fig. 9). Large individuals tend to be concentrated in the Arroyo riparian zone (Fig. 9d). Small to moderately large individuals occurred regularly in the Upper Herbaceous Wetland and Arroyo riparian zones (Fig. 9a, b & c). There was a decline in moderately large and large individuals in all vegetation zones (Fig. 9c & d). There was also a decline in small (<2") short individuals (<4.5'), but a corresponding increase into the small and tall (>4.5') class that may reflect recruitment of short individuals from 2006 into the tall class by 2010. Saltcedar stems show a similar pattern, except for an increase in small, short stems in the Woody Riparian zone (Fig 10).

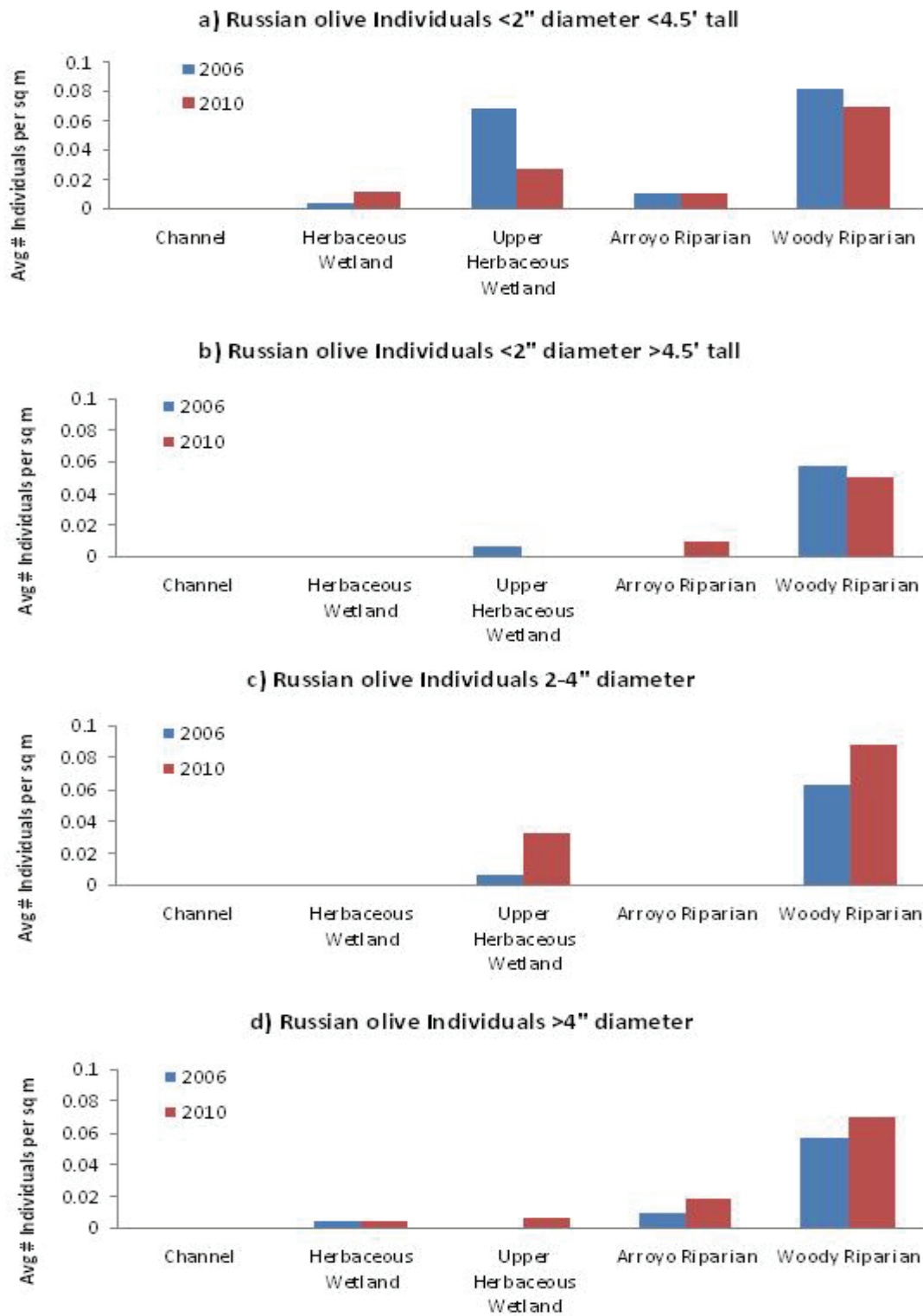


Figure 7. Number of Russian olive individuals per meter square by size class, vegetation zone and year.

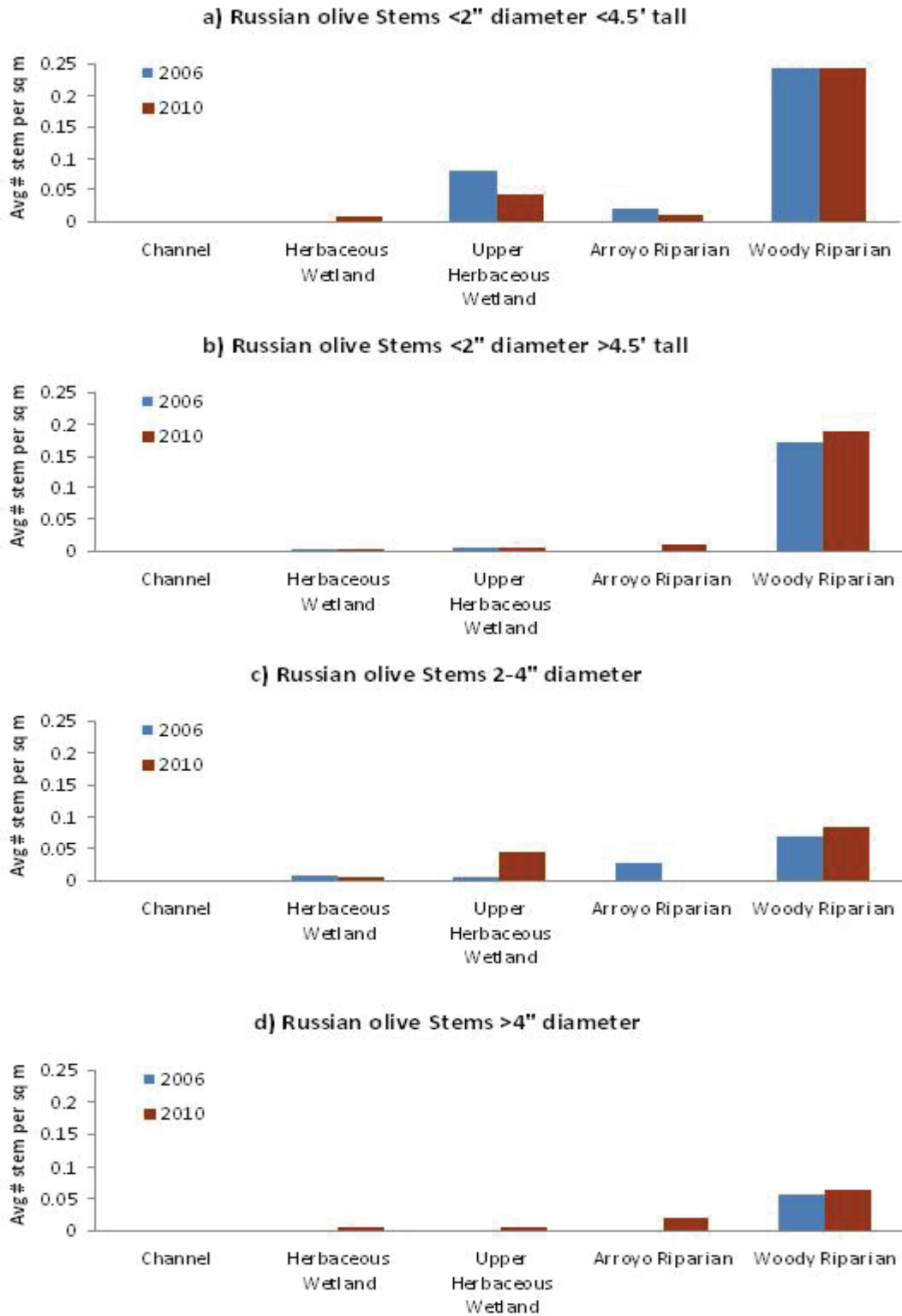


Figure 8. Number of Russian olive stems per square meter by size class, vegetation zone and year.

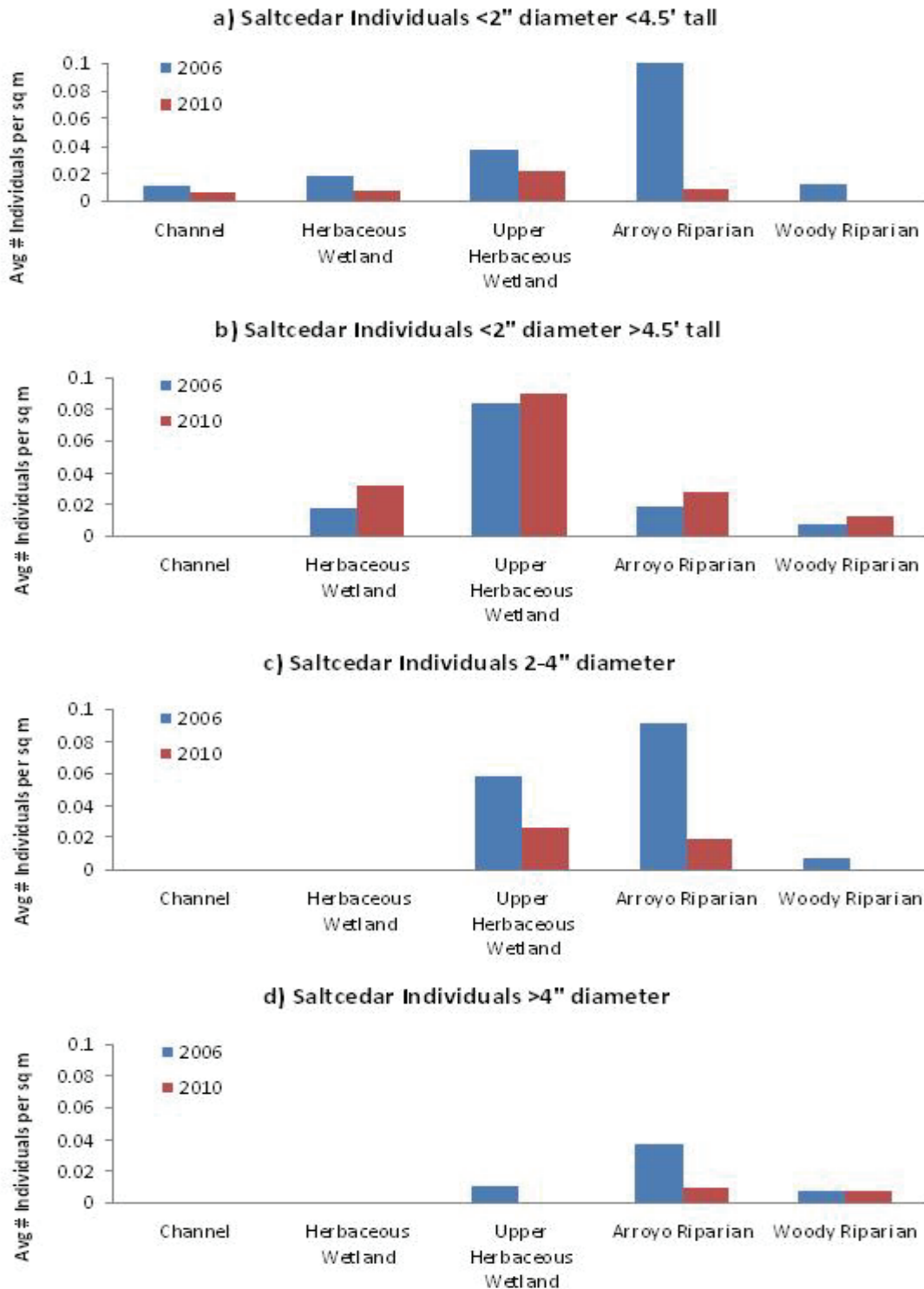


Figure 9. Number of saltcedar individuals per square meter by size class, vegetation zone and year.

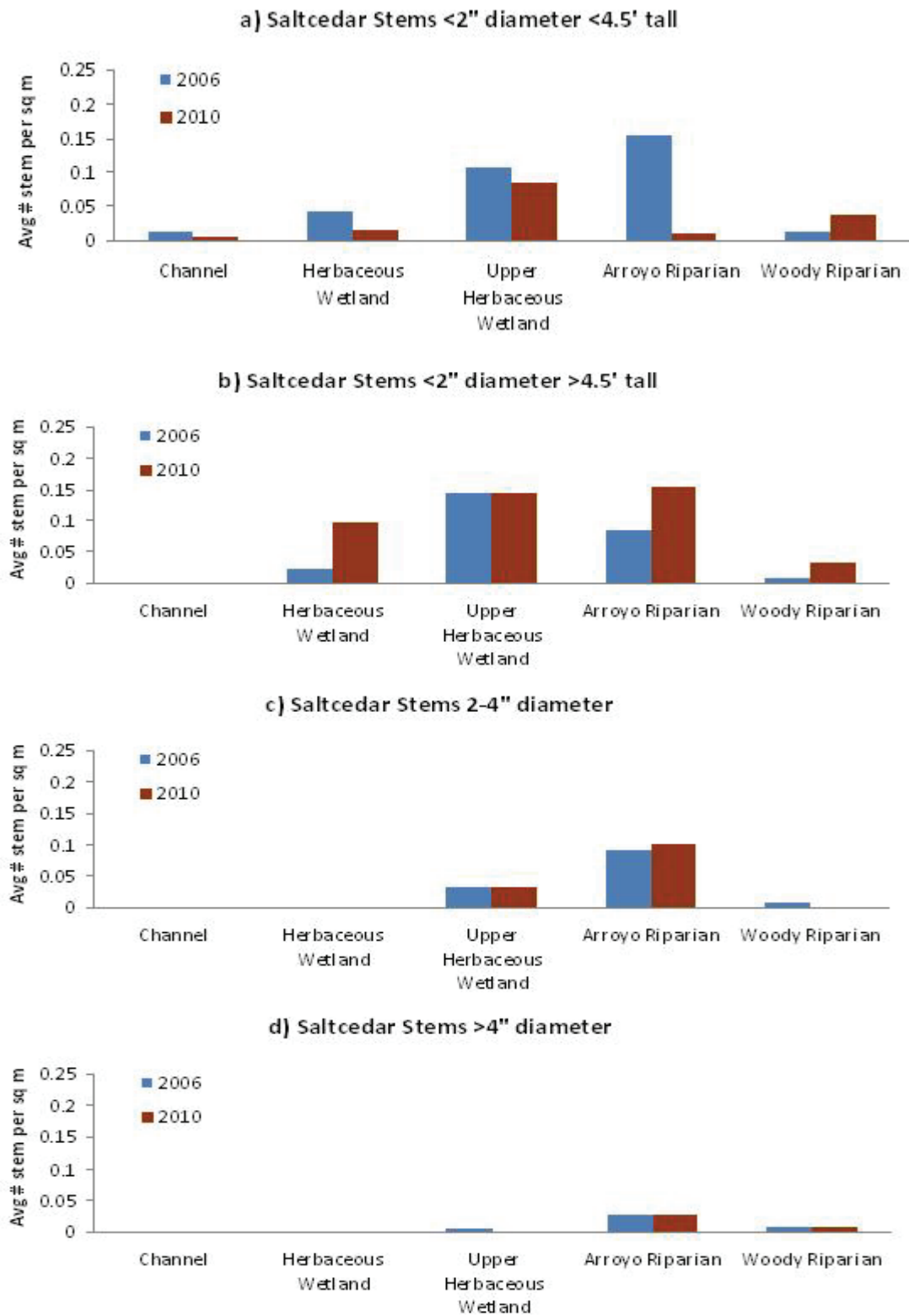


Figure 10. Number of saltcedar stems per square meter by size class, vegetation zone and year.

Discussion

With the removal of livestock within the study reach, we detected both positive and negative trends with respect to vegetation responses. Among the positives there was significant increase in grass cover, especially within the floodplain. This was due in part to increases in existing-grass standing biomass, but also to the expansion of grasses into areas of the floodplain that were previously dominated by exotic forbs (watercress and red clover) or bare exposed soil. Some of this expansion is due to a direct decrease in grazing, but a decrease in trampling may also be a factor. The dual role of grazing and its inherent trampling in altering the floodplain was most evident by the response of the active channel to removal of cattle between 2006 and 2010. The aquatic zone bordering the active channel went from being dominated by the exotic forb watercress to being dominated by the native knotgrass. There was a concomitant 50% narrowing, as well as a deepening (personal observation), of the active channel, as the banks recovered from trampling and loss of vegetation. Remeasuring the cross-section profiles of the transects, which were last measured in 2005, would help quantify this change. The deeper, narrower channel with more heavily vegetated banks should also have a positive effect on the aquatic fauna of the Santa Fe River in this reach (McIver and McInnis 2007).

Although graminoid cover increased across all vegetation zones, the largest increase was from an exotic pasture grass, tall fescue. Tall fescue became the dominant species in the herbaceous wetland vegetation zone, and co-dominant in the channel vegetation zone in 2010, replacing both other exotics (creeping bentgrass) and native species (knotgrass, alkali muhly, common threesquare). It is unknown if the dominance of tall fescue is a short-lived successional stage as part of the floodplain recovery process, or if it will prevent other, potentially native, wetland species from reclaiming the floodplain.

Woody cover also increased, but the increase was among exotic species in zones other than the Woody Riparian. The major increaser was Russian olive, with saltcedar playing a lesser role in some of the vegetation zones. Within the Woody Riparian Zone, both Russian olive and salt cedar were more or less stable. The zones where the encroachment of exotic woody species was most prevalent were the Arroyo Riparian and the Upper Herbaceous Wetland. In both, Russian olive is not quite yet the dominant species, but it is trending towards becoming so, perhaps within a few years. There appeared to be a correlation between the decline in the native rubber rabbitbrush within the Arroyo Riparian zone and an increase in Russian olive. Although currently small, there is also a trend for increasing exotic woody cover within the active floodplain in both the Herbaceous Wetland and even the Channel vegetation zones. Young plants of all three native woody riparian species (cottonwood, Goodding's willow and coyote willow) are palatable, and may be removed by livestock before they can become established. However, even with cattle removed over the last few years there has been no concurrent increase in native woody species. Without some sort of active management of exotics and/or reintroduction of native woody species, the entire floodplain may be at risk of becoming dominated almost exclusively by exotic phreatophytes.

References

- Ludwig, J. A., and J. M. Cornelius. 1987. *Locating discontinuities along ecological gradients*. Ecology 68 (2):448-450.
- McIver, J. D., and M. L. McInnis. 2007. *Cattle grazing effects on macroinvertebrates in an Oregon mountain stream*. Rangeland Ecology and Management 60:293-303.
- Milford, E., E. Muldavin, Y. Chauvin, and A. Browder. 2006. Santa Fe River Riparian Vegetation Monitoring: Report 2003-2005. Natural Heritage New Mexico Publ. No. 06-GTR-305, Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM, 50 p.
- Milford, E., E. Muldavin, Y. Chauvin, and A. Browder. 2007. Santa Fe River Riparian Vegetation Monitoring: Report 2006. Natural Heritage New Mexico Publ. No. 07-GTR-317, Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM, 19 p.

Appendix A

UTM coordinates for the end-point rebar of all the transects.

UTM locations for transect end-point rebars

Datum: NAD83 Zone 13 recorded 2010

Transect	Rebar#	Easting	Northing
03SF001	1	392003	3934759
03SF001	4	392022	3934745
03SF002	1	392250	3934778
03SF002	4	392239	3934763
03SF003	1	392594	3934735
03SF003	4	392611	3934723
03SF005	1	393036	3934793
03SF005	4	393053	3934782
03SF006	1	393476	3935170
03SF006	4	393480	3935149
03SF007	1	393660	3935331
03SF007	4	393935	3935481
03SF008	1	393938	3935517
03SF008	4	393935	3935331
03SF009	1	394287	3935510
03SF009	4	394291	3935481
03SF010	1	394626	3935651
03SF010	4	394637	3935643

Appendix B

Monitoring photos from upstream looking downstream across transect line, for each transect from four years: 2003, 2005, 2008, 2010.

Transect: 03SF001
View towards
downstream

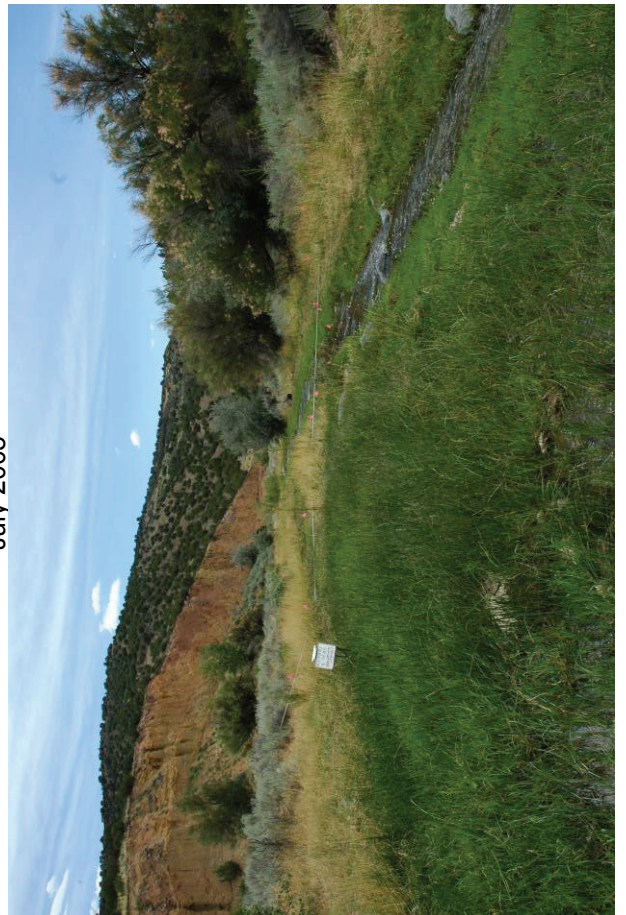
September 2003



July 2008



July 2005



August 2010



Transect: 03SF002
View towards
downstream

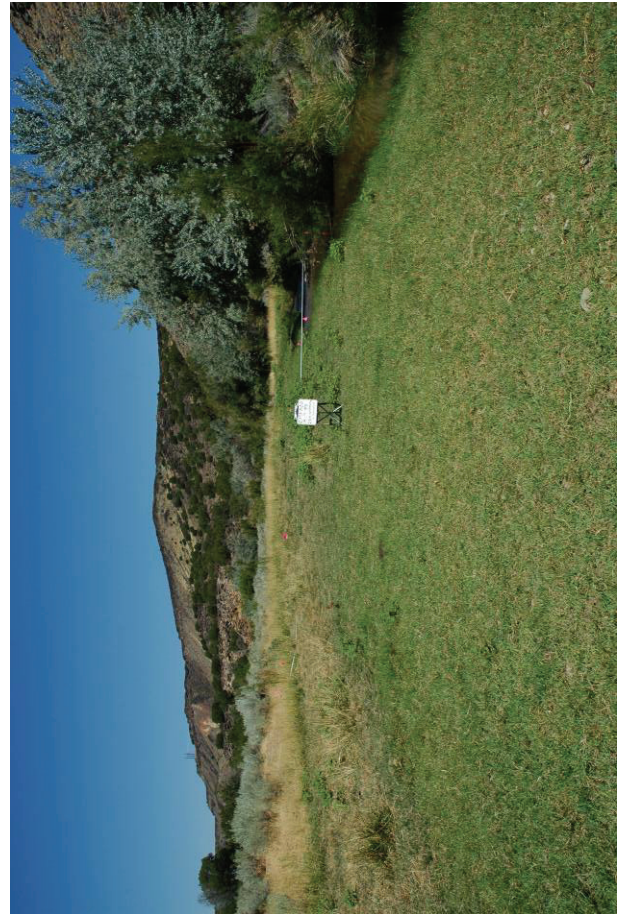
September 2003



July 2008



July 2005



August 2010



Transect: 03SF003
View towards
downstream

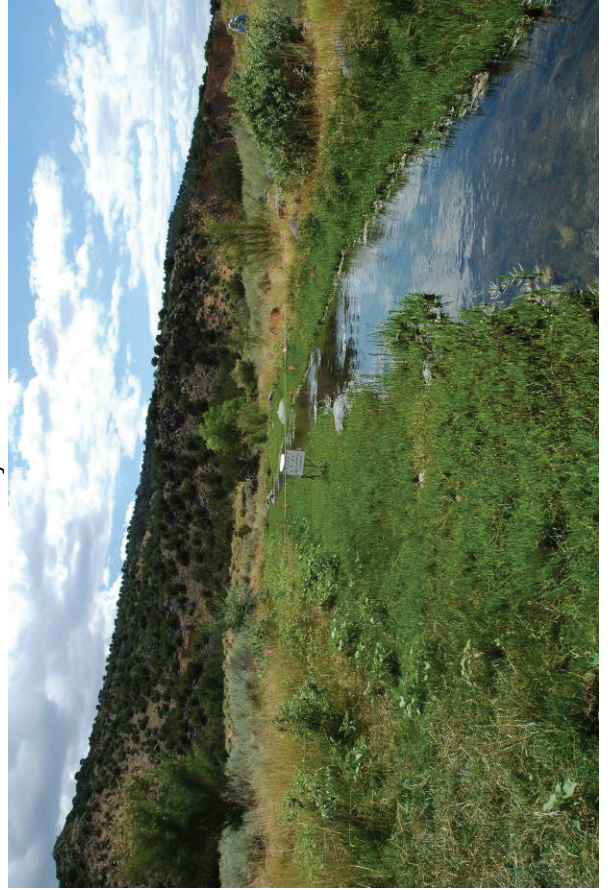
September 2003



July 2008



July 2005



August 2010

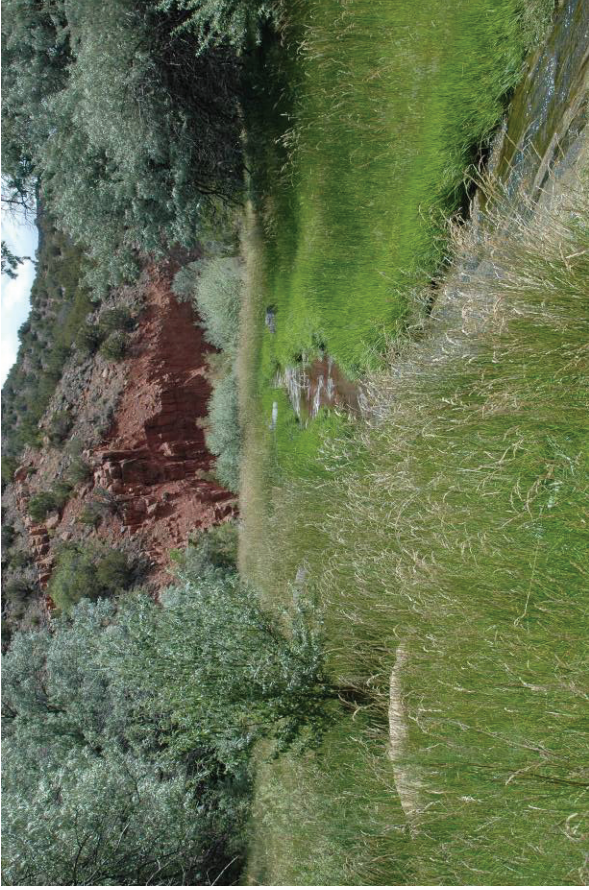


Transect: 03SF005
View towards
downstream

September 2003



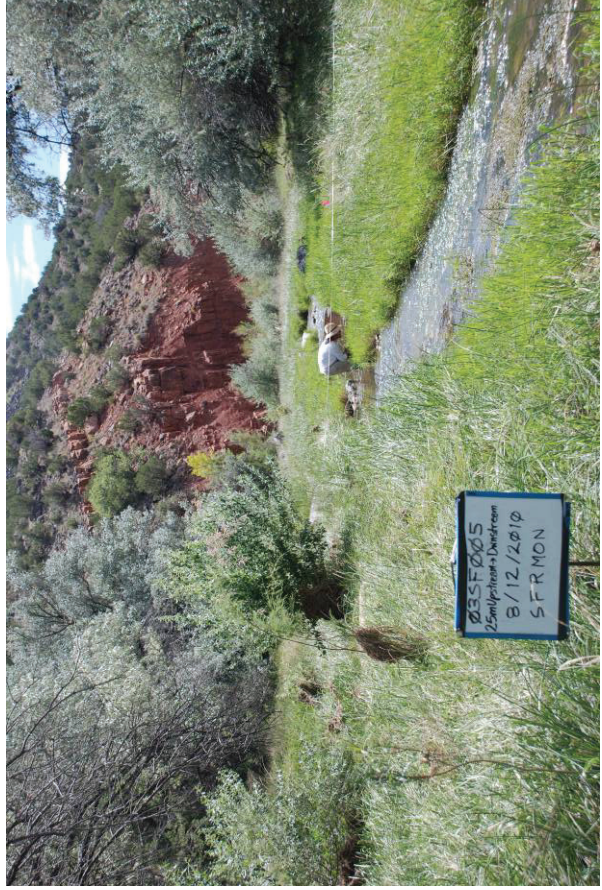
July 2008



July 2005



August 2010



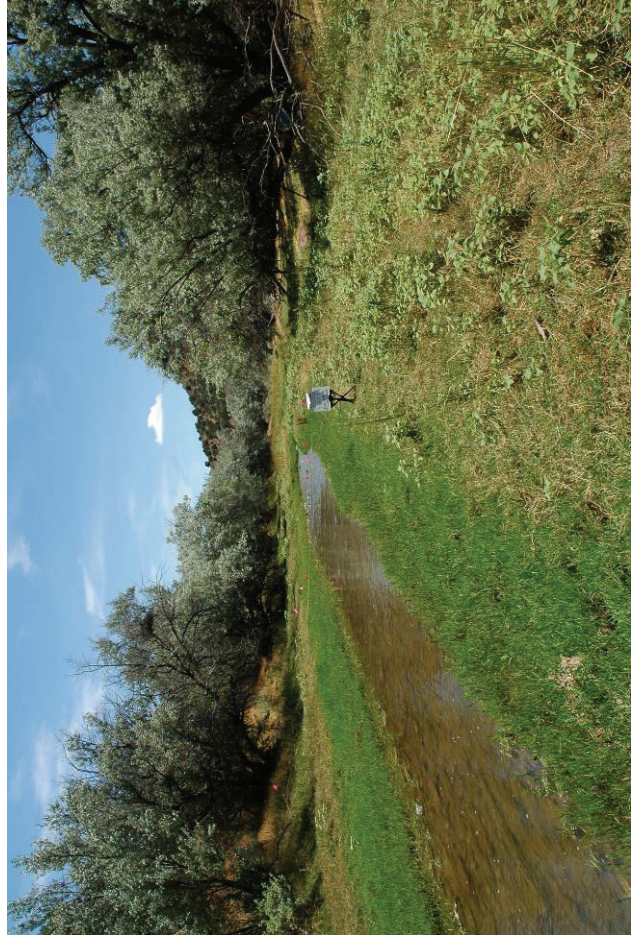
September 2003



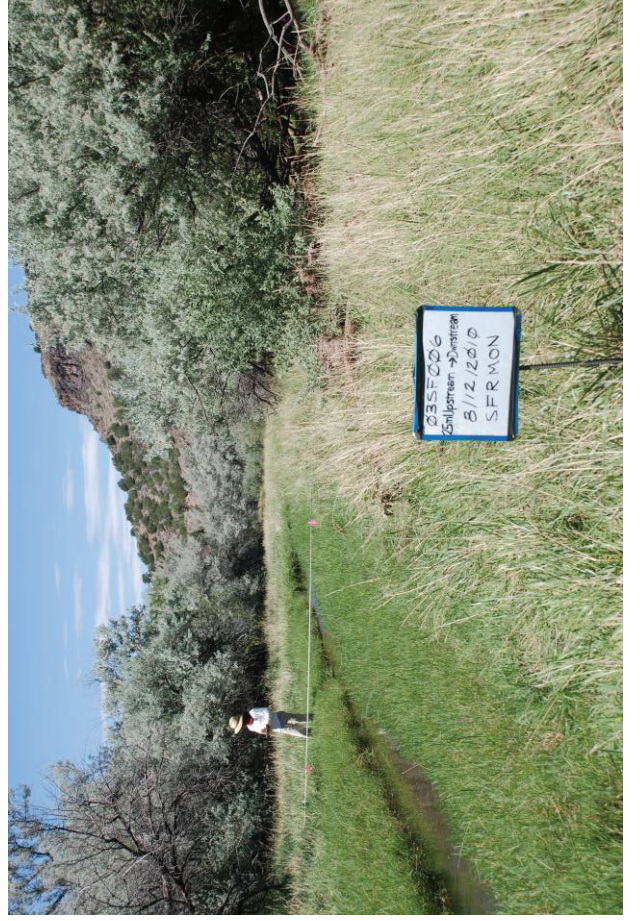
July 2008



July 2005



August 2010



September 2003



July 2008



July 2005



August 2010



Transect: 03SF008
View towards
downstream

September 2003



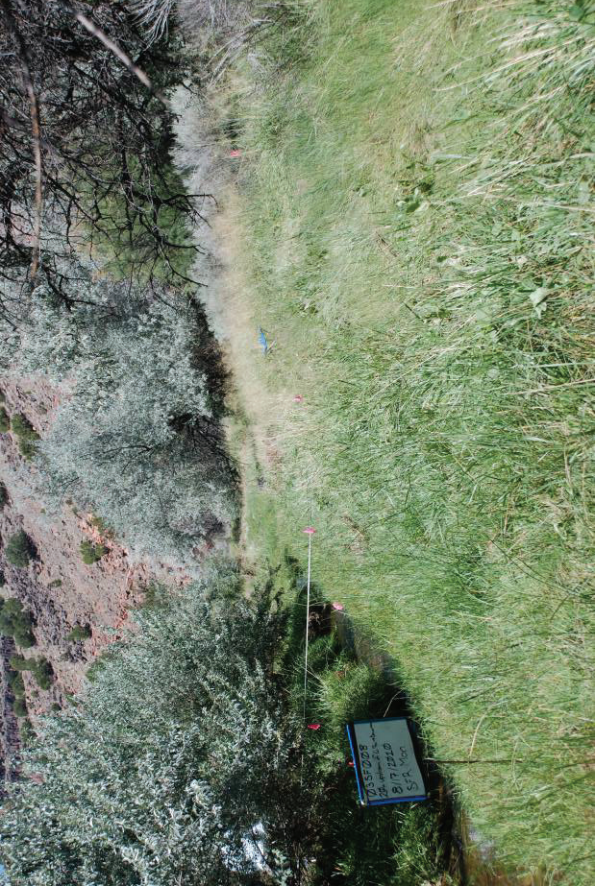
July 2008



July 2005



August 2010



Transect: 03SF009
View towards
downstream

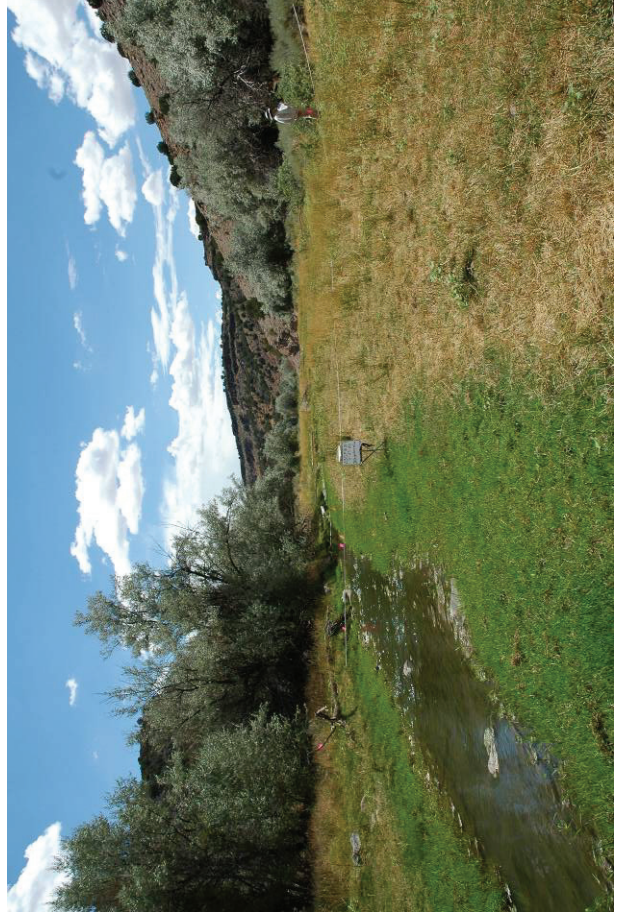
September 2003



July 2008



July 2005



August 2010

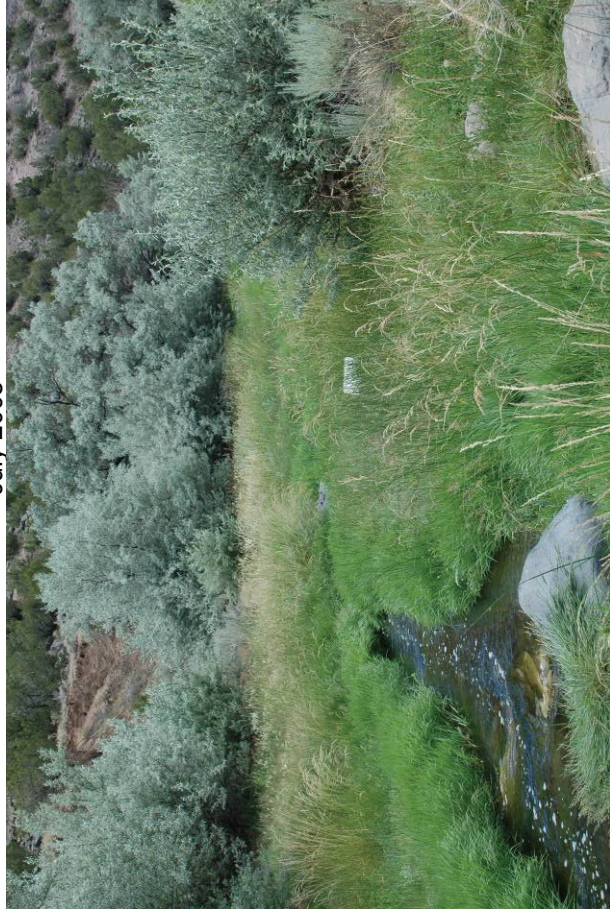


Transect: 03SF010
View towards
downstream

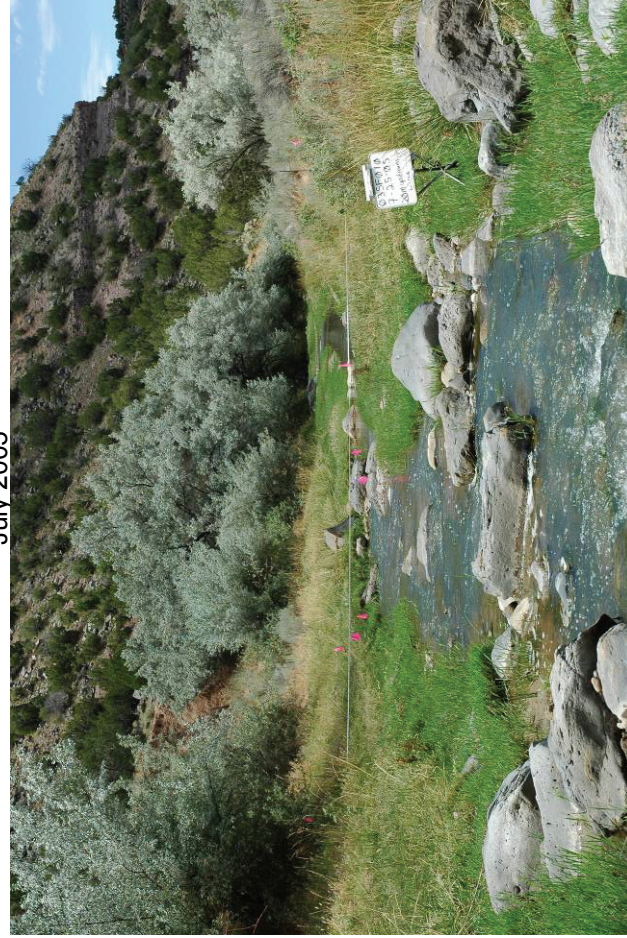
September 2003



July 2008



July 2005



August 2010



B-

Appendix C

For each of the five major vegetation zones average percent cover for all recorded species by year. Organized by vegetation zone, starting with the Channel and proceeding outward toward the Woody Riparian zone.

Channel

Species Name	Common Name	Origin	Average Cover by Year			
			2003	2004	2005	2010
Trees						
Elaeagnus angustifolia	Russian olive	I		6.76	7.431	5.681
Shrubs						
Rhus trilobata	skunkbush sumac	N			0.079	
Tamarix chinensis	saltcedar	I	0.034			
Graminoids						
Agrostis stolonifera	creeping bentgrass	I	2.284	16.75	15.65	12
Cyperus spp.	flatsedge		0.056			
Distichlis spicata	inland saltgrass	N	0.056			0.068
Echinochloa crus-galli	barnyardgrass	I	2.034	1.977	0.738	
Eleocharis palustris	common spikerush	N	0.023	1.38	3.347	0.384
Elymus repens	quackgrass	I			0.34	
Eragrostis pectinacea	tufted lovegrass	N	0.636	0.17		
Festuca arundinacea	tall fescue	I	0.113	1.886	2.261	24.6
Hordeum jubatum	foxtail barley	N				0.09
Juncus arcticus var. balticus	Baltic rush	N			0.056	
Muhlenbergia asperifolia	alkali muhly	N	0.056	0.068	0.125	0.09
Paspalum distichum	knotgrass	N	8.965	12.36	17.04	36.22
Polypogon monspeliensis	annual rabbitsfoot grass	I		1.215	0.09	
Schoenoplectus pungens	common threesquare	N	0.744	1.782	1.745	8.331
unidentified graminoid - seedling	unidentified graminoid - seedling					0.295
Forbs						
Argentina anserina	silverweed cinquefoil	N	0.056	0.056	0.09	0.102
Berula erecta	cutleaf waterparsnip	N		0.704	0.034	0.522
Calibrachoa parviflora	seaside petunia	N	0.113	0.056	0.215	
Chenopodium incanum	mealy goosefoot	N			0.005	
Cirsium vulgare	bull thistle	I		0.17		
Conyza canadensis	Canadian horseweed	N		0.023		
Melilotus officinalis	yellow sweetclover	I		0.09		
Mimulus glabratus	roundleaf monkeyflower	N	0.818	1.125	0.126	
Plantago major	common plantain	I				0.181
Polygonum aviculare	prostrate knotweed	I	0.034	0.137		
Polygonum persicaria	Lady's thumb	I	0.375	1.342	1.835	0.011
Portulaca oleracea	common purslane	N		0.022		
Ranunculus cardiophyllus	heartleaf buttercup	N	0.073			
Ranunculus cymbalaria	alkali buttercup	N			0.136	
Rorippa nasturtium-aquaticum	watercress	I	15.21	24.3	0.069	
Rumex crispus	curly dock	I	0.17	0.534	0.364	0.727
Sonchus asper	spiny sowthistle	I	0.056			
Taraxacum officinale	common dandelion	I				0.193
Trifolium pratense	red clover	I	0.785	0.694	0.284	0.227

Channel continued

	Species Name	Common Name	Origin	Average Cover by Year			
				2003	2004	2005	2010
Forbs continued							
	unidentified forb - seedling	unidentified forb - seedling					0.014
	Veronica anagallis-aquatica	water speedwell	N	1.954	0.887	0.454	
	Xanthium strumarium	rough cocklebur	N	0.09	0.852	3.659	0.795

**Herbaceous
Wetland**

Species Name	Common Name	Origin	Average Cover by Year				
			2003	2004	2005	2010	
Forbs							
<i>Almutaster pauciflorus</i>	alkali marsh aster	N	0.013	0.205	0.02	0.191	
<i>Amaranthus hybridus</i>	slim amaranth	N		0.017			
<i>Ambrosia acanthicarpa</i>	flatspine burr ragweed	N		0.395	0.273	0.027	
<i>Anemopsis californica</i>	yerba mansa	N	0.02	0.013	0.068	0.431	
<i>Argentina anserina</i>	silverweed cinquefoil	N	0.205	0.623	0.352	0.547	
<i>Berula erecta</i>	cutleaf waterparsnip	N		0.458	0.102	0.047	
<i>Bidens cernua</i>	nodding beggarstick	I		0.174			
<i>Calibrachoa parviflora</i>	seaside petunia	N	0.041				
<i>Chamaesyce serpyllifolia</i>	thymeleaf sandmat	N	0.207	0.052		0.264	
<i>Chamaesyce serrula</i>	sawtooth sandmat	N	0	0.003			
<i>Conyza canadensis</i>	Canadian horseweed	N	0.102	0.116	0.116	0.054	
<i>Equisetum laevigatum</i>	smooth horsetail	N			0.001	0.154	
<i>Gaura mollis</i>	velvetweed	N				0.103	
<i>Gaura parviflora</i>	velvetweed	N	0				
<i>Grindelia nuda</i> var. <i>aphanactis</i>	curlytop gumweed	N	0.013		0.013		
<i>Grindelia squarrosa</i>	curlycup gumweed	N				0.15	
<i>Kochia scoparia</i>	common kochia	I	0.136	1.045	0.089	0.342	
<i>Lactuca serriola</i>	prickly lettuce	I			0.034		
<i>Melilotus officinalis</i>	yellow sweetclover	I	0.006	0.931	0.075	0.185	
<i>Mimulus glabratus</i>	roundleaf monkeyflower	N	0.069	0.178	0.003		
<i>Plantago major</i>	common plantain	I				0.273	
<i>Polygonum aviculare</i>	prostrate knotweed	I	0.311	0.272	0.164	0.297	
<i>Polygonum persicaria</i>	Lady's thumb	I	0.01	0.41	0.39	0.013	
<i>Portulaca oleracea</i>	common purslane	N	0.036	0.312		0.013	
<i>Ranunculus cardiophyllus</i>	heartleaf buttercup	N	0.001				
<i>Ranunculus cymbalaria</i>	alkali buttercup	N	0.092	0.205	0.075	0.164	
<i>Rorippa nasturtium-</i> <i>aquaticum</i>	watercress	I	1.602	2.294	0		
<i>Rumex crispus</i>	curly dock	I		0.068		0.068	
<i>Salsola tragus</i>	prickly Russian thistle	I		0		0.027	
<i>Schkuhria multiflora</i>	manyflower false threadleaf	N		0.013			
<i>Symphyotrichum ericoides</i> var. <i>ericoides</i>	heath aster	N				0.136	
<i>Taraxacum officinale</i>	common dandelion	I	0.041	0.109	0.102	0.13	
<i>Trifolium pratense</i>	red clover	I	17.41	17.54	13.53	0.085	
<i>Tribulus terrestris</i>	puncturevine	I	0.069	0.028			
unidentified forb - seedling	unidentified forb - seedling					0.001	
<i>Veronica anagallis-aquatica</i>	water speedwell	N	0.082		0.068		
<i>Xanthium strumarium</i>	rough cocklebur	N	1.339	11.01	6.003	1.349	

Upper Herbaceous Wetlands

Species Name	Common Name	Origin	Average Cover by Year				
			2003	2004	2005	2010	
Trees							
Elaeagnus angustifolia	Russian olive	I	8.583	10.65	9.315	25.21	
Shrubs							
Ericameria nauseosa	rubber rabbitbrush	N	0.769	0.236	0.694	2.189	
Tamarix chinensis	saltcedar	I	0.821	1.536	1.104	9.315	
Sub-Shrubs							
Gutierrezia sarothrae	broom snakeweed	N	0.031	0.252	0.6		
Opuntia phaeacantha	tulip pricklypear	N					0.001
Graminoids							
Agrostis stolonifera	creeping bentgrass	I	0.589	1.063	2.61	0.189	
Bouteloua barbata	sixweeks grama	N	0.03	0.436		0.042	
Bouteloua gracilis	blue grama	N	0.285	0.378	0.052	0.368	
Bromus catharticus	rescuegrass	I		0.106	0.726	1.389	
Bromus japonicus	Japanese brome	I	0.001	0.127	0.694	0.605	
Bromus tectorum	cheatgrass	I		0.003	2.257	0.222	
Cenchrus spinifex	sandbur	N	0.21	0.053	0.105	0.026	
Chloris verticillata	tumble windmill grass	N			0.01		
Cynodon dactylon	bermudagrass	I	0.484	0.757	0.389	2.273	
Distichlis spicata	inland saltgrass	N	2.664	2.483	4.042	0.863	
Echinochloa crus-galli	barnyardgrass	I	0.41				
Eleocharis palustris	common spikerush	N	0.021				
Elymus elymoides	bottlebrush squirreltail	N		0.084			
Elymus lanceolatus ssp. riparius	streambank wheatgrass	N					1.484
Elymus x pseudorepens	false quackgrass	N					1.421
Elymus repens	quackgrass	I			0.422	2.684	
Eragrostis pectinacea	tufted lovegrass	N	0.007	0.012			
Festuca arundinacea	tall fescue	I	6.965	9.726	6.063	20.79	
Hordeum jubatum	foxtail barley	N				0.389	
Hordeum jubatum ssp. intermedium	intermediate barley	N		0.063			
Hordeum murinum ssp. glaucum	smooth barley	I	0.001	0.118	1.063	0.284	
Juncus arcticus var. balticus	Baltic rush	N		0.001	0.211	0.336	
Muhlenbergia asperifolia	alkali muhly	N	7.389	9.968	4.315	5.916	
Munroa squarrosa	false buffalograss	N	0.001				
Paspalum distichum	knotgrass	N	0.211				
Pascopyrum smithii	western wheatgrass	N	0.215	0.653	0.878	5.294	
Poa annua	bluegrass	I		0.116	0.2		
Poa compressa	Canada bluegrass	I			0.126		
Poa pratensis	Kentucky bluegrass	I				0.41	
Polypogon monspeliensis	annual rabbitsfoot grass	I			0.41		
Schoenoplectus pungens	common threesquare	N	1.216	1.743	1.184	1.38	
Sporobolus airoides	alkali sacaton	N	0.947	0.789	1.536	2.684	
Sporobolus cryptandrus	sand dropseed	N	1.058	1.102	0.263	7.342	
unidentified graminoid	unidentified graminoid		0.048	0.001			
unidentified graminoid - seedling	unidentified graminoid - seedling						0.01
Vulpia octoflora	sixweeks fescue	N	0.006		1.021	0.048	
Forbs							
Almutaster pauciflorus	alkali marsh aster	N	0.126	0.284	0.157	0.263	
Amaranthus hybridus	slim amaranth	N	0.033	0.003			
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.68	4.244	0.602		

Upper Herbaceous Wetlands continued

Species Name	Common Name	Origin	Average Cover by Year				
			2003	2004	2005	2010	
Forbs continued							
Anemopsis californica	yerba mansa	N	9.968	11.56	10.44	10.14	
Argentina anserina	silverweed cinquefoil	N		0.178	0.157		
Atriplex prostrata	triangle orache	N					0.057
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.015	0.007			0.126
Chamaesyce serrula	sawtooth sandmat	N	0.009				
Chenopodium atrovirens	pinyon goosefoot	N		1.284			
Chenopodium incanum	mealy goosefoot	N	0.264	0.032			
Conyza canadensis	Canadian horseweed	N	0.136	1.402	0.489		0.073
Croton texensis	Texas croton	N		0.505	0.001		
Cryptantha minima	little cryptantha	N	0.011	0.011	0.378		0.073
Dalea candida var. oligophylla	white prairieclover	N		0.001			
Descurainia spp.	tansymustard				0.021		
Descurainia obtusa	blunt tansymustard	N					0.052
Equisetum laevigatum	smooth horsetail	N					0.01
Erigeron flagellaris	trailing fleabane	N					0.294
Euphorbia exstipulata	squareseed spurge	N	0.005	0.002			
Gaura mollis	velvetweed	N					0.084
Kallstroemia hirsutissima	hairy caltrop	N	0.015				
Kochia scoparia	common Kochia	I	1.487	6.333	1.257		5.447
Lactuca serriola	prickly lettuce	I			0.115		
Machaeranthera pinnatifida	lacy tansyaster	N	0.227	0.026	0.18		
Melilotus officinalis	yellow sweetclover	I		0.673	0.284		0.052
Mentzelia multiflora	manyflowered mentzelia	N			0.01		
Plantago patagonica	woolly plantain	N			0.063		
Polygonum aviculare	prostrate knotweed	I	0.564	0.577	1.212		0.136
Portulaca oleracea	common purslane	N	0.493	1.094			0.006
Ratibida tagetes	green prairie coneflower	N	0.242	0.568	0.921		2.4
Rumex crispus	curly dock	I	0.105	0.105	0.031		0.021
Salsola tragus	prickly Russian thistle	I	0.178	2.137	0.011		0.243
Schkuhria multiflora	manyflower false threadleaf	N		0.01			
Solanum elaeagnifolium	silverleaf nightshade	N	0.021	0.115	0.042		
Sphaeralcea coccinea	scarlet globemallow	N		0.01			
Stephanomeria pauciflora	brownplume wirelettuce	N		0.242	0.126		
Symphyotrichum ericoides var. ericoides	heath aster	N					0.105
Taraxacum officinale	common dandelion	I	0.073	0.042			
Tragopogon pratensis	meadow salsify	I					0.031
Trifolium pratense	red clover	I	2.778	1.252	2.105		
Tribulus terrestris	puncturevine	I	0.957	0.37			0.001
unidentified forb	unidentified forb		0.006				
Xanthium strumarium	rough cocklebur	N	0.884	2.938	2.094		0.921

Arroyo Riparian

Species Name	Common Name	Origin	Average Cover by Year				
			2003	2004	2005	2010	
Trees							
Elaeagnus angustifolia	Russian olive	I	1.544	5.944	5.908	17.45	
Shrubs							
Ericameria nauseosa	rubber rabbitbrush	N	37.85	37.05	27.74	22.55	
Tamarix chinensis	saltcedar	I	2.909	9.818	11.64	12.38	
Sub-Shrubs							
Gutierrezia sarothrae	broom snakeweed	N	0.09	0.036			
Graminoids							
Agrostis stolonifera	creeping bentgrass	I	0.363	0.854	0.672	0.109	
Bouteloua barbata	sixweeks grama	N	0.009				
Bromus catharticus	rescuegrass	I	0.009	0.181	0.018		
Bromus japonicus	Japanese brome	I	0.09		0.181	1.572	
Bromus tectorum	cheatgrass	I	0.803	1.772	18.17	3.774	
Cenchrus spinifex	sandbur	N	0.009	0.018			
Distichlis spicata	inland saltgrass	N	1.063	0.454	0.309	0.745	
Elymus x pseudorepens	false quackgrass	N					1.154
Elymus repens	quackgrass	I					3.636
Eragrostis pectinacea	tufted lovegrass	N	0.02	0.436			
Festuca arundinacea	tall fescue	I	0.363	0.418	0.763	3.663	
Hordeum murinum ssp. glaucum	smooth barley	I	0.001	0.263	2.71	0.2	
Juncus arcticus var. balticus	Baltic rush	N			0.009		
Muhlenbergia asperifolia	alkali muhly	N	1.081	2.709	2.181	0.836	
Munroa squarrosa	false buffalograss	N	0.001				
Pascopyrum smithii	western wheatgrass	N	0.9	1.31	3.409	5.909	
Poa annua	bluegrass	I			0.036		
Polypogon monspeliensis	annual rabbitsfoot grass	I			0.274		
Schoenoplectus pungens	common threesquare	N	0.109	0.054	0.09		
Sporobolus cryptandrus	sand dropseed	N	3.921	6.818	1.918	7.269	
unidentified graminoid - seedling	unidentified graminoid - seedling						0.081
Vulpia octoflora	sixweeks fescue	N	0.054		0.003		
Forbs							
Amaranthus hybridus	slim amaranth	N	0.776	0.043			
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.654	2.44	0.156	1.454	
Boerhavia spicata	creeping spiderling	N		0.145		0.009	
Brassicaceae	mustard family				0.018		
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.189	0.287		0.721	
Chamaesyce serrula	sawtooth sandmat	N		0.147		0.036	
Chenopodium incanum	mealy goosefoot	N	0.018				
Conyza canadensis	Canadian horseweed	N			0.09		
Cucurbita foetidissima	buffalo gourd	N		0.09			
Dalea candida var. oligophylla	white prairieclover	N		0.09			
Descurainia spp.	tansymustard				0.009		
Equisetum laevigatum	smooth horsetail	N			0.009	0.109	
Gaura mollis	velvetweed	N				1.381	
Gaura parviflora	velvetweed	N	0.036		0.272		
Grindelia nuda var. aphanactis	curlytop gumweed	N	0.018	0.218	0.69		
Heterotheca villosa	hairy goldenaster	N				0.018	
Kallstroemia hirsutissima	hairy caltrop	N		0.072			
Kochia scoparia	common kochia	I	2.19	6.854		0.836	
Lactuca serriola	prickly lettuce	I			0.036		

Arroyo Riparian continued

Species Name	Common Name	Origin	Average Cover by Year			
			2003	2004	2005	2010
Forbs continued						
Machaeranthera pinnatifida	lacy tansyaster	N	0.254	0.327	0.22	
Melilotus officinalis	yellow sweetclover	I	0.009		0.29	
Physaria fendleri	Fendler's bladderpod	N				0.218
Plantago patagonica	woolly plantain	N			0.018	
Polygonum aviculare	prostrate knotweed	I	0.136	0.181	0.018	0.145
Portulaca oleracea	common purslane	N	0.265	0.338		
Salsola tragus	prickly Russian thistle	I	0.056	0.572		
Schkuhria multiflora	manyflower false threadleaf	N		0		
Scorzonera laciniata	cutleaf vipergrass	I				0.018
Solanum elaeagnifolium	silverleaf nightshade	N				0.909
Taraxacum officinale	common dandelion	I		0.018		0.036
Tidestromia lanuginosa	wooly tidestromia	N		0.036		
Tribulus terrestris	puncturevine	I	1.347	1.085		0.156
Verbascum thapsus	common mullein	I	0.272	0.272		
Xanthisma gracile	slender goldenweed	N				0.036
Xanthisma spinulosum	lacy tansyaster	N				0.129
Xanthium strumarium	rough cocklebur	N	0.163	0.181		

Woody Riparian

Species Name	Common Name	Origin	Average Cover by Year			
			2003	2004	2005	2010
Trees						
Elaeagnus angustifolia	Russian olive	I	47.71	62.25	62.39	61.81
Juniperus monosperma	oneseed juniper	N	3.312	3.437	3.437	5.25
Shrubs						
Ericameria nauseosa	rubber rabbitbrush	N	16.75	11.31	7.837	6.487
Tamarix chinensis	saltcedar	I	9	10.25	11.23	7.25
Sub-Shrubs						
Gutierrezia sarothrae	broom snakeweed	N	0.001			0.287
Graminoids						
Agrostis stolonifera	creeping bentgrass	I	0.1	0.875	1.262	0.562
Bouteloua barbata	sixweeks grama	N	0.006			
Bromus catharticus	rescuegrass	I		0.001	0.025	0.35
Bromus japonicus	Japanese brome	I		0.002		0.287
Bromus tectorum	cheatgrass	I	0.545	1.163	6.94	2.8
Carex praegracilis	clustered field sedge	N	0.568	0.487	0.7	0.018
Cyperus spp.	flatsedge		0.006			
Distichlis spicata	inland saltgrass	N	2.231	4.138	2.75	4.512
Echinochloa crus-galli	barnyardgrass	I	0.062			
Elymus elymoides	bottlebrush squirreltail	N		1.337		
Elymus lanceolatus ssp. riparius	streambank wheatgrass	N				2.3
Elymus x pseudorepens	false quackgrass	N				1.618
Elymus repens	quackgrass	I			0.737	0.225
Eragrostis pectinacea	tufted lovegrass	N	0.015			
Festuca arundinacea	tall fescue	I	3.732	6.568	2.387	11.31
Hordeum jubatum	foxtail barley	N				0.412
Hordeum jubatum ssp. intermedium	intermediate barley	N		0.281	0.187	
Hordeum murinum ssp. glaucum	smooth barley	I	0.093	0.591	12.52	3.52
Juncus arcticus var. balticus	Baltic rush	N	0.062	0.013	0.15	
Muhlenbergia asperifolia	alkali muhly	N	4.468	6.145	4.326	3.25
Paspalum distichum	knotgrass	N	0.025	0.025	0.037	
Pascopyrum smithii	western wheatgrass	N	0.55	0.875	1.562	2.7
Poa annua	bluegrass	I	0.8	0.35	0.168	
Polypogon monspeliensis	annual rabbitsfoot grass	I			0.187	
Schoenoplectus pungens	common threesquare	N	0.577	0.112	0.488	0.093
Sporobolus airoides	alkali sacaton	N	0.437	0.626	0.625	0.85
Sporobolus cryptandrus	sand dropseed	N	2.245	2.011	0.206	4.693
Vulpia octoflora	sixweeks fescue	N			0.05	
Forbs						
Amaranthus hybridus	slim amaranth	N	0.063	0.19		0.312
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.775	1.487	0.038	
Anemopsis californica	yerba mansa	N	1.443	2	1.137	3.231
Argentina anserina	silverweed cinquefoil	N	0.287	0.3	0.325	0.012
Artemisia ludoviciana	white sagebrush	N				0.006
Atriplex prostrata	triangle orache	N				0.262
Brassicaceae	mustard family			0.012		
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.017	0.093		0.001
Chamaesyce serrula	sawtooth sandmat	N	0.001			
Chenopodium atrovirens	pinyon goosefoot	N		0.25		
Chenopodium fremontii	Fremont's goosefoot	N				0.337

Woody

Riparian continued

Species Name	Common Name	Origin	Average Cover by Year			
			2003	2004	2005	2010
Forbs continued						
Chenopodium incanum	mealy goosefoot	N	0.012	0.34		
Cirsium vulgare	bull thistle	I	0.087		0.212	0.006
Conyza canadensis	Canadian horseweed	N	0.018	0.012	0.401	
Croton texensis	Texas croton	N	0.006			
Dalea candida var. oligophylla	white prairieclover	N	0.025	0.312		
Equisetum laevigatum	smooth horsetail	N			0.001	
Erigeron flagellaris	trailing fleabane	N				0.25
Erodium cicutarium	redstem stork's bill	I		0.193		
Euphorbia davidii	David's spurge	I				0.012
Grindelia nuda var. aphanactis	curlytop gumweed	N	0.062			
Heterotheca villosa	hairy goldenaster	N		0.15	0.001	
Ipomoea cristulata	transpecos morningglory	N				0.006
Ipomopsis longiflora	flaxflowered ipomopsis	N	0.001			
Ipomoea spp.	morning glory		0.037			
Kochia scoparia	common kochia	I	6.332	17.99	5.031	9.963
Lactuca serriola	prickly lettuce	I	0.012		0.05	0.025
Malva neglecta	common mallow	N	0.001	0.062		
Mirabilis linearis	narrowleaf four o'clock	N		0.062		0.3
Physaria fendleri	Fendler's bladderpod	N				0.062
Polygonum aviculare	prostrate knotweed	I	0.556	0.447	0.177	0.175
Polygonum persicaria	Lady's thumb	I	0.125			
Portulaca oleracea	common purslane	N	0.18	0.342		
Rumex crispus	curly dock	I	0.026	0.012		0.025
Salsola tragus	prickly Russian thistle	I	0.012	0.112	0.062	0.063
Schkuhria multiflora	threadleaf	N	0.013			
Scorzonera laciniata	cutleaf vipergrass	I	0.212			
Sisyrinchium demissum	dwarf blue-eyed grass	N		0.062	0.125	
Sisymbrium spp.	hedgemustard				0.062	
Solanum elaeagnifolium	silverleaf nightshade	N	0.012			0.275
Sonchus asper	spiny sowthistle	I		0.025		
Taraxacum officinale	common dandelion	I	0.837	0.312	0.187	0.05
Trifolium pratense	red clover	I	0.312	0.165	0.15	
Tribulus terrestris	puncturevine	I	0.045			0.025
unidentified forb	unidentified forb		0.002			
unidentified forb - seedling	unidentified forb - seedling					0.026
Xanthium strumarium	rough cocklebur	N	0.012	1.725	0.001	0.112

Appendix D

Inclusive species list from all transects across all years.

Species Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Trees				
<i>Elaeagnus angustifolia</i>	Russian olive	ELAANG	ELAN	I
<i>Juniperus monosperma</i>	oneseed juniper	JUNMON	JUMO	N
<i>Salix gooddingii</i>	Goodding's willow	SALGOO	SAGO	N
<i>Ulmus pumila</i>	Siberian elm	ULMPUM	ULPU	I
Shrubs				
<i>Ericameria nauseosa</i>	rubber rabbitbrush	ERINAU	ERNA10	N
<i>Rhus trilobata</i>	skunkbush sumac	RHUTRI	RHTR	N
<i>Salix exigua</i>	coyote willow	SALEXI	SAEX	N
<i>Tamarix chinensis</i>	saltcedar	TAMCHI	TACH2	I
Sub-Shrubs				
<i>Gutierrezia sarothrae</i>	broom snakeweed	GUTSAR	GUSA2	N
<i>Opuntia phaeacantha</i>	tulip pricklypear	OPUPHA	OPPH	N
Graminoids				
<i>Agrostis gigantea</i>	redtop	AGRGIG	AGGI2	I
<i>Agrostis stolonifera</i>	creeping bentgrass	AGRSTO	AGST2	I
<i>Bouteloua barbata</i>	sixweeks grama	BOUBAR	BOBA2	N
<i>Bouteloua gracilis</i>	blue grama	BOUGRA	BOGR2	N
<i>Bromus catharticus</i>	rescuegrass	BROCAT	BRCA6	I
<i>Bromus japonicus</i>	Japanese brome	BROJAP	BRJA	I
<i>Bromus tectorum</i>	cheatgrass	BROTEC	BRTE	I
<i>Carex praegracilis</i>	clustered field sedge	CARPRA	CAPR5	N
<i>Cenchrus spinifex</i>	sandbur	CENSPI	CESP4	N
<i>Chloris verticillata</i>	tumble windmill grass	CHLVER	CHVE2	N
<i>Cynodon dactylon</i>	bermudagrass	CYNDAC	CYDA	I
<i>Cyperus</i> spp.	flatsedge	CYPERU	CYPER	
<i>Distichlis spicata</i>	inland saltgrass	DISSPI	DISP	N
<i>Echinochloa crus-galli</i>	barnyardgrass	ECHCRU	ECCR	I
<i>Eleocharis palustris</i>	common spikerush	ELEPAL	ELPA3	N
<i>Elymus elymoides</i>	bottlebrush squirreltail	ELYELY	ELEL5	N
	streambank			
<i>Elymus lanceolatus</i> ssp. <i>riparius</i>	wheatgrass	ELYLANR	ELLAR	N
<i>Elymus repens</i>	quackgrass	ELYREP	ELRE4	I
<i>Elymus x pseudorepens</i>	false quackgrass	ELYPSE	ELPS	N
<i>Eragrostis pectinacea</i>	tufted lovegrass	ERAPEC	ERPE	N
<i>Festuca arundinacea</i>	tall fescue	FESARU	FEAR3	I
<i>Hordeum jubatum</i>	foxtail barley	HORJUB	HOJU	N
<i>Hordeum jubatum</i> ssp. <i>intermedium</i>	intermediate barley	HORJUBI	HOJUI	N
<i>Hordeum murinum</i> ssp. <i>glaucum</i>	smooth barley	HORMURG	HOMUG	I
<i>Juncus arcticus</i> var. <i>balticus</i>	Baltic rush	JUNARCB	JUARB5	N
<i>Muhlenbergia asperifolia</i>	alkali muhly	MUHASP	MUAS	N
<i>Munroa squarrosa</i>	false buffalograss	MUNSQU	MOSQ	N
<i>Pascopyrum smithii</i>	western wheatgrass	PASSMI	PASM	N

Species Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Graminoids continued				
<i>Paspalum distichum</i>	knotgrass	PASDIS	PADI6	N
<i>Poa annua</i>	bluegrass	POAANN	POAN	I
<i>Poa compressa</i>	Canada bluegrass	POACOM	POCO	I
<i>Poa pratensis</i>	Kentucky bluegrass	POAPRA	POPR	I
<i>Polypogon interruptus</i>	ditch rabbitsfoot grass	POLINT	POIN7	I
<i>Polypogon monspeliensis</i>	annual rabbitsfoot grass	POLMON	POMO5	I
<i>Schoenoplectus pungens</i>	common threesquare	SCHPUN	SCPU10	N
<i>Sporobolus airoides</i>	alkali sacaton	SPOAIR	SPAI	N
<i>Sporobolus cryptandrus</i>	sand dropseed	SPOCRY	SPCR	N
unidentified graminoid	unidentified graminoid	UNIDG	2GRAM	
unidentified graminoid - seedling	- seedling	UNIDGS		
<i>Vulpia octoflora</i>	sixweeks fescue	VULOCT	VUOC	N
Forbs				
<i>Almutaster pauciflorus</i>	alkali marsh aster	ALMPAU	ALPA14	N
<i>Amaranthus hybridus</i>	slim amaranth	AMAHYB	AMHY	N
<i>Ambrosia acanthicarpa</i>	flatspine burr ragweed	AMBACA	AMAC2	N
<i>Anemopsis californica</i>	yerba mansa	ANECAL	ANCA10	N
<i>Argentina anserina</i>	silverweed cinquefoil	ARGANS	ARAN7	N
<i>Artemisia ludoviciana</i>	white sagebrush	ARTLUD	ARLU	N
<i>Atriplex prostrata</i>	triangle orache	ATRPRO	ATPR	N
<i>Berula erecta</i>	cutleaf waterparsnip	BERERE	BEER	N
<i>Bidens cernua</i>	nodding beggarstick	BIDCER	BICE	I
<i>Boerhavia spicata</i>	creeping spiderling	BOESPI	BOSP	N
Brassicaceae	mustard family	BRASSI2	BRASSI	
<i>Calibrachoa parviflora</i>	seaside petunia	CALPAR	CAPA47	N
<i>Chamaesyce serpyllifolia</i>	thymeleaf sandmat	CHASER2	CHSE6	N
<i>Chamaesyce serrula</i>	sawtooth sandmat	CHASER3	CHSE7	N
<i>Chenopodium atrovirens</i>	pinyon goosefoot	CHEATR	CHAT	N
<i>Chenopodium fremontii</i>	Fremont's goosefoot	CHEFRE	CHFR3	N
<i>Chenopodium incanum</i>	mealy goosefoot	CHEINC	CHIN2	N
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	CIVU	I
<i>Conyza canadensis</i>	Canadian horseweed	CONCAN	COCA5	N
<i>Croton texensis</i>	Texas croton	CROTEX	CRTE4	N
<i>Cryptantha minima</i>	little cryptantha	CRYMIN	CRMI5	N
<i>Cucurbita foetidissima</i>	buffalo gourd	CUCFOE	CUFO	N
<i>Dalea candida</i> var. <i>oligophylla</i>	white prairieclover	DALCANO	DACAO	N
<i>Descurainia obtusa</i>	blunt tansymustard	DESOBT	DEOB	N
<i>Descurainia</i> spp.	tansymustard	DESCUR	DESCU	
<i>Equisetum laevigatum</i>	smooth horsetail	EQUAE	EQLA	N
<i>Erigeron flagellaris</i>	trailing fleabane	ERIFLA	ERFL	N
<i>Erodium cicutarium</i>	redstem stork's bill	EROCIC	ERIC6	I
<i>Euphorbia davidii</i>	David's spurge	EUPDAV	EUDA5	I
<i>Euphorbia exstipulata</i>	squareseed spurge	EUPEXS	EUEX4	N
<i>Gaura mollis</i>	velvetweed	GAUMOL	GAMO5	N
<i>Gaura parviflora</i>	velvetweed	GAUPAR	GAPA6	N

Species Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Forbs continued				
Grindelia nuda var. aphanactis	curlytop gumweed	GRINUDA	GRNUA	N
Grindelia squarrosa	curlycup gumweed	GRISQU	GRSQ	N
Heterotheca villosa	hairy goldenaster transpecos	HETVIL	HEVI4	N
Ipomoea cristulata	morningglory	IPOCRI	IPCR	N
Ipomoea spp.	morning glory	IPOMOE	IPOMO	
Ipomopsis longiflora	flaxflowered ipomopsis	IOLON	IPLO2	N
Kallstroemia hirsutissima	hairy caltrop	KALHIR	KAHI	N
Kochia scoparia	common kochia	KOCSCO	KOSC	I
Lactuca serriola	prickly lettuce	LACSER	LASE	I
Machaeranthera pinnatifida	lacy tansyaster	MACPIN		N
Malva neglecta	common mallow	MALNEG	MANE	N
Melilotus officinalis	yellow sweetclover manyflowered	MELOFF	MEOF	I
Mentzelia multiflora	mentzelia roundleaf	MENMUL	MEMU3	N
Mimulus glabratus	monkeyflower	MIMGLA	MIGL	N
Mirabilis linearis	narrowleaf four o'clock	MIRLIN	MILI3	N
Physaria fendleri	Fendler's bladderpod	PHYFEN	LEFE	N
Plantago major	common plantain	PLAMAJ	PLMA2	I
Plantago patagonica	woolly plantain	PLAPAT	PLPA2	N
Polygonum aviculare	prostrate knotweed	POLAVI	POAV	I
Polygonum persicaria	Lady's thumb	POLPER	POPE3	I
Portulaca oleracea	common purslane	POROLE	POOL	N
Ranunculus cardiophyllus	heartleaf buttercup	RANCAR	RACA4	N
Ranunculus cymbalaria	alkali buttercup green prairie	RANCYM	RACY	N
Ratibida tagetes	coneflower	RATTAG	RATA	N
Rorippa nasturtium-aquaticum	watercress	RORNAS	RONA2	I
Rumex crispus	curly dock	RUMCRI	RUCR	I
Salsola tragus	prickly Russian thistle manyflower false	SALTRA	SATR12	I
Schkuhria multiflora	threadleaf	SCHMUL	SCMU6	N
Scorzonera laciniata	cutleaf vipergrass	SCOLAC	SCLA6	I
Sisyrinchium demissum	dwarf blue-eyed grass	SISDEM	SIDE4	N
Solanum elaeagnifolium	silverleaf nightshade	SOLELA	SOEL	N
Sonchus asper	spiny sowthistle	SONASP	SOAS	I
Sphaeralcea coccinea	scarlet globemallow brownplume	SPHCOC	SPCO	N
Stephanomeria pauciflora	wirelettuce	STPAU	STPA4	N
Symphotrichum ericoides var. ericoides	heath aster	SYMERIE	SYERE	N
Taraxacum officinale	common dandelion	TAROFF	TAOF	I
Tidestromia lanuginosa	wooly tidestromia	TIDLAN	TILA2	N
Tragopogon pratensis	meadow salsify	TRAPRA	TRPR	I
Tribulus terrestris	puncturevine	TRITER	TRTE	I
Trifolium pratense	red clover	TRIPRA	TRPR2	I
unidentified forb	unidentified forb	UNIDF	2FORB	

Species Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Forbs continued				
Verbascum thapsus	common mullein	VERTHA	VETH	I
Veronica anagallis-aquatica	water speedwell	VERANA	VEAN2	N
Xanthisma gracile	slender goldenweed	XANGRA	MAGR10	N
Xanthisma spinulosum	lacy tansyaster	XANSPI2	MAPI	N
Xanthium strumarium	rough cocklebur	XANSTR	XAST	N