Santa Fe River
Riparian Vegetation Monitoring

A decade of Vegetation and Channel change from 2003 to 2013

Natural Heritage New Mexico Report – 14-GTR-383

April 2015

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A decade of Vegetation and Channel change from 2003 to 2013[1]

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April 2015

Executive Summary

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, New Mexico in 2003. The intent of this program is to monitor long-term changes in the riparian zone due to changes in livestock management. Nine monitoring transects were established in September 2003. Sampling was focused on riparian and wetland vegetation within the active floodplain, on number of individuals of woody species, and on stream-channel cross-section topography. Vegetation cover was measured in 2003, 2004, 2005, 2010 and 2013. Woody individuals were censused in 2006, 2010, and 2013. The stream-channel cross-sectional topography of all nine transects was surveyed in 2005 and 2013. 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 2013 data and on trends observed across the entire monitoring period.

With the removal of livestock within the study reach, we detected both positive and negative trends with respect to vegetation responses. Among the positives, total grass cover almost doubled, going from 32% in 2003 to 61% in 2013, and the average height of graminoids increased by more than 300% to 35 cm in 2013. On the negative side, by 2013 the dominant grass in all vegetation zones was the exotic tall fescue (*Festuca arundinaceae*), with an average cover of 70% in the mesic herbaceous zone, where it was most prevalent. Tall fescue replaced both other exotics (creeping bentgrass) and native species (knotgrass, alkali muhly, common threesquare). Tall fescue does not currently have any legal status, but it is considered a problem invasive species by a number of different states, government agencies, and plant conservation groups. It tends to form monocultural stands that exclude native herbaceous species and may have deleterious effects on some birds and wildlife. Treatment may be required to allow a native-dominated herbaceous layer to return to the study area.

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[1] Final report Cooperative Agreement Award No. L12AC20119.

Total woody cover also increased throughout the study area, reaching 32% in 2013, up from 24% in 2003. However, the increase was only observed in exotic species, primarily Russian olive (*Elaeagnus angustifolia*). Saltcedar (*Tamarix ramosissima*) cover also increased initially, but in 2013 saltcedar throughout the study area was being defoliated by the saltcedar beetle (*Diorhabda carinulata*). In other infested areas in the West, it is estimated that four years of beetle defoliation will yield 60% mortality within a stand. Hence, the long-term effect of the beetle within the study area is still evolving. If the beetles remain in the canyon and are effective in killing significant portions of the saltcedar, a large amount of standing deadwood will remain behind whose management will need to be addressed.

There are indications that exotic Russian olive is encroaching into floodplain vegetation zones not occupied by it in 2003. Overall, Russian olive has become the dominant woody species in all zones, and is noticeably more present within the floodplain than it was in 2003. Native woody riparian species (cottonwood, Goodding's willow and coyote willow) are scattered within the canyon, however there has been no significant establishment of native species on transects. The lag in recovery by native woody species with grazing removal has been observed on other rivers, and active restoration of native woody species may be necessary for complete recovery of the riparian system. Without 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.

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 2005 and 2013. There was an average reduction of 3.2 ft. in channel width, with an average increase of 0.4 ft. in depth across all transects from 2005 to 2013. This halved the average width/depth ratio from 2005 to 2013. This was accompanied by a noticeable alteration in the channel geometry, with steeper and more clearly defined banks at the majority of transects. The narrower channel should concentrate the perennial flow. Channel changes like these are known to decrease stream temperatures, decrease evaporation, and increase groundwater exchange. Similarly, the deeper, narrower channel with more heavily vegetated banks can have a positive effect on the aquatic fauna in streams such as the Santa Fe.

The dramatic changes like these seen on the Santa Fe River have also been reflected in other research on the recovery of riparian zones after livestock removal in the West. These changes can have important, positive implications for soil fertility and long-term cover crop maintenance, plus bird and aquatic habitat improvement. While on the Santa Fe significant improvements were seen due to livestock removal in as few as four to six years, some aspects of the ecosystem have not recovered as quickly. In particular, native woody vegetation may require active restoration to recover from intensive livestock use and the competition of established exotic species.

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Cover: Transect No. 03SF008 along the Santa Fe River (Photo by E. Milford).

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, New Mexico 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 2003. Sampling was focused on riparian and wetland vegetation within the active floodplain. Transects averaged 26 meters in length, but varied depending on the width of the floodplain, and extended 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 2003 and 2004, in late July 2005, and in August 2010 (Milford et al. 2011). A protocol for assessing changes in number of individuals and stems for woody species was initiated in 2006, and repeated in 2010 (Milford et al. 2007). Both vegetation cover and woody individuals and stems were measured in August 2013. In 2005, the stream-channel cross-sectional topography of all nine transects was surveyed (Milford et al. 2006; Plewa 2009). These cross-sections were repeated in 2013 so that changes in the channel morphology could be analyzed.

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 2013 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 from 1768 m (5800 ft) at the upper end to 1737 m (5700 ft) at the lower, resulting in a gentle stream gradient (approximately 1-2%). The floodplain averages only about 60-100 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 km^2 (18.20 sq. mi) and from the City of Santa Fe sewage treatment facility. The majority of the flow from the upper (montane) watershed is held in the McClure and Nichols Reservoirs for municipal use by the city of Santa Fe (Borchert et al. 2010). Since 1999 the channel through Santa Fe (below the reservoirs) has been dry an average of 220 days per year (Borchert et al. 2010). Thus, the base flow within the study area comes primarily from discharged effluent from the City of Santa Fe Wastewater Treatment Plant, from Cienega Creek and from springs in the Santa Fe Canyon (Grant 2002).

With the establishment of the first reservoir in 1926, the study area has been largely disconnected from its historic hydrograph (Grant 2002). To understand the current flow regime, data was taken from the gage on the Santa Fe River above Cochiti Lake (Gage Station 08317200), which is below the study area. Data for this gage is available for the years 1970-1999, and 2004-2013. Data from 1970-1999 represent the period prior to vegetation monitoring, while 2004-2013 data show the average flow for the monitoring period. Stream flow peaks between March and May. For the gage period prior to vegetation monitoring the peak flow was 20 cfs (cubic feet per second) on average and occurred in the month of April, while during the vegetation-monitoring period peak flow was only 10 cfs and occurred in March (Figure 2). The majority of the local precipitation arrives during late summer and early fall (Table 1) and, hence, in a given year, there can be secondary peaks in stream flow between August and September in response to large monsoonal rainstorms. However, late-summer base flows are typically low, dipping below 2 cfs in July for the 2004-2013 monitoring period.

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 NHNM 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. From 2008 through 2013, grazing was limited to only a few trespass cattle during the summers.

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). From 2003 to 2013, sampling was focused on riparian and wetland vegetation within the active floodplain with the intent of detecting major changes in species composition and structure. 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 to125 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. Two additional tagged stakes were located along the transect within the active floodplain to improve repeatability when setting measuring tapes. 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 the end stake and one in the reverse direction from the end stake; one looking upstream; one looking downstream (from a point just upstream of the transect at a distance 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 vegetation zones, and the left and right banks of the active channel (open water).

Vegetation cover was measured in 2003, 2004, 2005, 2010 and 2013, 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.

Table 1. Summary temperature and precipitation data from 1924 through 2012 for weather station Santa Fe CAA Airport (298078), approximately 15 km northeast of the study area (source: www.wrcc.dri.edu/).

	Temperature Averages (° F)			Precipitation (in)		
	Max.	Min.	Mean	Mean	High	Low
Winter	44.7	19.8	32.2	1.21	2.11	0.52
Spring	63.7	34.7	49.2	1.72	2.86	0.37
Summer	84.8	55.4	70.1	4.42	8.81	1.62
Fall	66.3	37.7	52	2.19	5.84	0.3
Annual	64.9	37.7	50.9	9.54	14.79	3.12

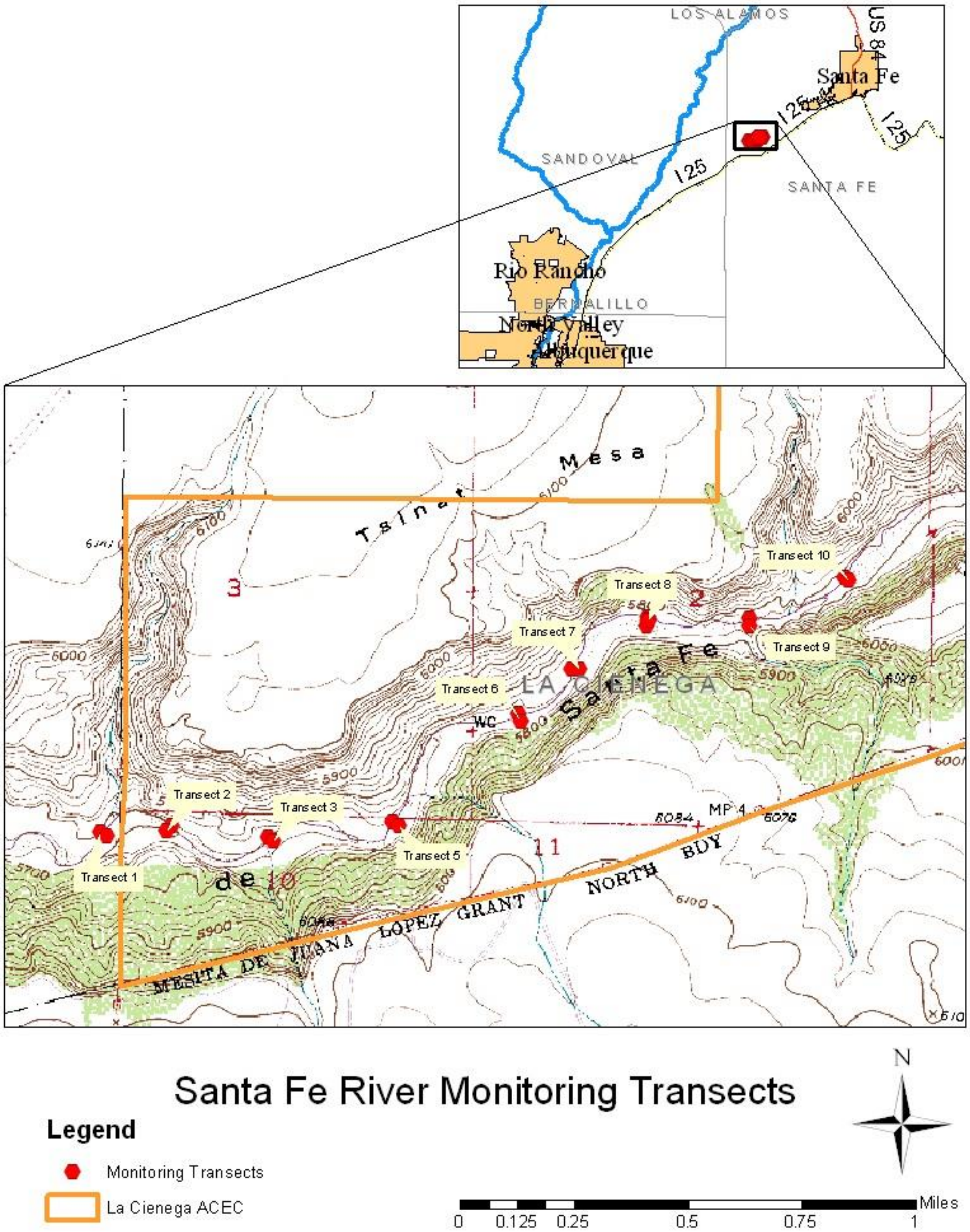


Figure 1. Study area for the Santa Fe River ACEC riparian monitoring program.

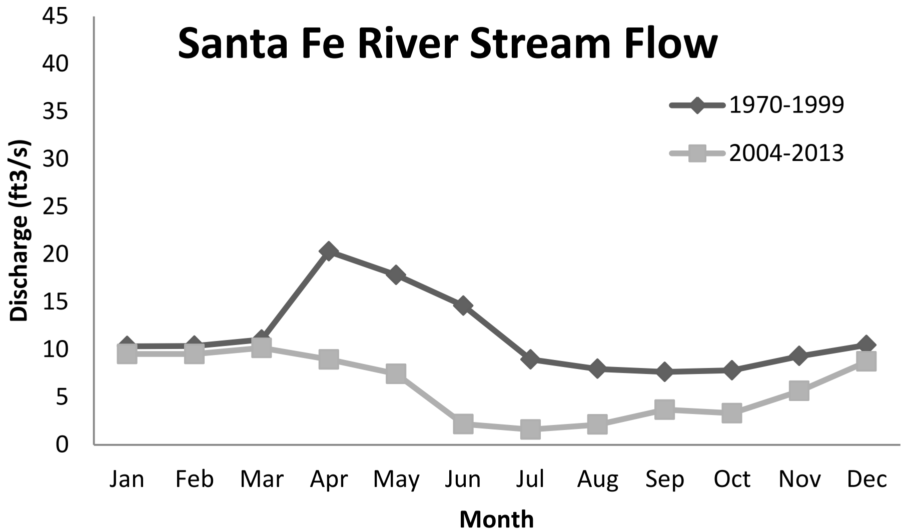


Figure 2. Average monthly discharge on the Santa Fe River above Cochiti Lake (Gage Station 08317200). The years 1970-1999 represent the period of gage data prior to vegetation monitoring, while 2004-2013 is the monitoring period. There was a gap in gage data.

In 2006, 2010 and 2013 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.

In 2005 and 2013, stream-channel cross-section data was taken along each of the nine established vegetation monitoring transects. Cross-sections began at the right bank rebar and depth information was recorded at every topographical change, and at vegetation community changes along the cross-section, with no more than 0.5m in between data points. Data was taken using a stadia rod and optical transit. The data for each cross-section was corrected and entered into the Reference Reach Spreadsheet (Mecklenburg and Ohio Department of Natural Resources 2006, available at http://ohiodnr.gov/). This spreadsheet calculates a cross-sectional area, width, depth, width to depth ratio, and additional parameters at a specified stage height set by the user. Since actual flows at the cross-sections are unknown, we developed an index based on a standard cross-sectional area to evaluate changes in channel geometries between 2005 and 2013. That is, a cross-sectional area of 5 ft^2 was used to approximate ordinary daily flow and a stage height through each section by which to calculate comparative widths, depths, and width/depth ratios. The index ignores slope and velocity (these were not measured) and is not intended to model actual stage heights or discharge but only to illustrate changes in channel morphology.

Vouchers of all plant species were taken, identified, and have been archived at the herbarium of the University of New Mexico, Museum of Southwestern Biology. The vegetation data were entered using Microsoft Access into the NHNM ecology database with tables specifically designed for this project. Over the past two decades the NHNM ecology database has been developed and populated with over 13,000 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. An electronic Data Addendum to 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 2010 vegetation monitoring report was published the name of one species has been changed. Watercress, previously *Rorippa nasturtium-aquaticum* is now *Nasturtium officinale*. The name has been updated in the database, and is used in this report. Three species names changed between 2005 and 2010, and those changes can be found in the 2010 report (Milford et al. 2011).

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 177 plant species were identified within in the study area across the five years of vegetation monitoring, but only 130 of those species were recorded within the monitoring quadrats (Appendix D). Since 2005 there has been an upward trend in native species richness, for graminoids and forbs (Fig. 3). Introduced species richness showed little variation during the period. In contrast, canopy cover of exotics increased among trees and graminoids, while natives remained stable or decreased (Fig. 4). Graminoid cover shifted from a nearly equal mix of natives and non-natives in 2005 to exotic-dominated in 2013. Overall, with the reduction in grazing between 2003 and 2013, both woody and graminoid total cover increased within the study area. In 2013, total average graminoid cover was 61% — almost two times higher than the 32% of 2003. Total woody cover increased about a third to 32% in 2013, from 24% in 2003, while total forb cover was slightly reduced to 15% in 2013, down from 19% in 2003.

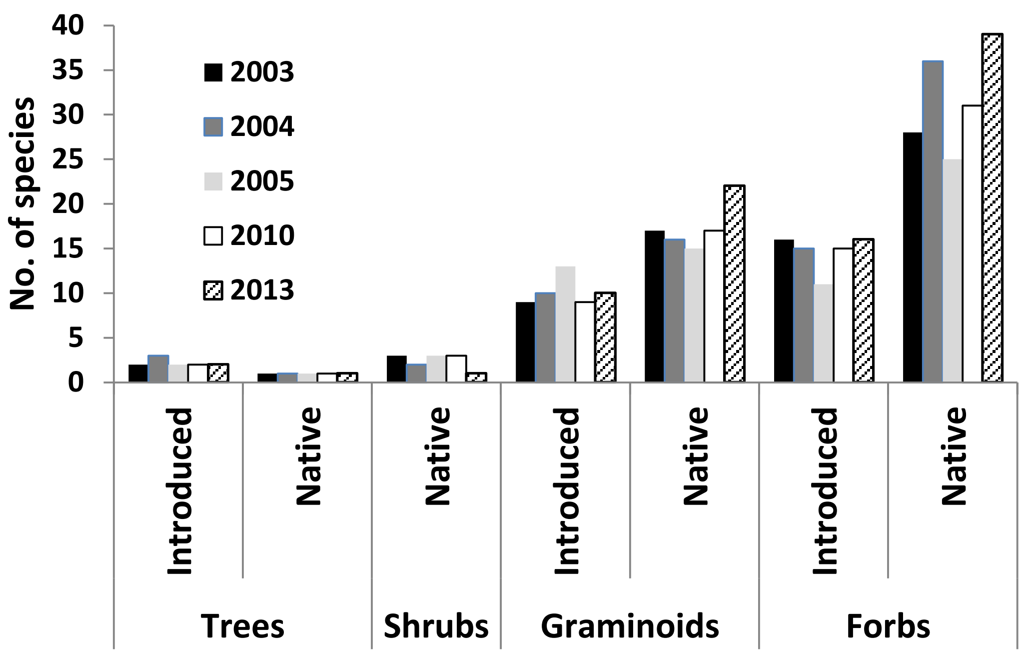


Figure 3. Species richness by lifeform and year.

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; 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 (*Nasturtium officinale-Veronica anagallis-aquatica*)	NASOFF-VERANA	Active Channel
Mesic Herbaceous Wetland	Creeping Bentgrass-Knotgrass Mesic Herbaceous Vegetation (*Agrostis stolonifera-Paspalum distichum*)	AGRSTO-PASDIS	Active Floodplain
	Common Threesquare Sparse Herbaceous Wetland (*Schoenoplectus pungens*)	SCHPUN	Active Floodplain
Upper Herbaceous Wetland	Tall Fescue-Alkali Muhly Upper Herbaceous (*Festuca arundinaceae-Muhlenbergia asperifolia*)	FESARU-MUHASP	Terrace slope
	Yerba Mansa/Alkali Muhly Upper Herbaceous (*Anemopsis californica-Muhlenbergia asperifolia*)	ANECAL/MUHASP	Terrace slope
	Sparse Upper Herbaceous	SPARSE UPPER HERB	Terrace slope
Woody Riparian	Russian Olive Riparian Woodland (*Elaeagnus angustifolia*)	ELAANG	Terrace
	Russian Olive/Rubber Rabbitbush Riparian Woodland (*Elaeagnus angustifolia/Ericameria nauseosus*)	ELAANG/ERINAU	Terrace
	Saltcedar Riparian Shrubland (*Tamarix chinensis*)	TAMCHI	Terrace
Arroyo Riparian	Rubber Rabbitbush Riparian Shrubland (*Ericameria nauseosus*)	ERINAU	Terrace

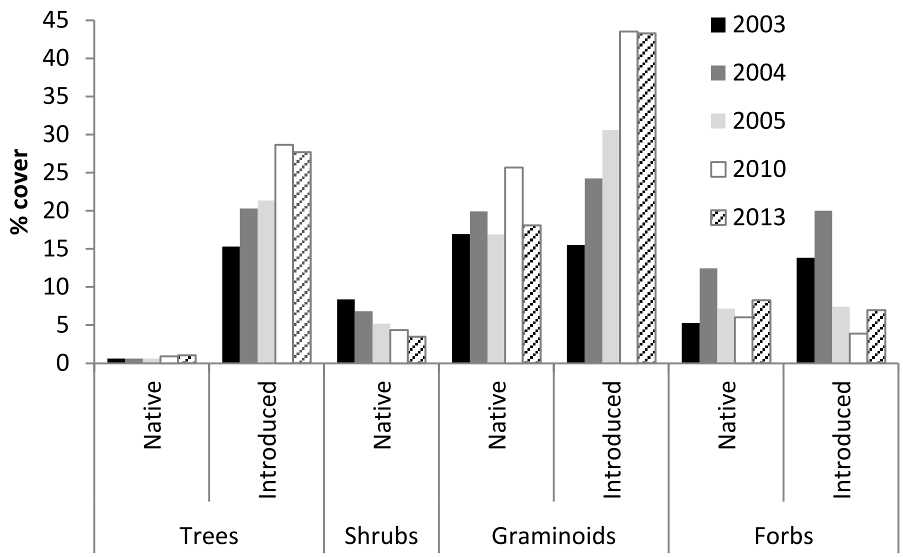


Figure 4. Total percent cover by lifeform, origin and year for all transects combined.

We also evaluated 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—comprised of the area of open water and the surrounding aquatic vegetation dominated by rooted vascular aquatic species—graminoid cover nearly quadrupled between 2003 and 2013 while forbs dramatically declined (Fig. 5a). The increase in grass cover was due in part to large increases in cover of the native species knotgrass (*Paspalum distichum*), common threesquare (*Schoenoplectus pungen)*, and the exotic species tall fescue (*Festuca arundinaceae*) between 2005 and 2010 (Fig. 5b). Between 2010 and 2013 exotic tall fescue continued to increase, but the natives knotgrass and common threesquare did not. 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 2013 cover declined. The exotic aquatic forb watercress (*Nasturtium officinale*) was a dominant species within the channel vegetation zone when sampling began in 2003. It increased somewhat in 2004, but then dramatically dropped in cover by 2005, and was reduced to trace amounts by 2010. The native aquatic forb water speedwell (*Veronica anagallis-aquatica*) also declined to trace amounts by 2010. The changes in species dominance within the active channel zone may be due in part to the morphological changes that occurred as the active channel recovered from intensive livestock use. The structural changes to the channel are discussed below in the cross-section analysis.

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). While woody cover is relatively low in this zone, between 2005 and 2010 cover increased as the cover of Russian olive (*Elaeagnus angustifolia*) doubled and then leveled off by 2013 (Fig 6a and b). Graminoid cover nearly doubled from 2003 to 2010 and more or less leveled off as well in 2013. However, the increase was driven by increases in exotic grass cover, while native species declined. The exotic tall fescue became the overwhelming dominant across the zone, increasing in cover by over 700%. Other herbaceous species that were previously dominant in this zone showed a decline between 2005 and 2013, with the exotic creeping bentgrass showing the largest declines followed by the native knotgrass, common threesquare, and alkali muhly (*Muhlenbergia asperifolia*). Forb cover declined from a high of 36% to less than 5% between 2004 and 2013, mostly among exotics. For example, the previously dominant and abundant red clover (*Trifolium pratense*) was reduced from 17% in 2004 to trace amounts in 2013.

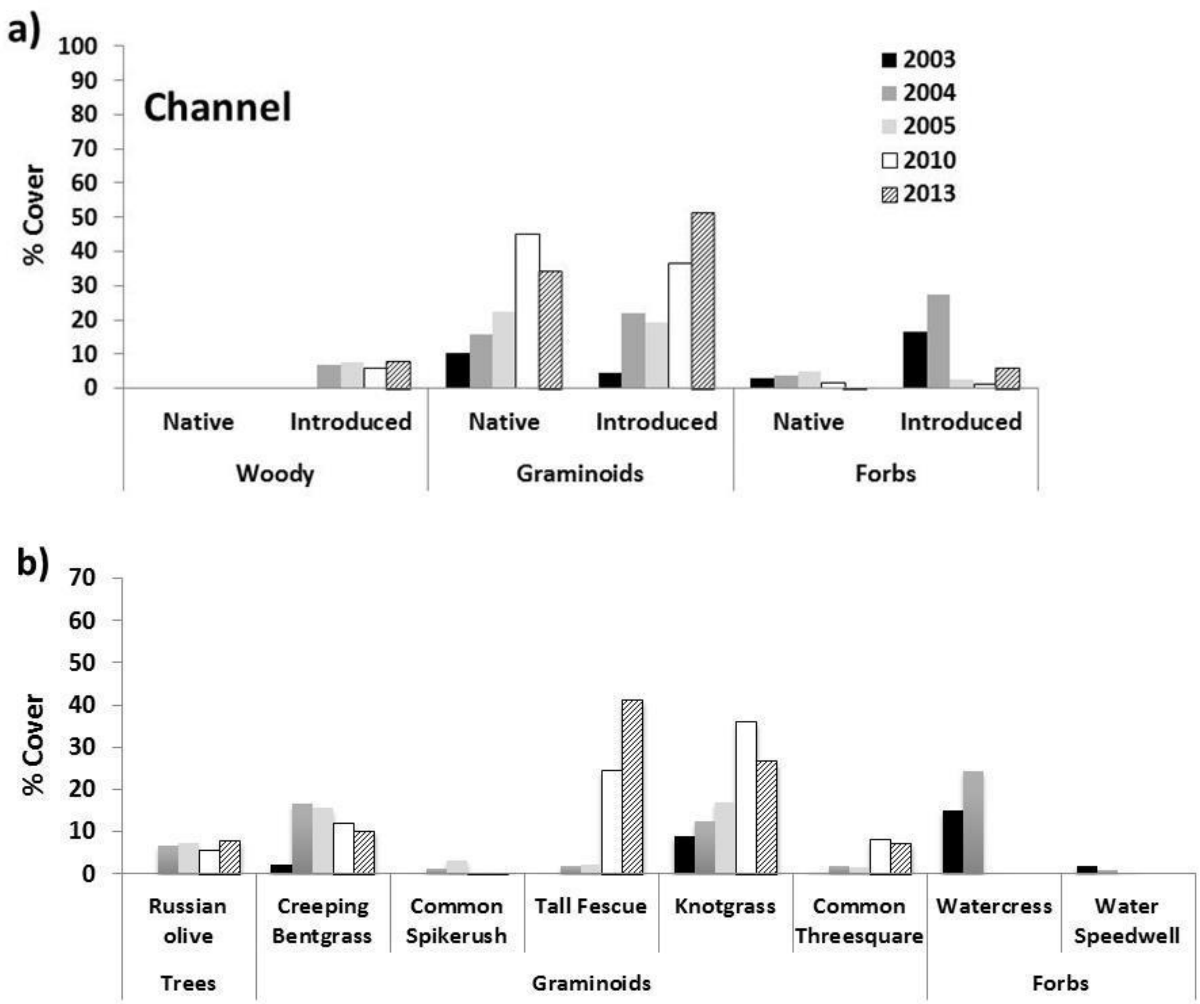
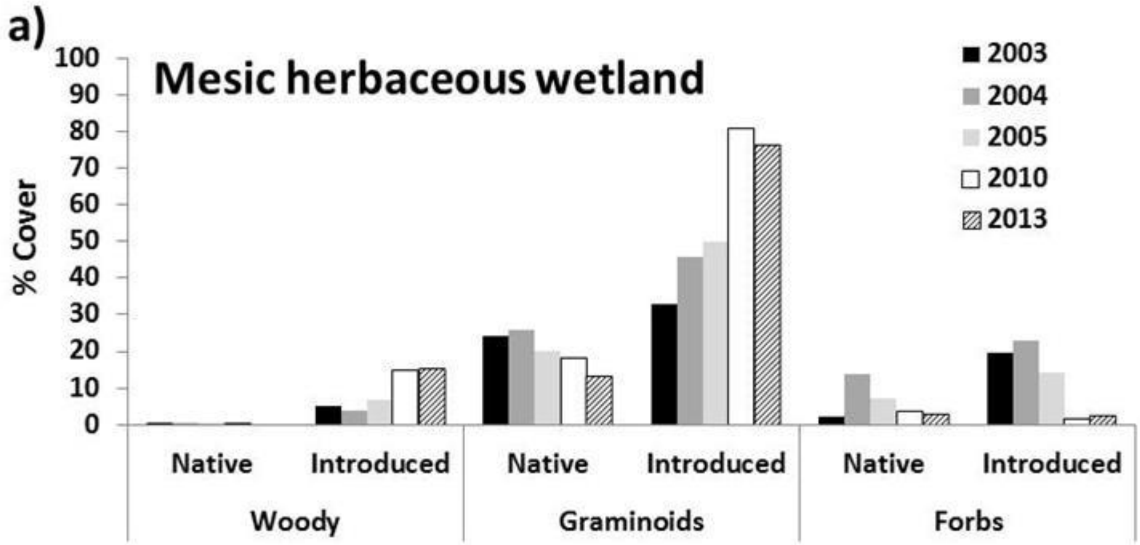


Figure 5. Channel: a) average total canopy cover by life form and origin; b) average total canopy cover by selected species and year (n = 88).



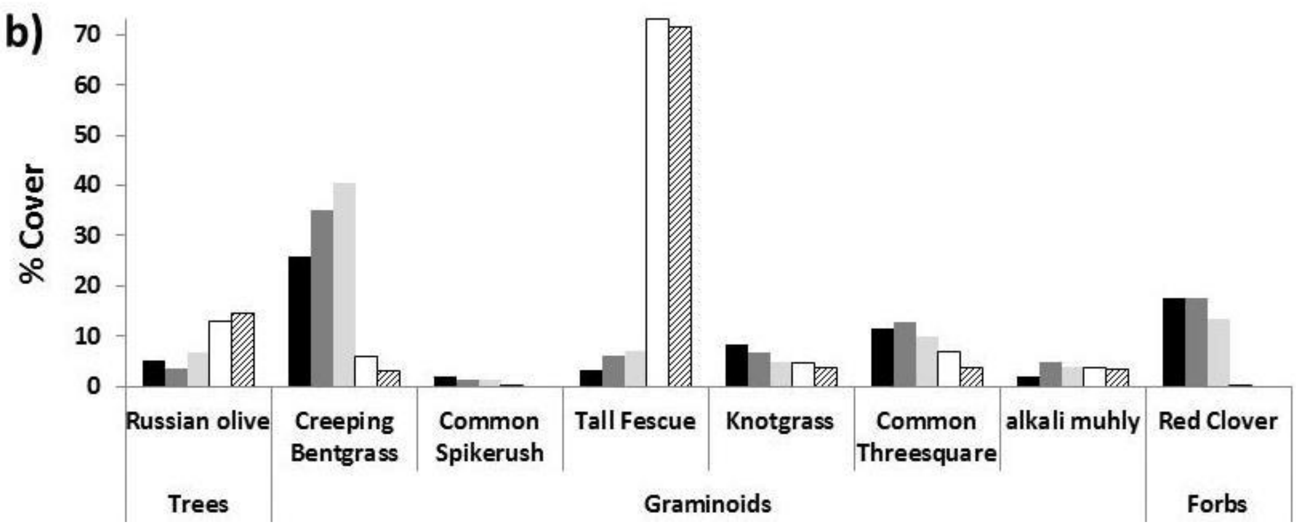


Figure 6. Mesic herbaceous wetland: a) average total canopy cover by life form and origin; b) average total canopy cover by selected species and year (n = 146).

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. While drier than the Mesic Herbaceous Zone, soils may still become saturated during high flows). It is comprised of three subzones: 1) Tall Fescue-Alkali Muhly; 2) Yerba Mansa (*Anemopsis californica*)/Alkali Muhly; and 3) the Sparse subzone. This third zone can have an overhanging canopy of Russian olive shrubs and trees extending from the upper terrace. Overall in this zone, both woody and graminoid cover increased between 2005 and 2010 (Fig. 7). However, there was a nearly 30% decrease in woody cover between 2010 and 2013. This was driven by decreases in cover for the exotics Russian olive and saltcedar (*Tamarix chinensis*), which had shown large increases in cover prior to 2013 (Fig. 7). As in the mesic herbaceous vegetation zone, tall fescue cover nearly tripled between 2005 and 2010, and it became the dominant grass maintaining this dominance into 2013. However, the native species western wheatgrass (*Pascopyrum smithii*), alkali muhly, and inland saltgrass (*Distichlis spicata*), showed decreases in cover, from 2010 to 2013, as part of the overall drop in native graminoid cover during that period. Only the native forb yerba mansa remained relatively stable in cover in the herbaceous layer across the monitoring period.

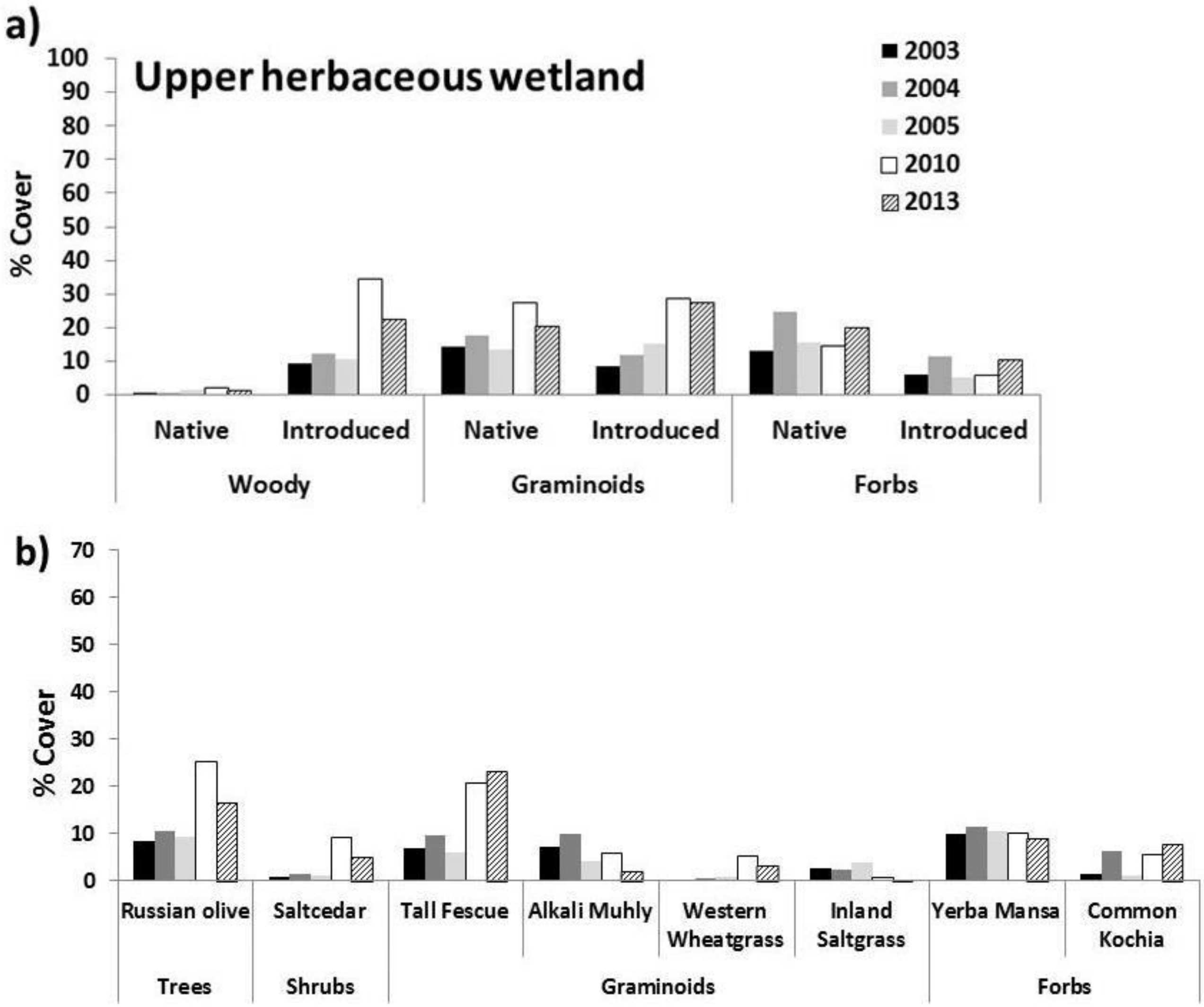


Figure 7. Upper Herbaceous Wetland: a) average total canopy cover by life form and origin; b) average total canopy cover by selected species and year (n = 95).

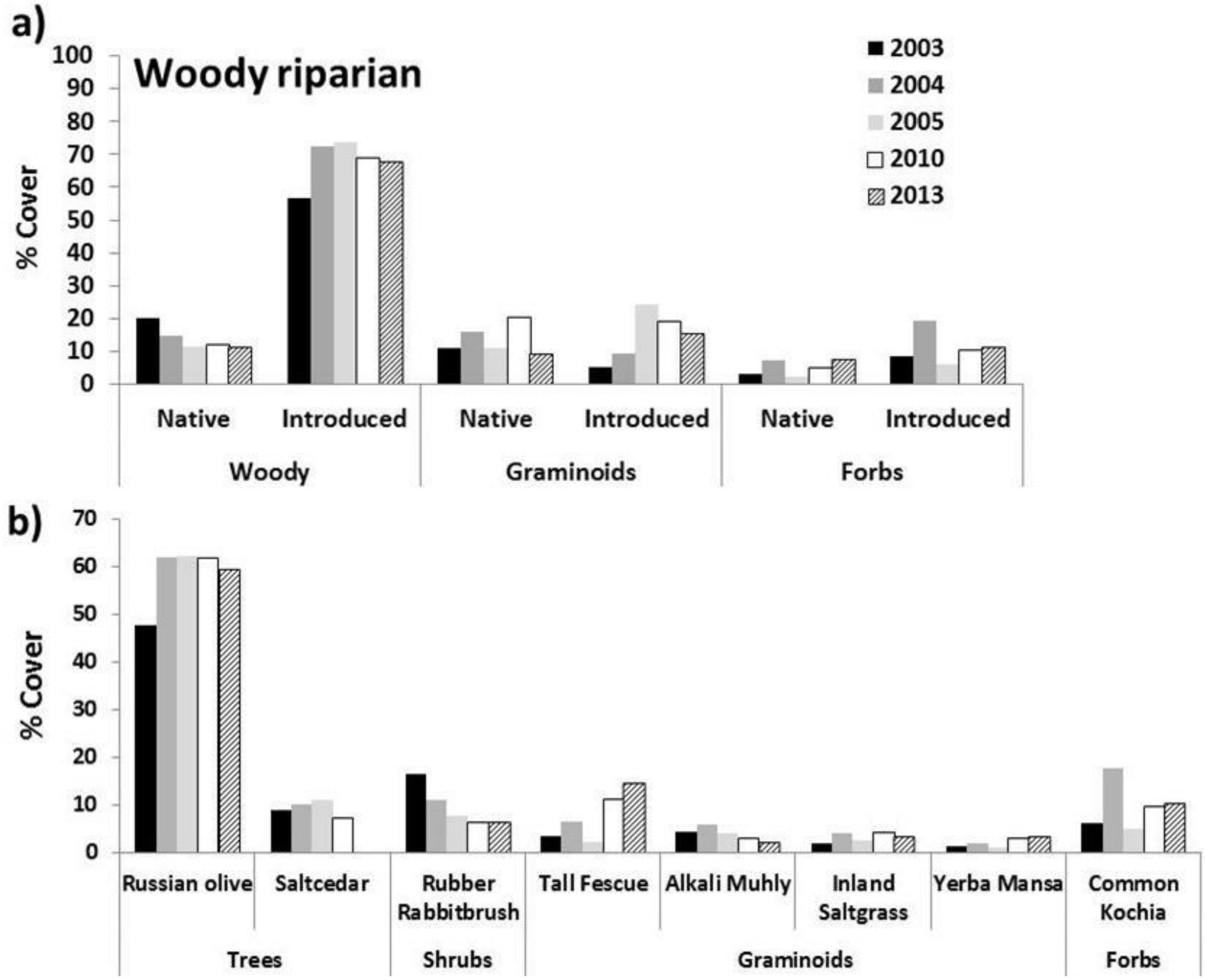


Figure 8. Woody riparian: a) average total canopy cover by life form and origin; b) average total canopy cover by selected species and year (n = 80).

The rarely flooded terraces support the Woody Riparian Zone dominated by either Russian olive or saltcedar. There are three subzones in the Woody Riparian: 1) Russian Olive; 2) Russian Olive/Rubber Rabbitbrush; and 3) Saltcedar. Overall, woody cover was dominated by Russian olive, and after showing an initial uptick in cover between 2003 and 2004, remained more or less stable from 2004 to 2013 (Fig 8). Rubber rabbitbrush showed a decline in cover across the monitoring period, with a 60% reduction in cover from 2003 to 2013. Saltcedar cover had been relatively low and remained more or less constant between 2003 and 2010, however, it was absent from the woody riparian zone by 2013. Most of the saltcedar within the study area had been heavily impacted by saltcedar beetles and was largely standing dead in 2013. Graminoid cover, particularly exotic graminoid cover, increased with the initial removal of grazing between 2003 and 2005. However, both native and exotic graminoid cover showed a downward trend in the following years. Only the exotic fall fescue continued to increase in cover in 2013. Inland saltgrass, yerba mansa and common kochia have had a fluctuating but persistent presence in the herbaceous layer across the study period.

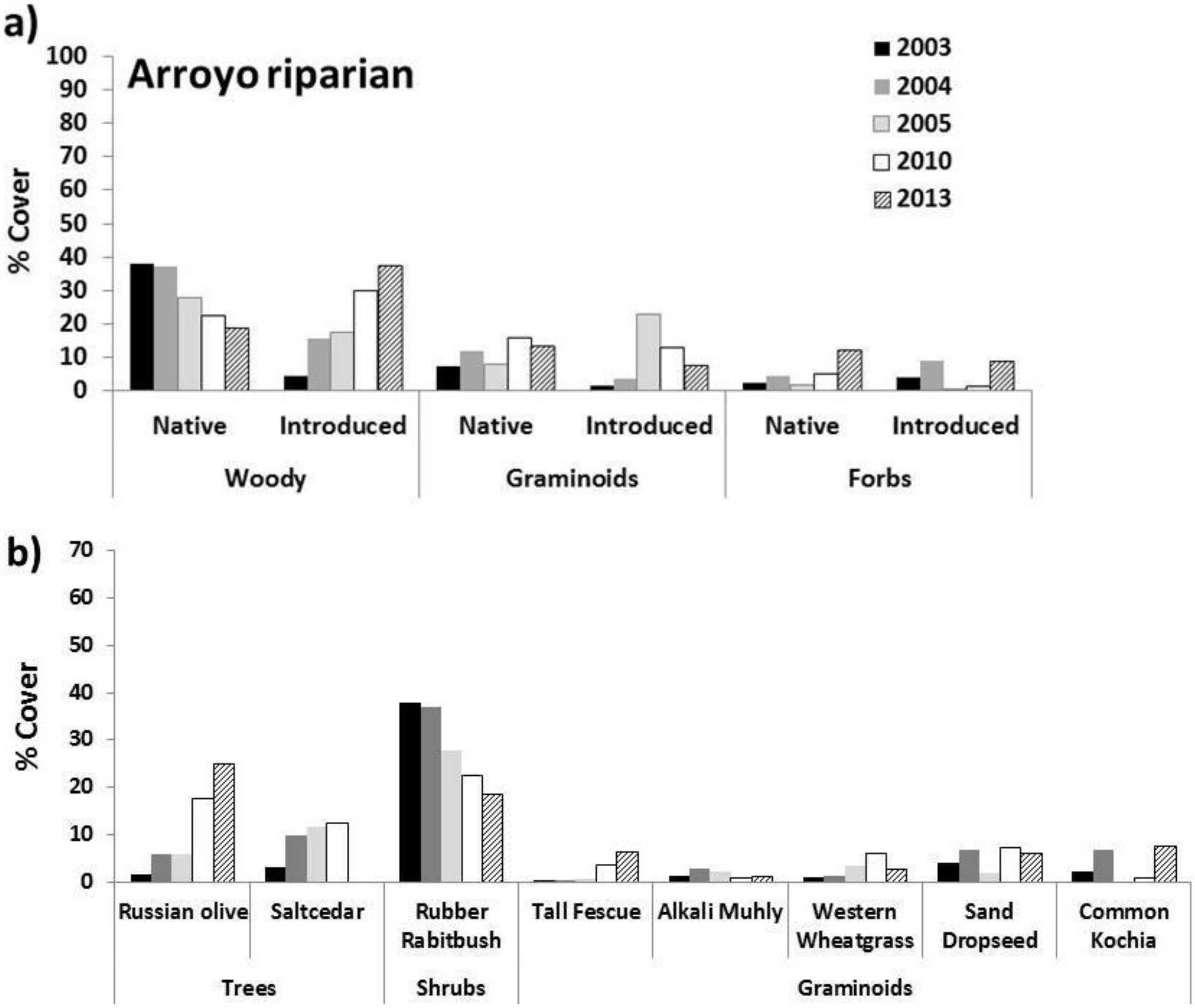


Figure 9. Arroyo riparian: a) average total canopy cover by life form and origin; b) average total canopy cover by selected species and year (n = 55).

The Arroyo Riparian zone is dominated by rubber rabbitbrush (*Ericameria nauseosa*), which is present on drier terraces and scour areas 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 declined while exotic species increased over the monitoring period (Fig. 9a). In particular, the native rubber rabbitbrush showed a large decline, while Russian olive increased (Fig. 9b). Saltcedar increased between 2003 and 2004 but was impacted by the saltcedar beetle in 2013. Russian olive increased steadily throughout the study period, exceeding the cover of rubber rabbitbush in the zone by 2013. The downward trend in herbaceous cover followed a similar pattern to that of the Woody Riparian zone except that the decrease in exotic grass cover was large enough that overall native grass cover was twice that of exotic by 2013. Tall fescue again showed a large increase in cover between 2005 and 2013, along with sand dropseed. Alkali muhly and western wheatgrass had low, persistent, but fluctuating cover.

Utilization

In all vegetation zones the average height of herbaceous vegetation (grasses and forbs) was less than eight centimeters in 2003 (Fig. 10). This reflected the combination of extreme drought conditions and high livestock utilization throughout the reach during that year, particularly as livestock concentrated in 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 starting in 2007, graminoid average height increased 300% and forbs 50% by 2013. Many of the grasses observed on these monitoring transects have the capacity to reach anywhere from 30 to 100 cm under normal moisture conditions. Given that average heights were approaching 40 cm in 2013 suggests that grazing was no longer a significant factor affecting standing crop biomass.

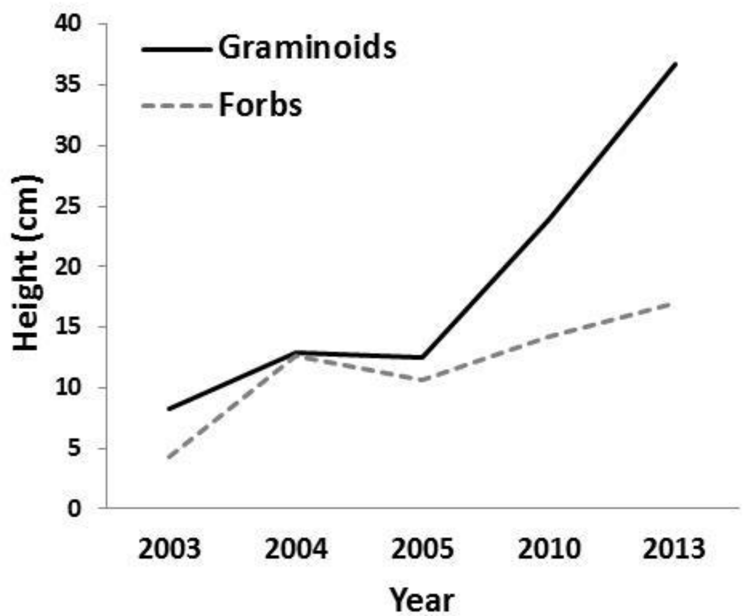


Figure 10. The mean height of graminoid and forb herbaceous vegetation increased following removal of most livestock.

Tree and shrub trends

Eight woody species were encountered within the woody species monitoring quads, although only seven were recorded each year (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 steady decline in number of quadrats occupied, with 39% less in 2013 than in 2006 (Table 3). Russian olive showed an increase between 2006 and 2010, then dropped back to 2006 levels in 2013, while saltcedar showed a slight decline from 2006 to 2013 in 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. 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 is a common upland species that occurs in arroyos and terraces adjacent to rivers throughout the state.

With respect to vegetation zones, rubber rabbitbrush was most common within the Arroyo Riparian vegetation zone, where it averaged 10,000 individuals/ha, a drop from the 2006 average of 15,000 individuals/ha. Most of these were smaller and presumably younger plants (Fig 11). It also occurred within the Woody Riparian zone but to a lesser degree and showed a steep decline between 2006 and 2013. In the Upper Herbaceous Wetland zone it is considered a transitional species. It was very rare in the active floodplain in all 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 2013 reflected the decline in cover that was observed in the vegetation-monitoring quadrats.

Table 3. Tree and shrub species observed on woody monitoring quadrats with number of quadrats occupied by year (*n* = 464).

	Species Name	Common Name	2006	2010	2013
Trees					
	Elaeagnus angustifolia	Russian olive	4.7%	6.9%	5.0%
	Juniperus monosperma	oneseed juniper	0.4%	0.4%	0.6%
	Salix gooddingii	Goodding's willow	0.2%	0.2%	0.2%
	Ulmus pumila	Siberian elm	0.2%	0.0%	0.0%
Shrubs					
	Atriplex canescens	fourwing saltbush	0.0%	0.2%	0.2%
	Ericameria nauseosa	rubber rabbitbrush	18.8%	14.2%	11.4%
	Ribes leptanthum	trumpet gooseberry	0.2%	0.2%	0.2%
	Tamarix chinensis	saltcedar	4.7%	4.5%	3.7%

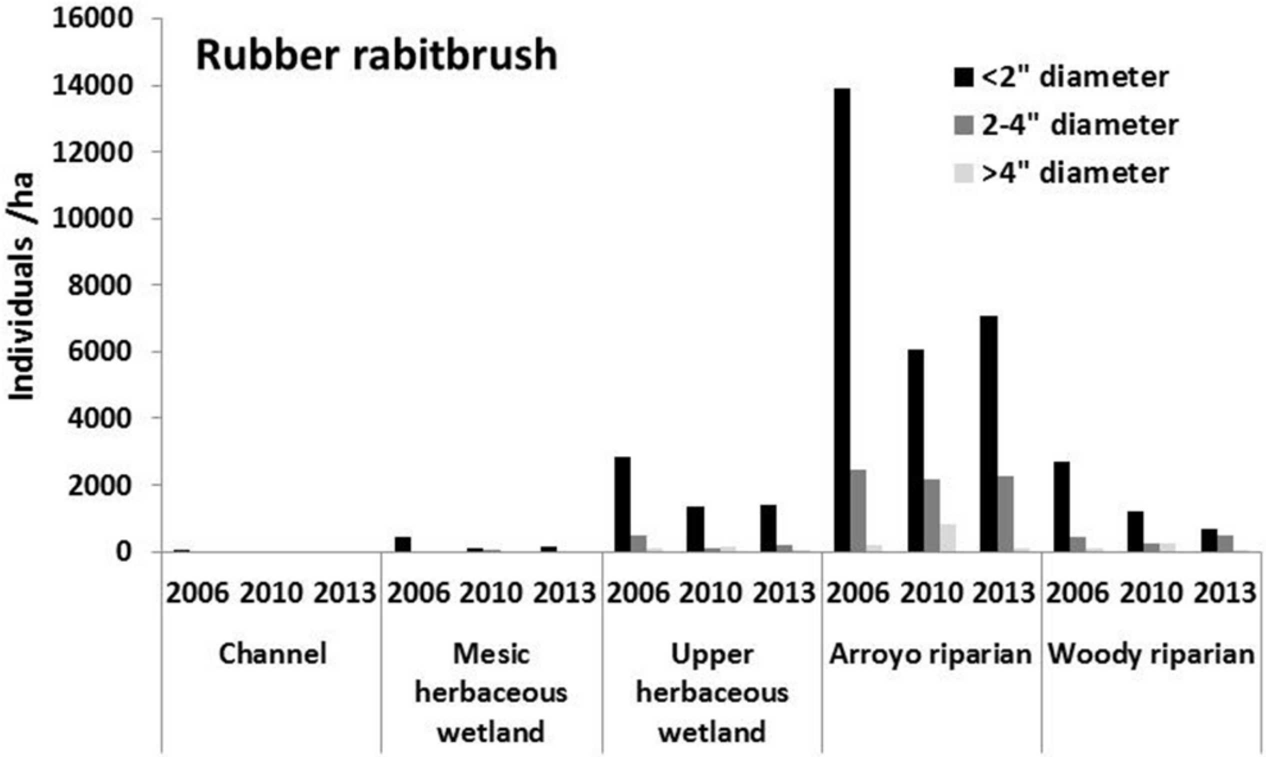


Figure 11. Rubber rabbitbrush density by basal-stem diameter class size, year, and vegetation zone.

Russian olive was the dominant riparian shrub and tree species across the study area. 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 but densities shifted across vegetation zones (Fig. 12). It was most prevalent in the Woody Riparian zone across all size classes. There was recruitment to the larger classes from 2006 to 2010 and fewer smaller individuals in the smallest class. Similarly, smaller individuals declined in the Upper Herbaceous Wetland with a shift to the larger sizes, suggesting that new young reproduction declined following livestock exclosure. Density was relatively low in the Arroyo Riparian zone and Mesic herbaceous wetland zones, suggesting less-than-optimal growing conditions in these very dry and very wet sites, respectively.

Saltcedar formed dense patches along the terrace edges and was scattered throughout the reach (Fig. 13). Initially in 2006, it was most abundant in the Upper Herbaceous Wetland and Arroyo riparian zones, occurring as small-to-large individuals. With the exception of the mid-size classes in the Upper Herbaceous zone, there was a precipitous decline in individuals in all size classes in subsequent years. In 2013, there was clear evidence of saltcedar beetle infestations that had led to widespread defoliation and possible mortality in the majority of saltcedar found on the transects.

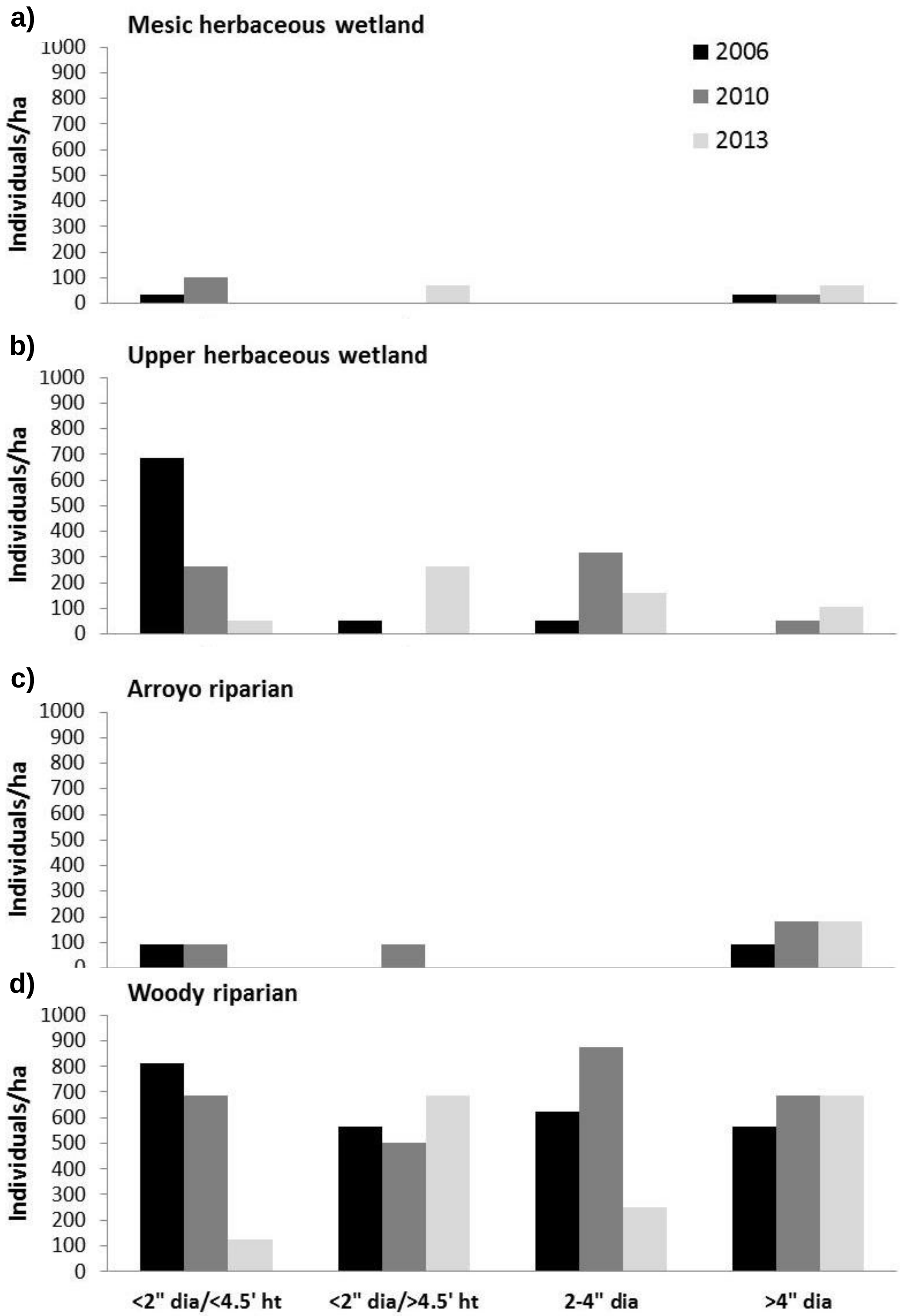


Figure 12. Density of Russian olive by year, vegetation zone, and size class.

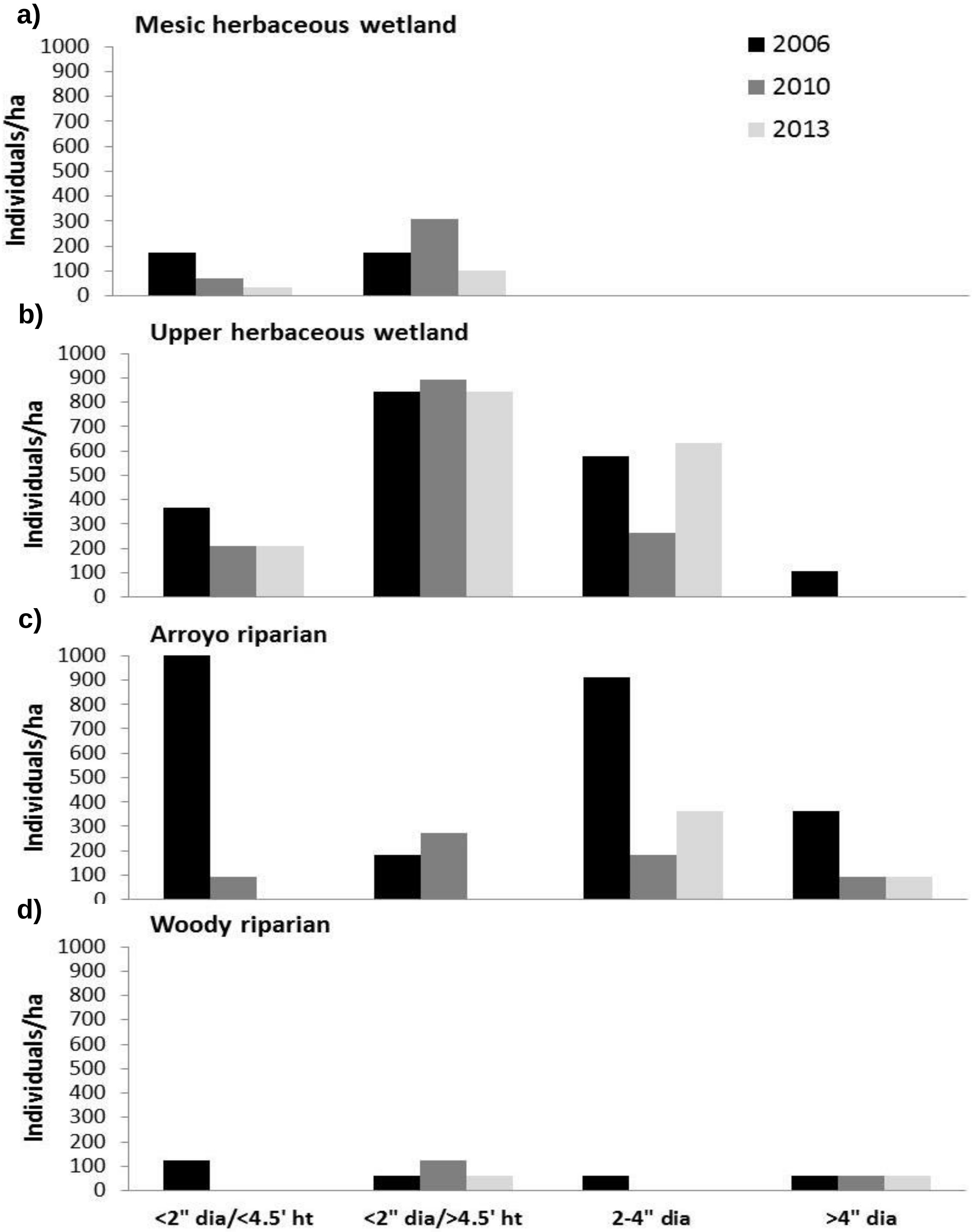


Figure 13. Density of saltcedar individuals by year, vegetation zone, and size class.

Cross-Section Analysis

At the cross-sectional index area of 5 ft^2, channel width decreased, depth increased, and width/depth ratio decreased for seven of the nine transects 2005 to 2013 (Table 4). Additionally, for the two transects where these variables did not follow the general trend, there was either no change or a very slight change in the opposite direction. Overall, there was an average reduction of 3.2 ft in channel width, with an average increase in 0.4 ft in depth across all transects from 2005 to 2013. This halved the average width/depth ratio from 2005 to 2013. This was accompanied by a noticeable alteration in the channel geometry, with steeper and more clearly defined banks at the majority of transects (Figures 14-22).

The photographic record of the area supports these findings (Figures 14-22). Banks have become more distinguishable and steeper as they are stabilized by the roots of the dense herbaceous community that lines the channel. As they have stabilized, they have concentrated the perennial flow, narrowing the channel. Bank undercutting is more apparent in 2013 photographs than in 2005 photographs.

Table 4. Width, maximum depth, and width/depth ratio and change in each for each transect and year taken for a cross-sectional area of 5 ft^2. Width and depth are measured in feet.

	Width			Max. Depth			Width/Depth Ratio		
Transect	2005	2013	Change	2005	2013	Change	2005	2013	Change
1	7.4	5.2	**-2.2**	0.9	1.1	**0.2**	11	5	**-6**
2	11.1	8.1	**-3**	0.8	0.9	**0.1**	24	13	**-11**
3	12.5	12.6	**0.1**	0.7	1.3	**0.6**	31	32	**1**
5	11.2	6	**-5.2**	0.6	1.1	**0.5**	25	7	**-18**
6	14.7	6.2	**-8.5**	0.5	1.3	**0.8**	43	8	**-35**
7	9.6	6.1	**-3.5**	0.7	1	**0.3**	18	7	**-11**
8	7.8	8.1	**0.3**	1.1	1.1	**0**	12	13	**1**
9	11.1	8.2	**-2.9**	0.6	0.8	**0.2**	25	13	**-12**
10	12.1	7.9	**-4.2**	0.7	1.4	**0.7**	29	12	**-17**
Average	10.8	7.6	**-3.2**	0.7	1.1	**0.4**	24.2	12.2	**-12.0**

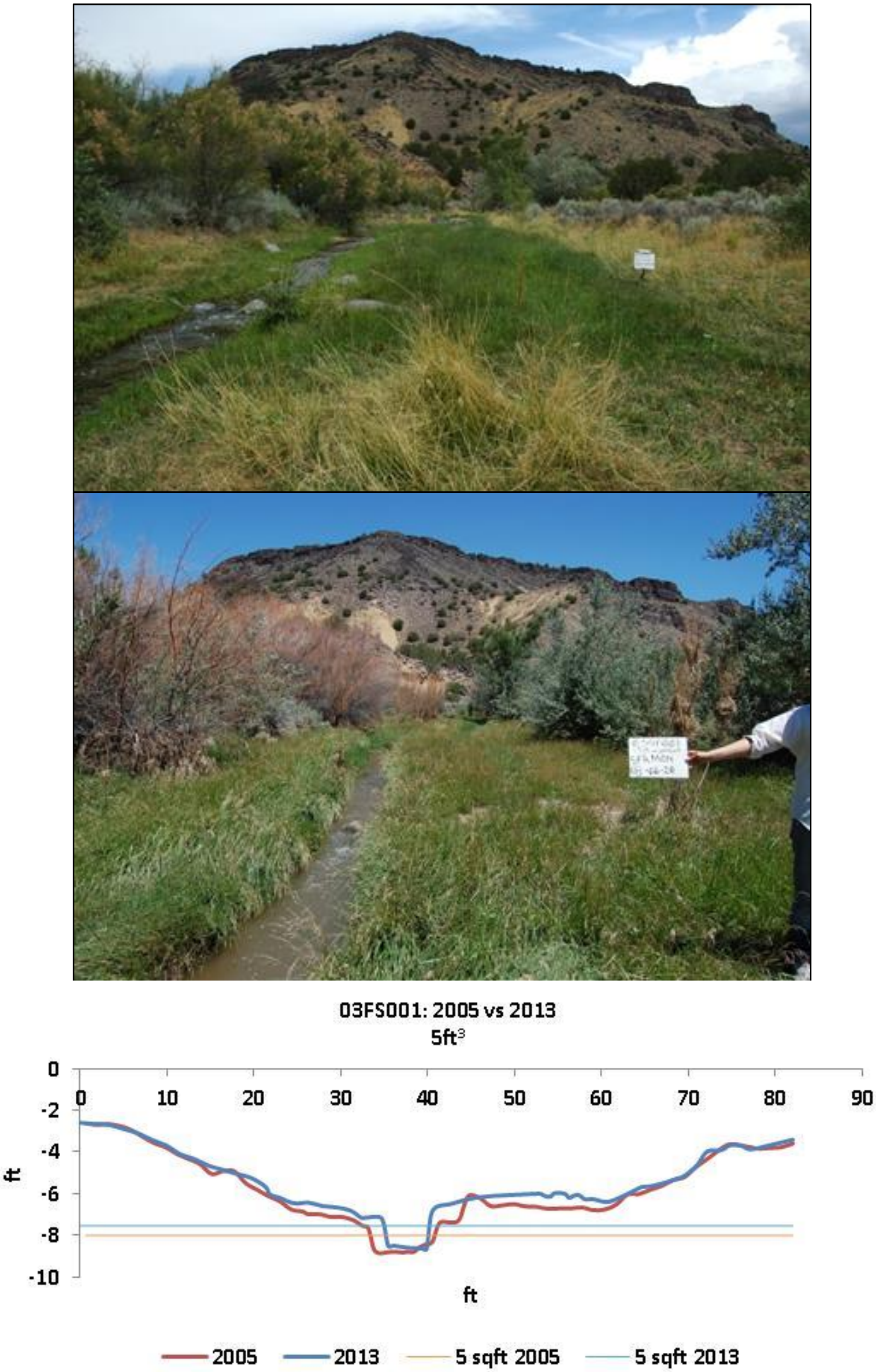


Figure 14. Transect 1 facing upstream; 2005 above, 2013 below.

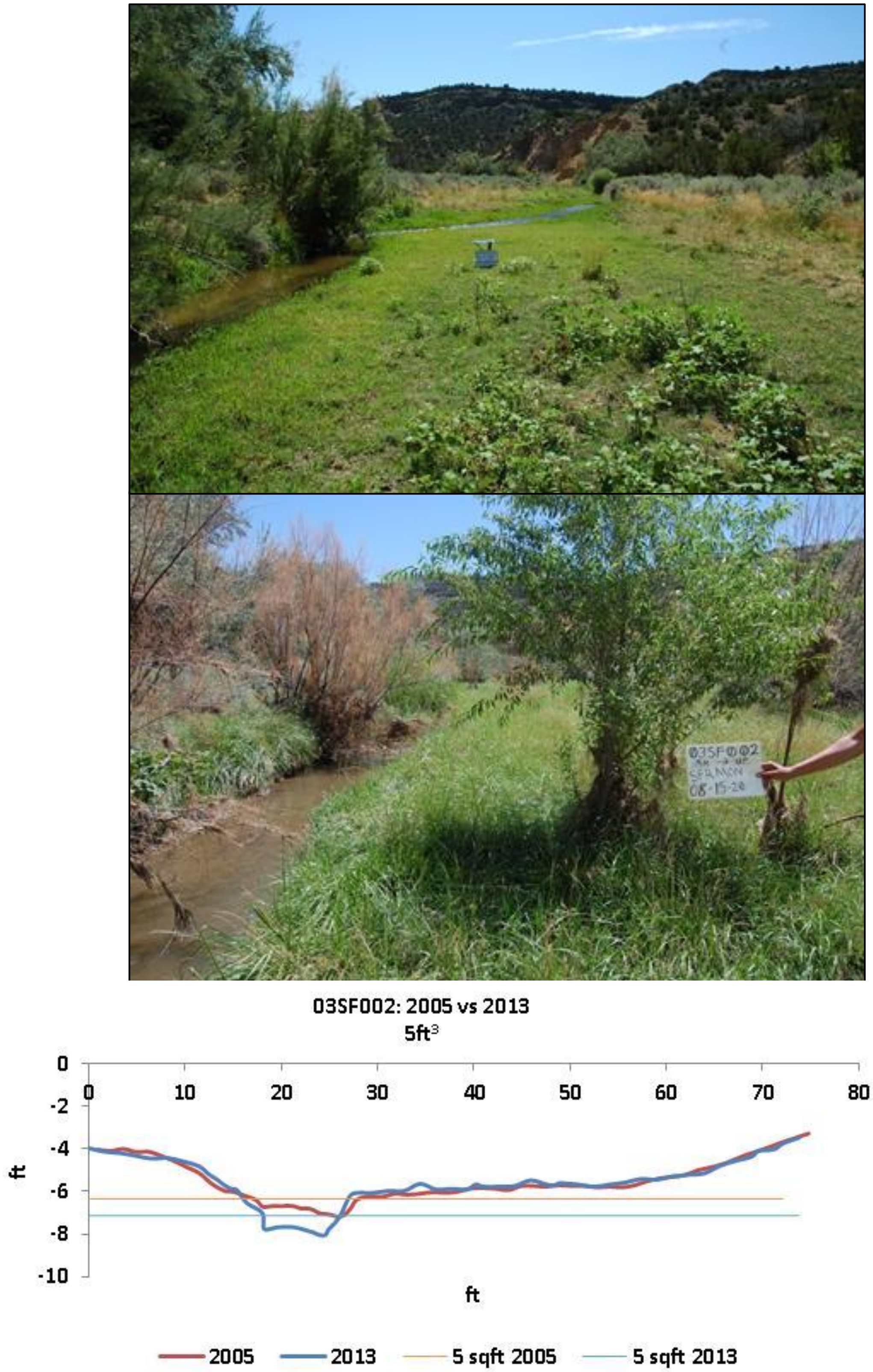


Figure 15. Transect 2 facing upstream; 2005 above, 2013 below.

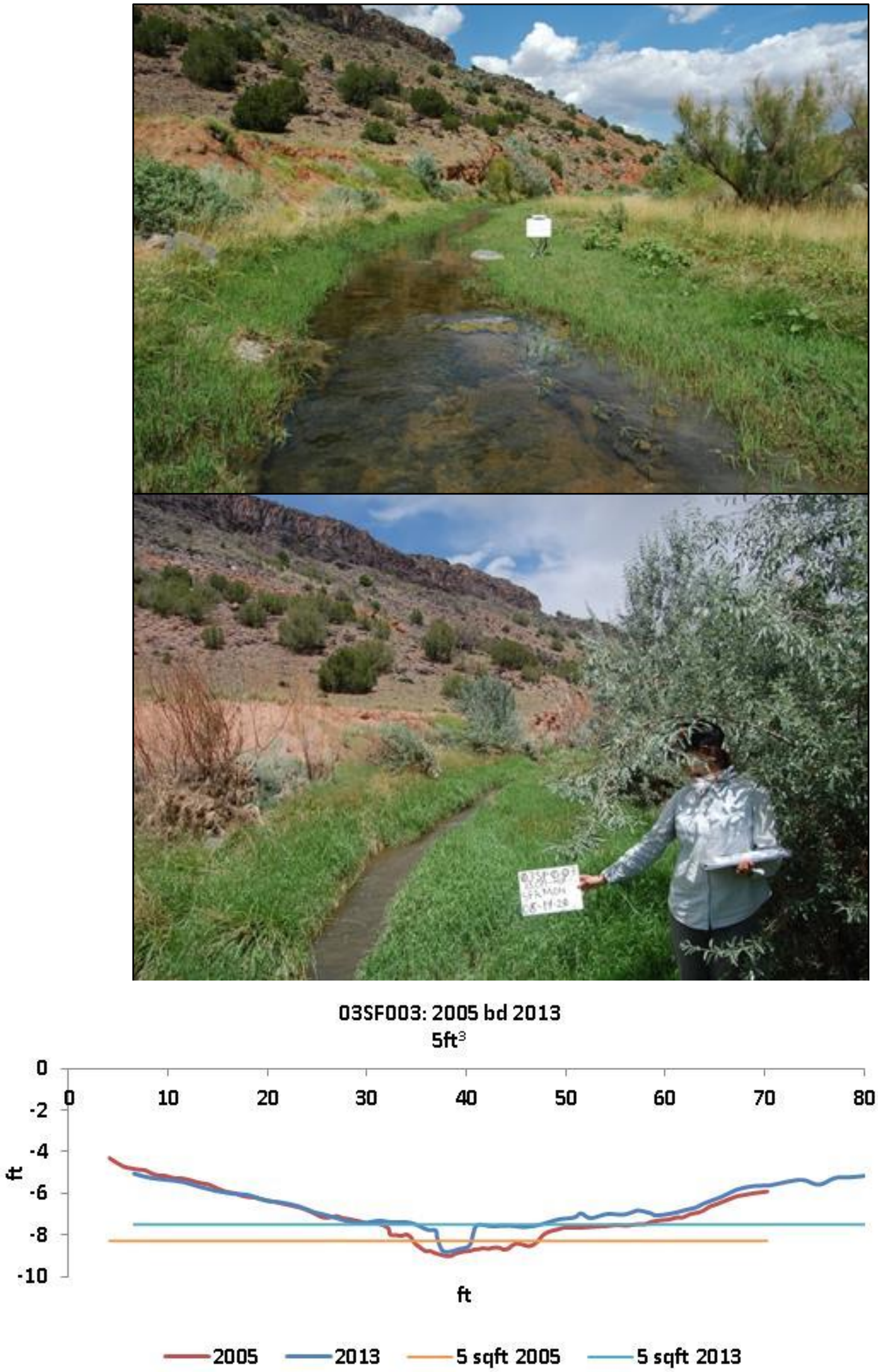


Figure 16. Transect 3 facing upstream; 2005 above, 2013 below.

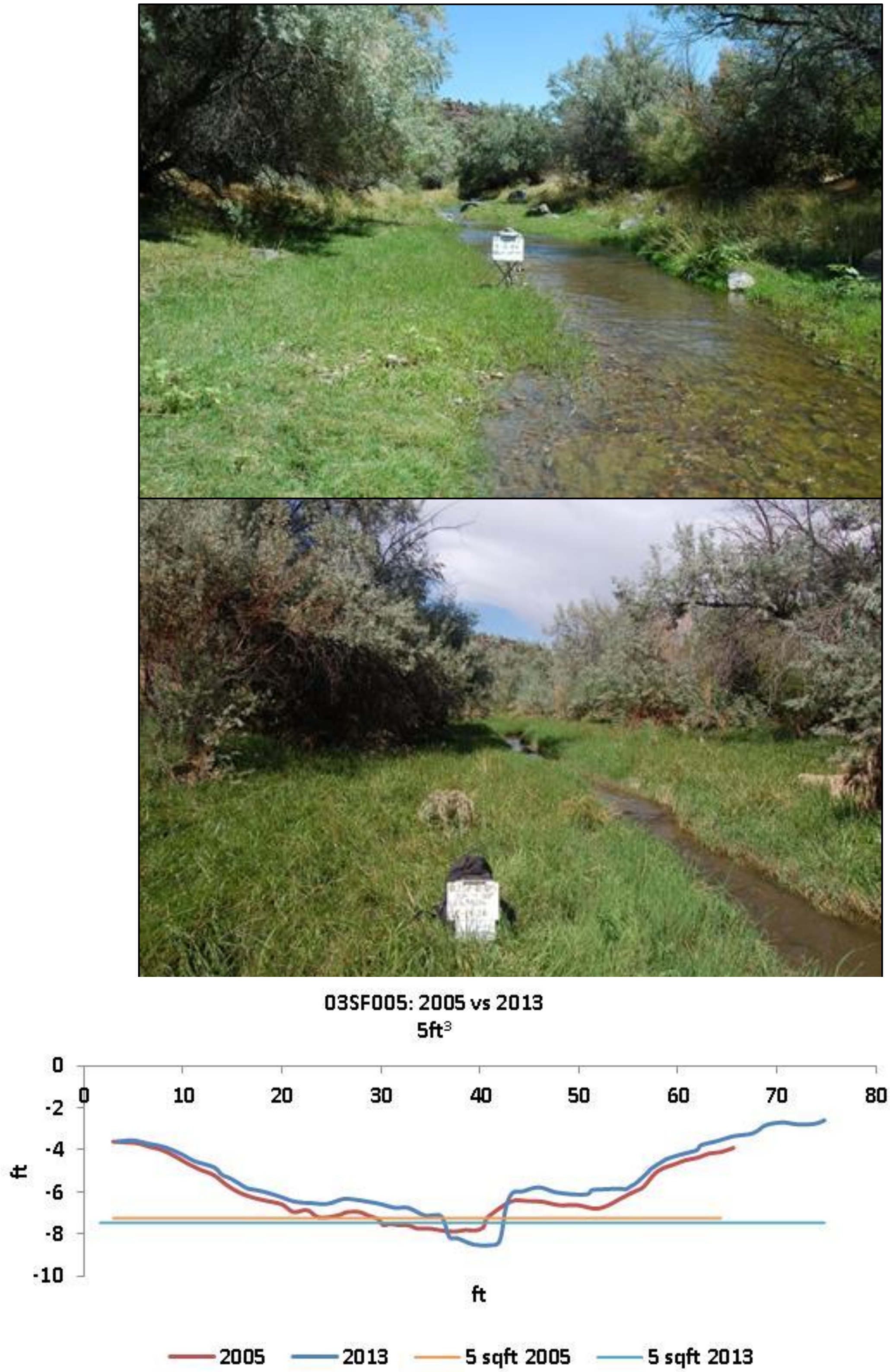


Figure 17. Transect 5 facing upstream; 2005 above, 2013 below.

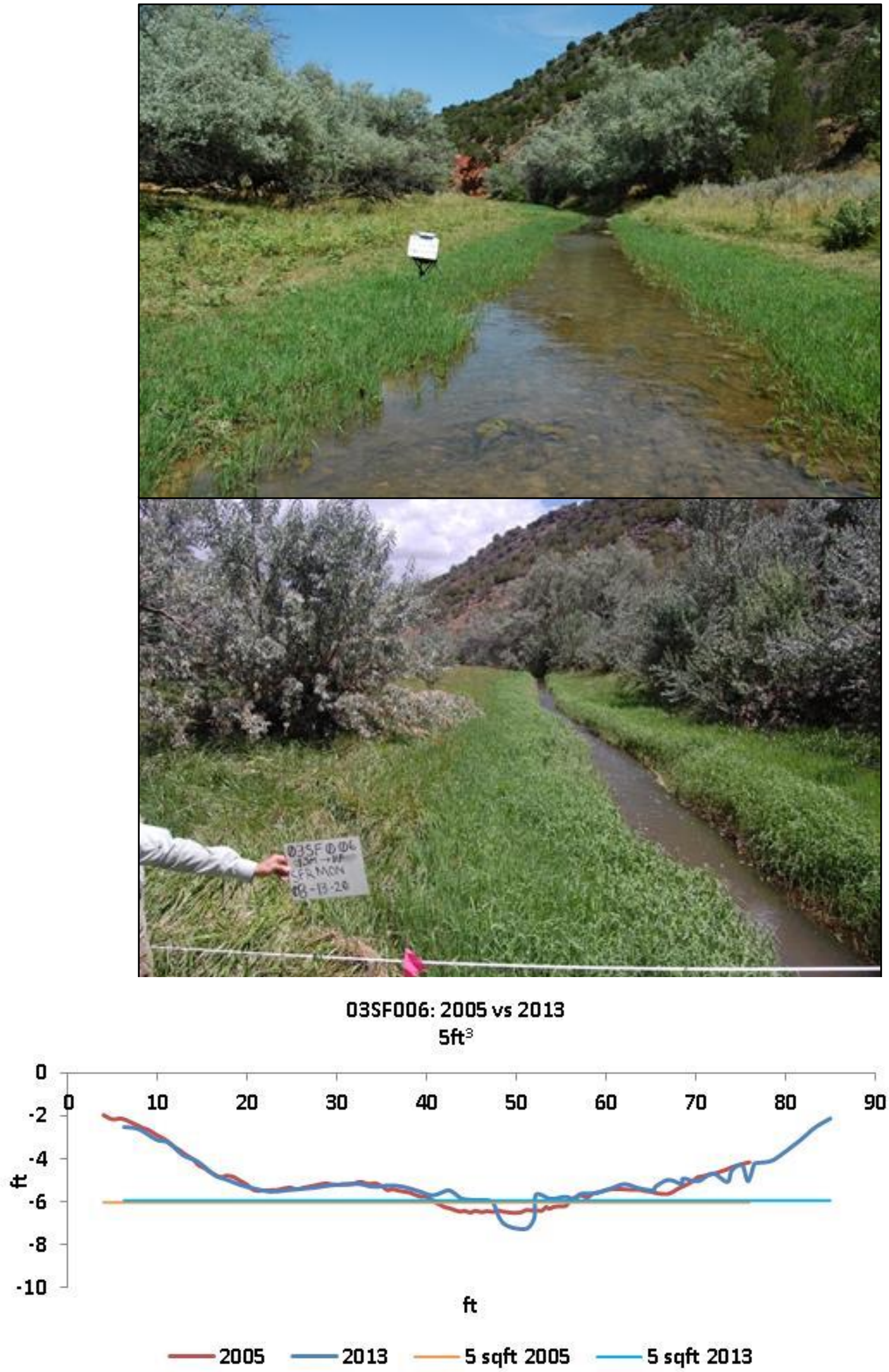


Figure 18. Transect 6 facing upstream; 2005 above, 2013 below.

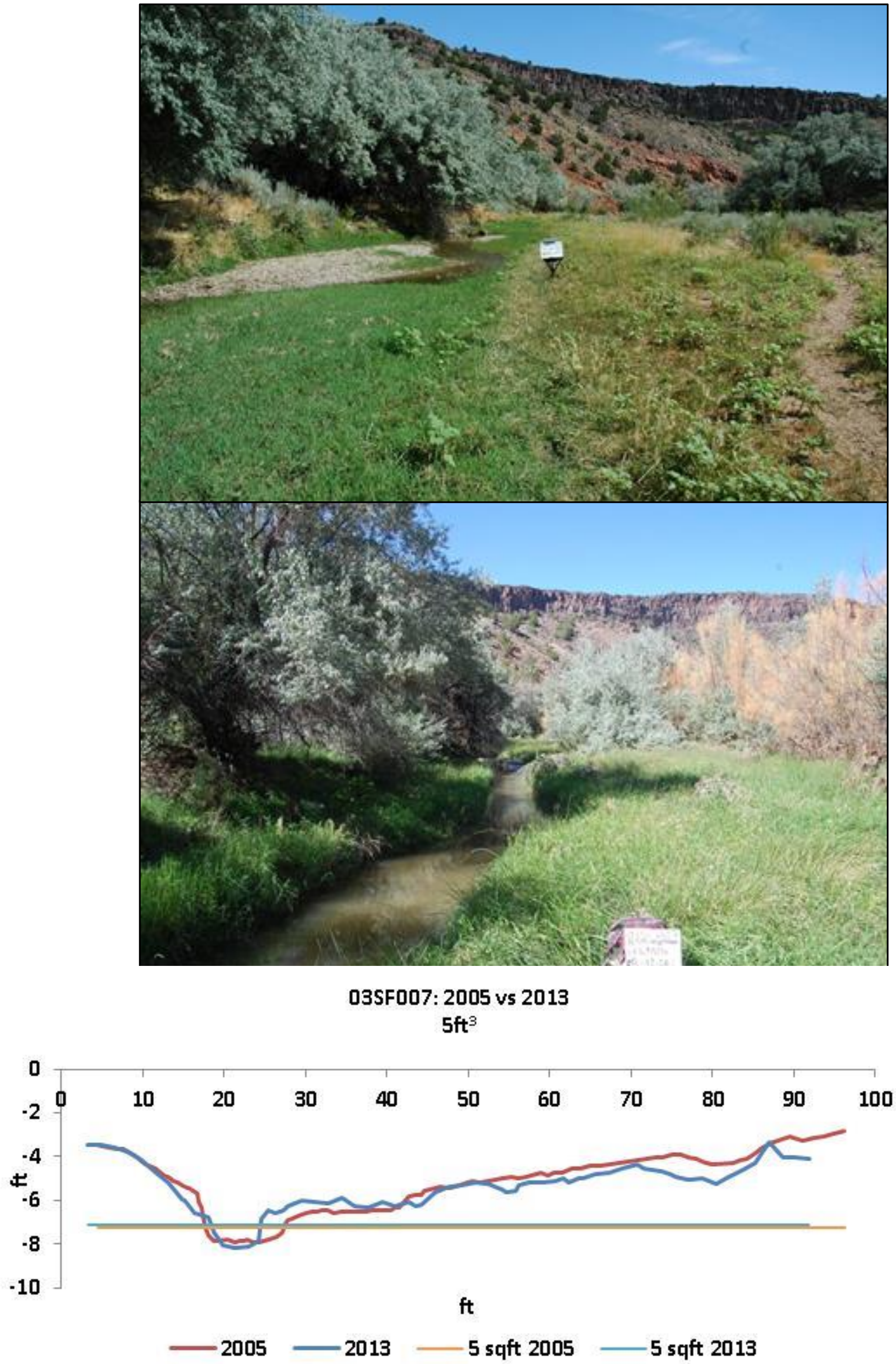


Figure 19. Transect 7 facing upstream; 2005 above, 2013 below.

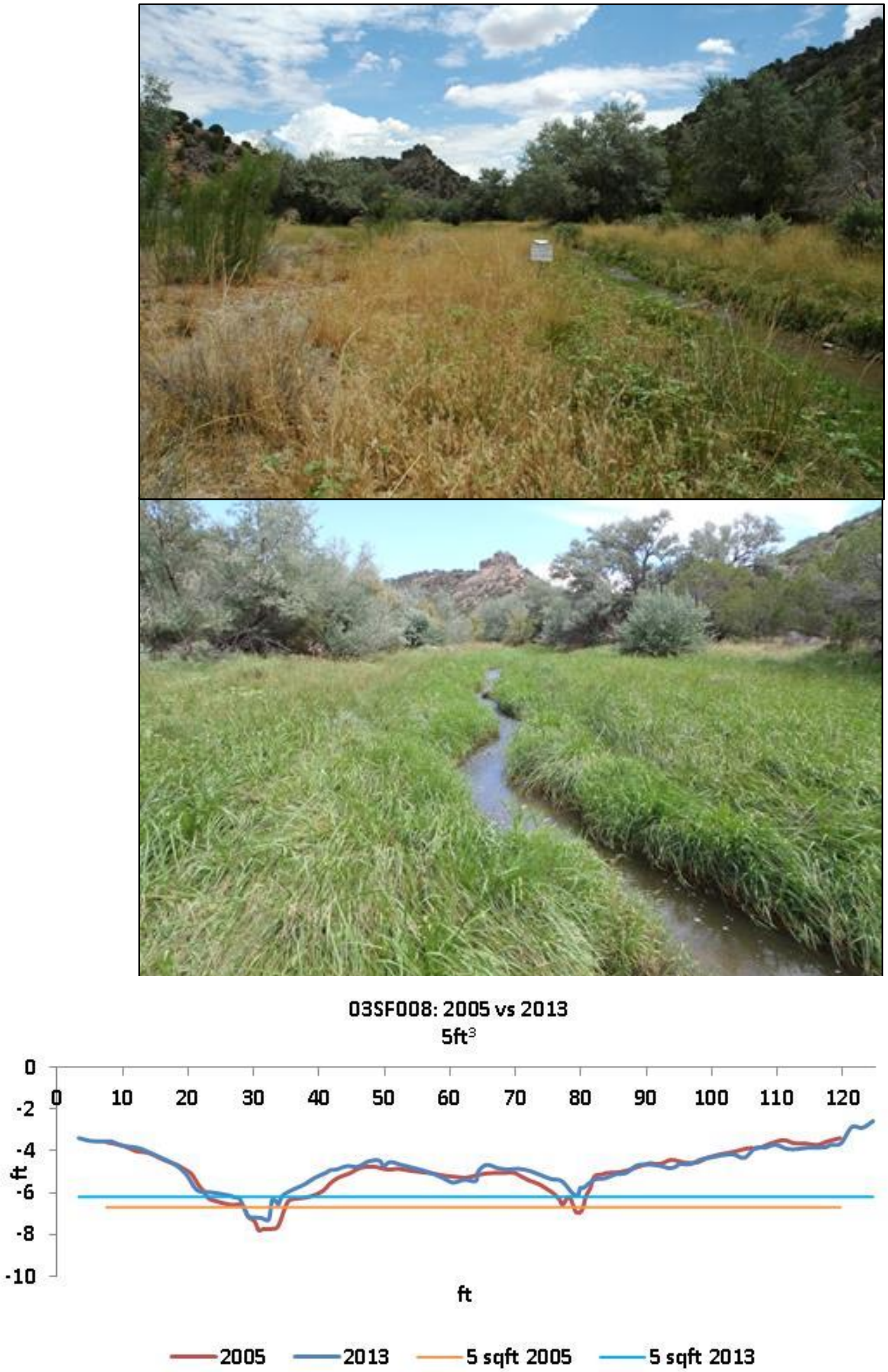


Figure 20. Transect 8 facing upstream; 2005 above, 2013 below.

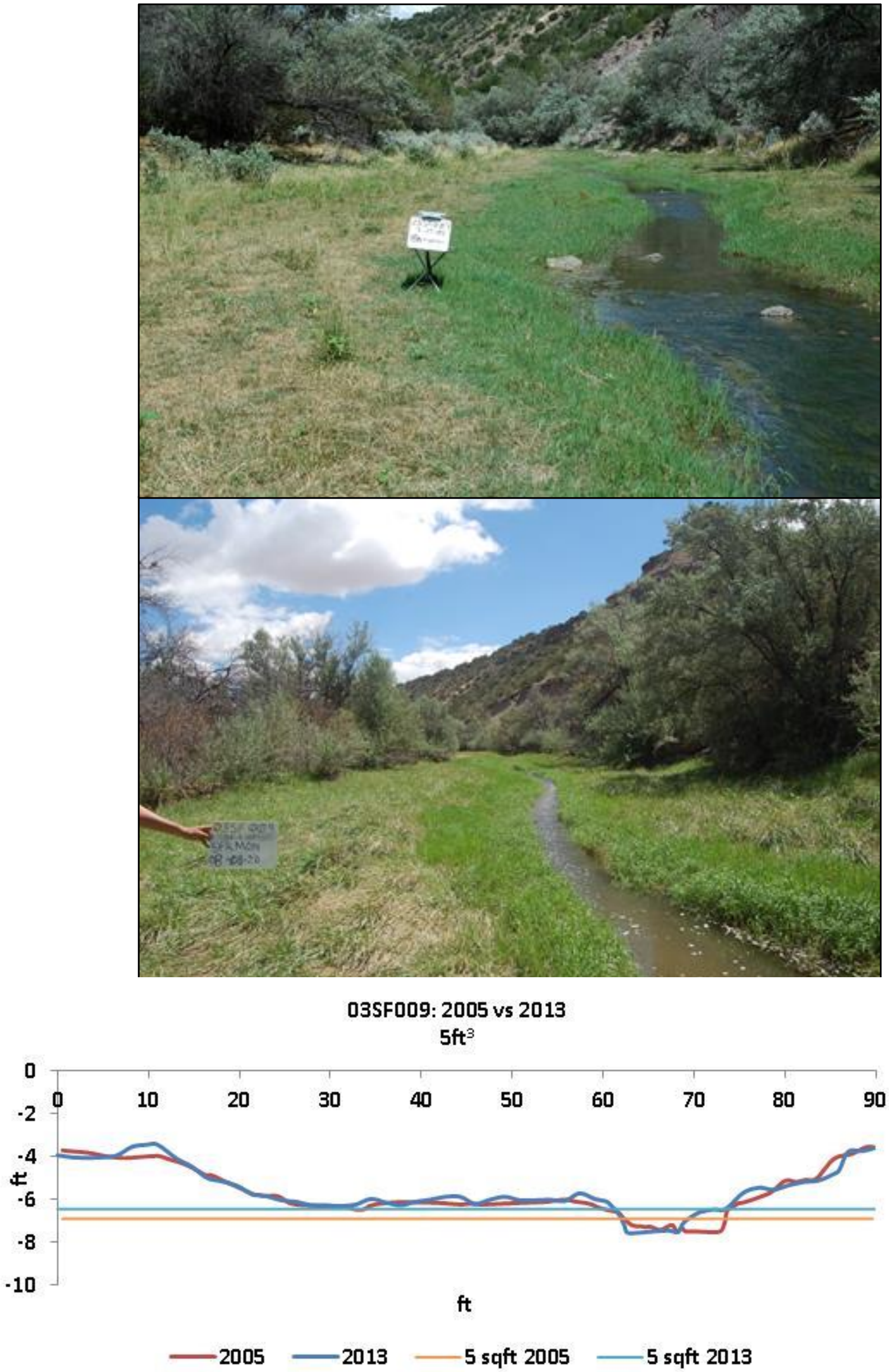


Figure 21. Transect 9 facing upstream; 2005 above, 2013 below.

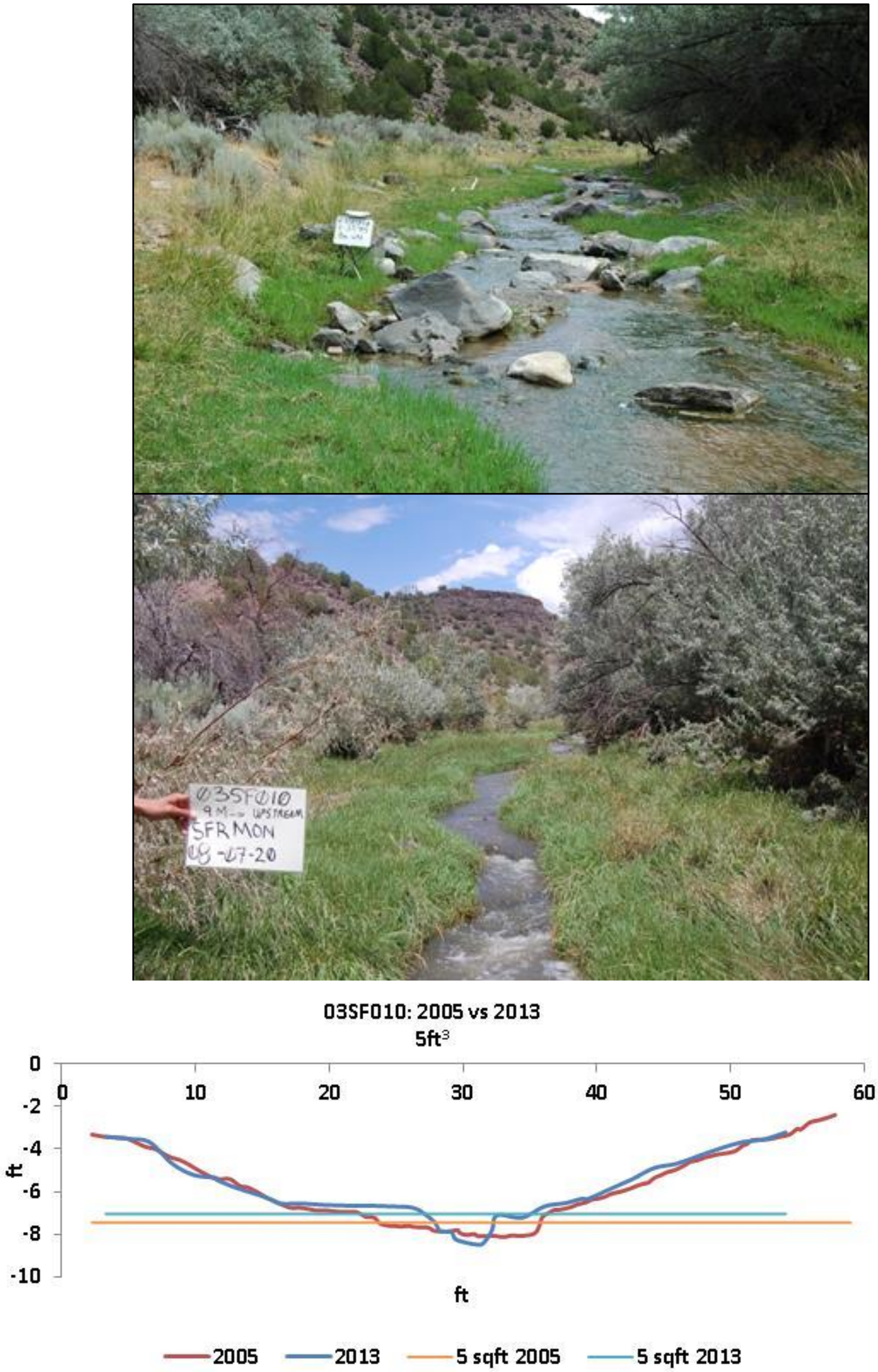


Figure 22. Transect 10 facing upstream; 2005 above, 2013 below.

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 had been previously dominated by exotic forbs (watercress and red clover) or bare exposed soil. Some of this expansion is likely due to a direct decrease in grazing; a decrease in trampling may also have been 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 2005 and 2013. The data from the cross-section profiles indicate that the banks have stabilized between 2005 and 2013, narrowing the channel and concentrating the perennial flow. This is likely to have decreased the temperature of the stream, decreased evaporation caused by sun exposure, and increased hyporheic exchange, based on knowledge of channel morphology and hydrology dynamics from other systems (Magilligan and McDowell 1997; Kauffman et al. 1983; Theurer et al. 1985). Banks have clearly steepened, and undercut banks are a more common feature in 2013 than in 2005. 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 (Herbst et al. 2012; 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, replacing both other exotics (creeping bentgrass) and native species (knotgrass, alkali muhly, common threesquare). Tall fescue was introduced in the United States in the 1800s, and was deliberately seeded in many locations for forage and/or soil conservation in the 1940s-1960s (Applegate 2005). It is not known if it was deliberately or accidentally introduced at the study site. Although tall fescue is not a state or federally listed weed species, it is considered an invasive species on native grasslands, one that is prone to spreading and potentially displacing native vegetation (Applegate 2005, Henson 2001). Additionally, an endophytic fungus is present in some varieties of tall fescue that can have deleterious effects on grazing animals as well as some native birds and other wildlife (Henson 2001). Based on available information it seems likely that the dominance of tall fescue within in the study area is unlikely to change without active management (Applegate 2005).

In 2013, saltcedar cover was reduced in all zones, primarily due to herbivory by saltcedar beetles. The majority of the saltcedar individuals within the study area were partly or totally defoliated. It is estimated that four years of beetle defoliation will yield 60% mortality within a stand (DiTomaso et al. 2013), so the long-term effect of the beetle within the study area is still evolving. If the beetles remain in the canyon, and are effective in killing significant portions of the saltcedar, a large amount of standing deadwood will remain behind unless further restoration activities are undertaken.

Even with the 2013 die-back of saltcedar, woody cover remained stable or increased in most vegetation zones. Where increases did occur it was among exotic Russian olive (and saltcedar prior to 2013) in zones other than the Woody Riparian. There are indications that exotic woody cover, particularly Russian olive, is encroaching into floodplain zones not occupied by it in 2003. In particular, in the Arroyo Riparian, Mesic Herbaceous Wetland and the Upper Herbaceous Wetland zones (Figs 5, 6 & 8). In fact, Russian olive has become the dominant woody species in both the Arroyo Riparian and Upper Herbaceous Wetland zones, and is noticeably more present within the floodplain than it was in 2003. A visual example of this encroachment is most evident in the photos from transects 6, 8 and 10 (Appendix B). 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. The lag in recovery by native woody species with grazing removal has been observed elsewhere, and active restoration of native woody species may be necessary for complete recovery of the riparian system (Hough-Snee et al. 2013). Without 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.

The dramatic changes seen here have also been reflected in other research on the recovery of riparian zones after livestock removal (Belsky et al. 1999; Krueper et al. 2003; Magilligan and McDowell 1997). These measured responses have included not just changes to the vegetation and active channel morphology, but also increases in belowground biomass, mean infiltration rate, and soil mineralization (Kauffman et al. 2004). The improvements in habitat have also led to significant improvements for breeding bird numbers (Krueper et al. 2003) as well as improved aquatic habitat (Magilligan and McDowell, 1997). Although we collected no empirical data on wildlife use or numbers, anecdotally more birds, wildlife and odonates were observed in 2010 and 2013 than in 2003-2005. As demonstrated here in the Santa Fe River, significant improvements can be seen due to livestock removal in as few as four to six years, (Krueper et al. 2003; Kauffman et al. 2004) although some aspects of the ecosystem do not recover so quickly. In particular, native woody vegetation may require active restoration to recover from intensive livestock use and the competition of established exotic species (Hough-Snee et al. 2013)

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Appendix A

UTM coordinates for the end-point rebar of all 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 eacb transect from four years: 2003, 2005, 2008, 2013.

Transect: 03SF001
View towards
downstream

September 2003

July 2008

July 2005

August 2013

Transect: 03SF002
View towards
downstream

September 2003

July 2008

July 2005

August 2013

Transect: 03SF003
View towards
downstream

September 2003

July 2008

July 2005

August 2013

Transect: 03SF005
View towards
downstream

September 2003

July 2008

July 2005

August 2013

Transect: 03SF006
View towards
downstream

September 2003

July 2008

July 2005

August 2013

Transect: 03SF007
View towards
downstream

September 2003

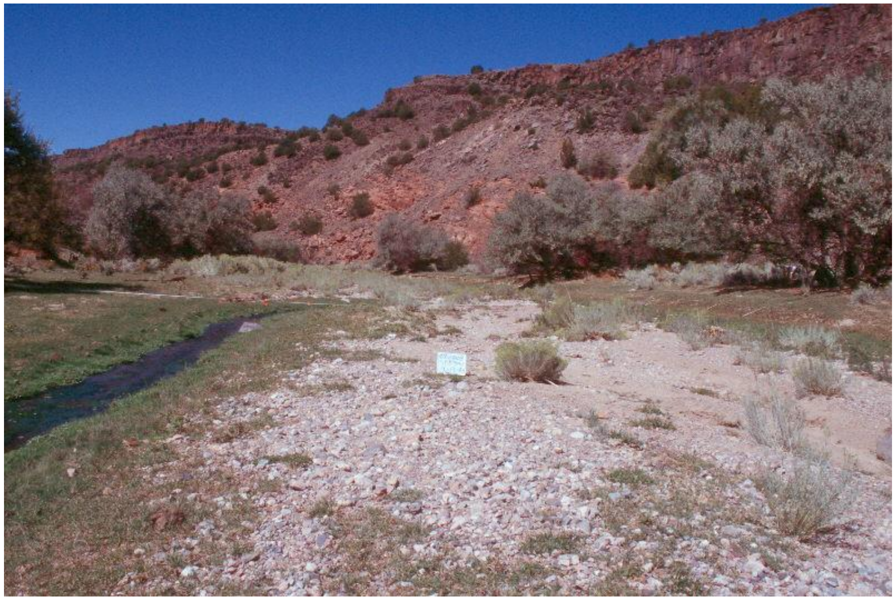
July 2008

July 2005

August 2013

Transect: 03SF008
View towards
downstream

September 2003



July 2008

July 2005

August 2013

Transect: 03SF009
View towards
downstream

September 2003

July 2008

July 2005

August 2013

Transect: 03SF010
View towards
downstream

September 2003

July 2008

July 2005

August 2013

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 to the Woody Riparian zone.

Channel

			Average Cover by Year				
Species Name	**Common Name**	**Origin**	**2003**	**2004**	**2005**	**2010**	**2013**
Trees							
Elaeagnus angustifolia	Russian olive	I		6.76	7.431	5.681	7.909
Tamarix chinensis	saltcedar	I	0.034				
Shrubs							
Rhus trilobata	skunkbush sumac	N			0.079		
Graminoids							
Agrostis stolonifera	creeping bentgrass	I	2.284	16.75	15.647	12	10.217
Cyperus spp.	flatsedge	N	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	0.148
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	24.602	41.193
Hordeum jubatum ssp. intermedium	intermediate barley	N				0.09	0.011
Juncus arcticus var. balticus	Baltic rush	N			0.056		0.011
Muhlenbergia asperifolia	alkali muhly	N	0.056	0.068	0.125	0.09	
Paspalum distichum	knotgrass	N	8.965	12.363	17.035	36.221	26.784
Polypogon monspeliensis	annual rabbitsfoot grass	I		1.215	0.09		
Schoenoplectus pungens	common threesquare	N	0.744	1.782	1.745	8.331	7.321
Schoenoplectus tabernaemontani	softstem bulrush	N					0.011
unidentified graminoid - seedling	unidentified graminoid - seedling					0.295	
Forbs							
Argentina anserina	silverweed cinquefoil	N	0.056	0.056	0.09	0.102	
Atriplex prostrata	triangle orache	N					0.004
Berula erecta	cutleaf waterparsnip	N		0.704	0.034	0.522	0.113
Calibrachoa parviflora	seaside petunia	N	0.113	0.056	0.215		
Chamaesyce serpyllifolia	thymeleaf sandmat	N					0.001
Chenopodium incanum	mealy goosefoot	N			0.005		
Cirsium vulgare	bull thistle	I		0.17			
Conyza canadensis	Canadian horseweed	N		0.023			0.011
Melilotus officinalis	yellow sweetclover	I		0.09			2.342
Mimulus glabratus	roundleaf monkeyflower	N	0.818	1.125	0.126		
Nasturtium officinale	watercress	I	15.205	24.296	0.069		
Persicaria maculosa	spotted ladysthumb	I	0.375	1.342	1.835	0.011	
Plantago major	common plantain	I				0.181	0.161
Polygonum aviculare	prostrate knotweed	I	0.034	0.137			0.045
Portulaca oleracea	common purslane	N		0.022			

Channel - continued

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Forbs - cont.							
Ranunculus cardiophyllus	heartleaf buttercup	N	0.073				
Ranunculus cymbalaria	alkali buttercup	N			0.136		
Rumex crispus	curly dock	I	0.17	0.534	0.364	0.727	2.806
Sonchus asper	spiny sowthistle	I	0.056				
Taraxacum officinale	common dandelion	I				0.193	0.306
Trifolium pratense	red clover	I	0.785	0.694	0.284	0.227	0.092
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	0.386
Algae/Cyanobacteria	algae/cyanobacteria					1.113	

Mesic Herbaceous Wetland

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Trees							
Elaeagnus angustifolia	Russian olive	I	4.943	3.663	6.697	13.041	14.431
Tamarix chinensis	saltcedar	I	0.199	0.122	0.075	1.575	0.136
Tamarix chinensis - dead	saltcedar - dead	I					0.636
Ulmus pumila	Siberian elm	I		0.013			
Shrubs							
Ericameria nauseosa	rubber rabbitbrush	N	0.102	0.213	0.136	0.034	
Rhus trilobata	skunkbush sumac	N			0.034		
Salix exigua	coyote willow	N	0.003				
Graminoids							
Agrostis gigantea	redtop	I				0.383	0.054
Agrostis stolonifera	creeping bentgrass	I	25.787	35.068	40.452	5.863	3.233
Bromus catharticus	rescuegrass	I	0.458	0.034		0.02	0.205
Bromus japonicus	Japanese brome	I			0.041	0.222	0.048
Bromus tectorum	cheatgrass	I			0.202	0.15	0.027
Cenchrus spinifex	sandbur	N	0.034	0.068			
Cynodon dactylon	bermudagrass	I		0.171	0.41	0.897	0.958
Distichlis spicata	inland saltgrass	N	0.143	0.239	0.089	0.047	
Echinochloa crus-galli	barnyardgrass	I	3.376	2.808	0.328		0.061
Eleocharis palustris	common spikerush	N	1.89	1.219	1.386	0.168	0.007
Elymus repens	quackgrass	I			0.006	0.102	0.034
Elymus x pseudorepens	false quackgrass	N				1.705	0.489
Eragrostis pectinacea	tufted lovegrass	N	0.191	0.082			0.02
Festuca arundinacea	tall fescue	I	3.247	6	7.171	72.986	71.691
Hordeum brachyantherum	meadow barley	N					0.054
Hordeum jubatum ssp. intermedium	intermediate barley	N		0.178		0.047	0.013
Hordeum murinum ssp. glaucum	smooth barley	I			0.167	0.027	0.007
Juncus arcticus var. balticus	Baltic rush	N	0	0.123	0.202	1.021	0.874
Muhlenbergia asperifolia	alkali muhly	N	1.965	4.657	3.828	3.565	3.273
Pascopyrum smithii	western wheatgrass	N				0.109	0.034
Paspalum distichum	knotgrass	N	8.315	6.798	4.747	4.52	3.777
Poa annua	bluegrass	I		1.123	0.547		
Poa pratensis	Kentucky bluegrass	N/I				0.095	0.205
Polypogon interruptus	ditch rabbitsfoot grass	I			0.006		
Polypogon monspeliensis	annual rabbitsfoot grass	I		0.624	0.559		
Schoenoplectus pungens	common threesquare	N	11.534	12.606	9.729	6.715	3.656
Sporobolus cryptandrus	sand dropseed	N	0.198	0.013	0.034	0.246	0.773
unidentified graminoid	unidentified graminoid		0.006				
unidentified graminoid - seedling	unidentified graminoid - seedling					0.191	
Forbs							
Almutaster pauciflorus	alkali marsh aster	N	0.013	0.205	0.02	0.191	0.041
Amaranthus hybridus	slim amaranth	N		0.017			0.102
Ambrosia acanthicarpa	flatspine burr ragweed	N		0.395	0.273	0.027	
Anemopsis californica	yerba mansa	N	0.02	0.013	0.068	0.431	0.561
Argentina anserina	silverweed cinquefoil	N	0.205	0.623	0.352	0.547	0.117
Atriplex prostrata	triangle orache	N					0.014
Berula erecta	cutleaf waterparsnip	N		0.458	0.102	0.047	0.089
Bidens cernua	nodding beggarstick	N		0.174			0.006
Calibrachoa parviflora	seaside petunia	N	0.041				
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.207	0.052		0.264	0.767
Chamaesyce serrula	sawtooth sandmat	N	0	0.003			
Chenopodium fremontii	Fremont's goosefoot	N					0

Mesic Herbaceous Wetland - continued

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Forbs - cont.							
Conyza canadensis	Canadian horseweed	N	0.102	0.116	0.116	0.054	0.706
Equisetum laevigatum	smooth horsetail	N			0.001	0.154	0.069
Euphorbia davidii	David's spurge	I					0
Gaura mollis	velvetweed	N	0			0.103	
Grindelia squarrosa	curlycup gumweed	N	0.013		0.013	0.15	
Helianthus annuus	common sunflower	N					0.02
Kochia scoparia	common kochia	I	0.136	1.045	0.089	0.342	0.287
Lactuca serriola	prickly lettuce	I			0.034		0.144
Melilotus officinalis	yellow sweetclover	I	0.006	0.931	0.075	0.185	1.246
Mimulus glabratus	roundleaf monkeyflower	N	0.069	0.178	0.003		
Nasturtium officinale	watercress	I	1.602	2.294	0		
Persicaria maculosa	spotted ladysthumb	I	0.01	0.41	0.39	0.013	
Plantago major	common plantain	I				0.273	0
Polygonum aviculare	prostrate knotweed	I	0.311	0.272	0.164	0.297	0.054
Portulaca oleracea	common purslane	N	0.036	0.312		0.013	0.006
Portulaca pilosa	kiss me quick	N					0.007
Ranunculus cardiophyllus	heartleaf buttercup	N	0.001				
Ranunculus cymbalaria	alkali buttercup	N	0.092	0.205	0.075	0.164	0.048
Rumex crispus	curly dock	I		0.068		0.068	0.113
Salsola tragus	prickly Russian thistle	I		0		0.027	
Schkuhria multiflora	manyflower false threadleaf	N		0.013			
Sonchus asper	spiny sowthistle	I					0.023
Symphyotrichum ericoides	heath aster	N					0.034
Symphyotrichum ericoides var. ericoides	heath aster	N				0.136	
Taraxacum officinale	common dandelion	I	0.041	0.109	0.102	0.13	0.137
Tragopogon pratensis	meadow salsify	I					0.02
Tribulus terrestris	puncturevine	I	0.069	0.028			0.037
Trifolium pratense	red clover	I	17.405	17.544	13.528	0.085	
unidentified forb - seedling	unidentified forb - seedling					0.001	0.012
Veronica anagallis-aquatica	water speedwell	N	0.082		0.068		
Xanthium strumarium	rough cocklebur	N	1.339	11.013	6.003	1.349	0.099

Upper Herbaceous Wetland

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Trees							
Elaeagnus angustifolia	Russian olive	I	8.583	10.652	9.315	25.21	16.403
Juniperus monosperma	oneseed juniper	N					0.368
Tamarix chinensis	saltcedar	I	0.821	1.536	1.104	9.315	5
Tamarix chinensis - dead	saltcedar - dead	I					1.263
Shrubs							
Ericameria nauseosa	rubber rabbitbrush	N	0.769	0.236	0.694	2.189	0.842
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	0.031
Bouteloua barbata	sixweeks grama	N	0.03	0.436		0.042	1.442
Bouteloua gracilis	blue grama	N	0.285	0.378	0.052	0.368	0.673
Bromus catharticus	rescuegrass	I		0.106	0.726	1.389	
Bromus japonicus	Japanese brome	I	0.001	0.127	0.694	0.605	0.115
Bromus tectorum	cheatgrass	I		0.003	2.257	0.222	0.715
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	2.726
Cyperus spp.	flatsedge	N					0.01
Distichlis spicata	inland saltgrass	N	2.664	2.483	4.042	0.863	0.454
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	0.242
Elymus repens	quackgrass	I			0.422	2.684	0.947
Elymus x pseudorepens	false quackgrass	N				1.421	
Eragrostis pectinacea	tufted lovegrass	N	0.007	0.012			3.243
Festuca arundinacea	tall fescue	I	6.965	9.726	6.063	20.789	23.189
Hordeum brachyantherum	meadow barley	N					0.073
Hordeum jubatum ssp. intermedium	intermediate barley	N		0.063		0.389	0.022
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	0.506
Muhlenbergia asperifolia	alkali muhly	N	7.389	9.968	4.315	5.916	2.1
Munroa squarrosa	false buffalograss	N	0.001				0.084
Pascopyrum smithii	western wheatgrass	N	0.215	0.653	0.878	5.294	3.286
Paspalum distichum	knotgrass	N	0.211				
Poa annua	bluegrass	I		0.116	0.2		
Poa compressa	Canada bluegrass	I			0.126		
Poa pratensis	Kentucky bluegrass	N/I				0.41	0.21
Polypogon monspeliensis	annual rabbitsfoot grass	I			0.41		
Schoenoplectus pungens	common threesquare	N	1.216	1.743	1.184	1.38	0.228
Sporobolus airoides	alkali sacaton	N	0.947	0.789	1.536	2.684	4.084
Sporobolus cryptandrus	sand dropseed	N	1.058	1.102	0.263	7.342	3.98
unidentified graminoid	unidentified graminoid		0.048	0.001			
unidentified graminoid - seedling	unidentified graminoid - seedling					0.01	0.022
Vulpia octoflora	sixweeks fescue	N	0.006		1.021	0.048	

Upper Herbaceous Wetland - continued

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Forbs							
Almutaster pauciflorus	alkali marsh aster	N	0.126	0.284	0.157	0.263	0.126
Amaranthus hybridus	slim amaranth	N	0.033	0.003			0.347
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.68	4.244	0.602		0.073
Anemopsis californica	yerba mansa	N	9.968	11.557	10.442	10.136	8.963
Argentina anserina	silverweed cinquefoil	N		0.178	0.157		
Asclepias subverticillata	whorled milkweed	N					0.105
Atriplex prostrata	triangle orache	N				0.057	0.18
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.015	0.007		0.126	1.055
Chamaesyce serrula	sawtooth sandmat	N	0.009				0.021
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	0.094
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 obtusa	blunt tansymustard	N				0.052	0.021
Descurainia spp.	tansymustard				0.021		0.01
Equisetum laevigatum	smooth horsetail	N				0.01	0.001
Erigeron flagellaris	trailing fleabane	N				0.294	
Erodium cicutarium	redstem stork's bill	I					0.011
Euphorbia davidii	David's spurge	I					0.054
Euphorbia exstipulata	squareseed spurge	N	0.005	0.002			
Gaura mollis	velvetweed	N				0.084	0.085
Grindelia squarrosa	curlycup gumweed	N					0.021
Kallstroemia parviflora	warty caltrop	N	0.015				
Kochia scoparia	common kochia	I	1.487	6.333	1.257	5.447	7.726
Lactuca serriola	prickly lettuce	I			0.115		
Melilotus officinalis	yellow sweetclover	I		0.673	0.284	0.052	1.042
Mentzelia multiflora	manyflowered mentzelia	N			0.01		
Persicaria maculosa	spotted ladysthumb	I					0.042
Plantago patagonica	woolly plantain	N			0.063		
Polygonum aviculare	prostrate knotweed	I	0.564	0.577	1.212	0.136	0.168
Portulaca oleracea	common purslane	N	0.493	1.094		0.006	6.337
Ratibida tagetes	green prairie coneflower	N	0.242	0.568	0.921	2.4	0.831
Rumex crispus	curly dock	I	0.105	0.105	0.031	0.021	0.211
Salsola tragus	prickly Russian thistle	I	0.178	2.137	0.011	0.243	0.452
Sanvitalia abertii	Albert's creeping zinnia	N					0.01
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		0.031
Symphyotrichum ericoides	heath aster	N					0.315
Symphyotrichum ericoides var. ericoides	heath aster	N				0.105	
Taraxacum officinale	common dandelion	I	0.073	0.042			
Tragopogon dubius	yellow salsify	I					0.01
Tragopogon pratensis	meadow salsify	I				0.031	0.085
Tribulus terrestris	puncturevine	I	0.957	0.37		0.001	0.758
Trifolium pratense	red clover	I	2.778	1.252	2.105		
unidentified forb	unidentified forb		0.006				
unidentified forb - seedling	unidentified forb - seedling						0.021
Verbesina encelioides	golden crownbeard	N					1.494
Xanthisma spinulosum	lacy tansyaster	N	0.227	0.026	0.18		0.063
Xanthium strumarium	rough cocklebur	N	0.884	2.938	2.094	0.921	0.106
Asteraceae	sunflower family						0.105

Arroyo Riparian

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Trees							
Elaeagnus angustifolia	Russian olive	I	1.544	5.944	5.908	17.454	24.909
Tamarix chinensis	saltcedar	I	2.909	9.818	11.636	12.381	
Tamarix chinensis - dead	saltcedar - dead	I					12
Shrubs							
Ericameria nauseosa	rubber rabbitbrush	N	37.854	37.054	27.736	22.545	18.618
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				1.101
Bromus catharticus	rescuegrass	I	0.009	0.181	0.018		0.09
Bromus japonicus	Japanese brome	I	0.09		0.181	1.572	
Bromus tectorum	cheatgrass	I	0.803	1.772	18.165	3.765	0.729
Cenchrus spinifex	sandbur	N	0.009	0.018			
Chloris verticillata	tumble windmill grass	N					0.036
Distichlis spicata	inland saltgrass	N	1.063	0.454	0.309	0.745	1.145
Elymus canadensis	Canada wildrye	N					0.018
Elymus repens	quackgrass	I				3.636	
Elymus x pseudorepens	false quackgrass	N				1.154	0.09
Eragrostis pectinacea	tufted lovegrass	N	0.02	0.436			0.654
Festuca arundinacea	tall fescue	I	0.363	0.418	0.763	3.663	6.4
Hordeum murinum ssp. glaucum	smooth barley	I	0.001	0.263	2.71	0.2	0.018
Juncus arcticus var. balticus	Baltic rush	N			0.009		
Muhlenbergia asperifolia	alkali muhly	N	1.081	2.709	2.181	0.836	1.263
Munroa squarrosa	false buffalograss	N	0.001				
Pascopyrum smithii	western wheatgrass	N	0.9	1.31	3.409	5.909	2.747
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	7.232	5.894
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			2.123
Amaranthus spp.	amaranth						0.009
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.654	2.44	0.156	1.454	0.018
Boerhavia spicata	creeping spiderling	N		0.145		0.009	0.427
Brassicaceae	mustard family				0.018		
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.189	0.287		0.721	1.761
Chamaesyce serrula	sawtooth sandmat	N		0.147		0.036	
Chenopodium incanum	mealy goosefoot	N	0.018				
Conyza canadensis	Canadian horseweed	N			0.09		0.772
Cucurbita foetidissima	buffalo gourd	N		0.09			1.472
Dalea candida var. oligophylla	white prairieclover	N		0.09			
Descurainia spp.	tansymustard				0.009		
Equisetum laevigatum	smooth horsetail	N			0.009	0.109	
Erodium cicutarium	redstem stork's bill	I					0.096
Euphorbia davidii	David's spurge	I					0.047
Gaura mollis	velvetweed	N	0.036		0.272	1.381	0.509
Grindelia squarrosa	curlycup gumweed	N	0.018	0.218	0.69		
Heterotheca villosa	hairy goldenaster	N				0.045	2

Arroyo Riparian - continued

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Forbs - cont.							
Ipomopsis longiflora	flaxflowered ipomopsis	N					0.036
Kallstroemia parviflora	warty caltrop	N		0.072			0.181
Kochia scoparia	common kochia	I	2.19	6.854		0.836	7.529
Lactuca serriola	prickly lettuce	I			0.036		0.149
Melilotus officinalis	yellow sweetclover	I	0.009		0.29		0.047
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			0.889
Portulaca pilosa	kiss me quick	N					0.021
Rumex crispus	curly dock	I					0.672
Salsola tragus	prickly Russian thistle	I	0.056	0.572			0.009
Schkuhria multiflora	manyflower false threadleaf	N		0			
Scorzonera laciniata	cutleaf vipergrass	I				0.018	
Senecio spartioides	broom groundsel	N					0.054
Solanum elaeagnifolium	silverleaf nightshade	N				0.909	1.454
Taraxacum officinale	common dandelion	I		0.018		0.036	
Tidestromia lanuginosa	wooly tidestromia	N		0.036			0.181
Tribulus terrestris	puncturevine	I	1.347	1.085		0.156	0.118
Verbascum thapsus	common mullein	I	0.272	0.272			
Xanthisma gracile	slender goldenweed	N				0.054	
Xanthisma spinulosum	lacy tansyaster	N	0.254	0.327	0.22	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	2013
Trees							
Elaeagnus angustifolia	Russian olive	I	47.712	62.25	62.387	61.812	59.175
Juniperus monosperma	oneseed juniper	N	3.312	3.437	3.437	5.25	4.937
Tamarix chinensis	saltcedar	I	9	10.25	11.225	7.25	
Tamarix chinensis - dead	saltcedar - dead	I					8.75
Shrubs							
Ericameria nauseosa	rubber rabbitbrush	N	16.75	11.312	7.837	6.487	6.25
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	0.001
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	0.373
Carex praegracilis	clustered field sedge	N	0.568	0.487	0.7	0.018	
Cyperus spp.	flatsedge	N	0.006				
Distichlis spicata	inland saltgrass	N	2.231	4.138	2.75	4.512	3.026
Echinochloa crus-galli	barnyardgrass	I	0.062				
Elymus elymoides	bottlebrush squirreltail	N		1.337			
Elymus lanceolatus ssp. riparius	streambank wheatgrass	N				2.3	0.875
Elymus repens	quackgrass	I			0.737	0.225	0.437
Elymus trachycaulus	slender wheatgrass	N					0.062
Elymus x pseudorepens	false quackgrass	N				1.618	0.013
Eragrostis pectinacea	tufted lovegrass	N	0.015				0.562
Festuca arundinacea	tall fescue	I	3.732	6.568	2.387	11.312	14.337
Hordeum brachyantherum	meadow barley	N					0.05
Hordeum jubatum ssp. intermedium	intermediate barley	N		0.281	0.187	0.412	
Hordeum murinum ssp. glaucum	smooth barley	I	0.093	0.591	12.515	3.52	0.165
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	2.05
Pascopyrum smithii	western wheatgrass	N	0.55	0.875	1.562	2.7	1.212
Paspalum distichum	knotgrass	N	0.025	0.025	0.037		
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	0.012
Sporobolus airoides	alkali sacaton	N	0.437	0.626	0.625	0.85	0.587
Sporobolus cryptandrus	sand dropseed	N	2.245	2.011	0.206	4.693	0.69
unidentified graminoid	unidentified graminoid						0.075
unidentified graminoid - seedling	unidentified graminoid - seedling						0.037
Vulpia octoflora	sixweeks fescue	N			0.05		
Forbs							
Amaranthus hybridus	slim amaranth	N	0.063	0.19		0.312	1.346
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.775	1.487	0.038		
Anemopsis californica	yerba mansa	N	1.443	2	1.137	3.231	3.087
Argentina anserina	silverweed cinquefoil	N	0.287	0.3	0.325	0.012	0.025
Artemisia ludoviciana	white sagebrush	N				0.006	
Atriplex prostrata	triangle orache	N				0.262	0.437
Bidens cernua	nodding beggarstick	N					0.187
Brassicaceae	mustard family			0.012			

Woody Riparian - continued

Species Name	Common Name	Origin	Average Cover by Year 2003	2004	2005	2010	2013
Forbs - cont.							
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.017	0.093		0.001	0.326
Chamaesyce serrula	sawtooth sandmat	N	0.001				
Chenopodium atrovirens	pinyon goosefoot	N		0.25			
Chenopodium fremontii	Fremont's goosefoot	N				0.337	
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		0.026
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	
Forb undifferentiated	undifferentiated forb						0.012
Gaura mollis	velvetweed	N					0.1
Grindelia squarrosa	curlycup gumweed	N	0.062				
Heterotheca villosa	hairy goldenaster	N		0.15	0.001		
Ipomopsis longiflora	flaxflowered ipomopsis	N	0.038			0.006	
Kochia scoparia	common kochia	I	6.332	17.988	5.031	9.963	10.198
Lactuca serriola	prickly lettuce	I	0.012		0.05	0.025	0.487
Malva neglecta	common mallow	I	0.001	0.062			
Melilotus officinalis	yellow sweetclover	I					0.003
Mirabilis linearis	narrowleaf four o'clock	N		0.062		0.3	0.062
Mirabilis oxybaphoides	smooth spreading four o'clock	N					0.013
Persicaria maculosa	spotted ladysthumb	I	0.125				
Physaria fendleri	Fendler's bladderpod	N				0.062	0.1
Polygonum aviculare	prostrate knotweed	I	0.556	0.447	0.177	0.175	
Portulaca oleracea	common purslane	N	0.18	0.342			0.572
Rumex crispus	curly dock	I	0.026	0.012		0.025	0.068
Salsola tragus	prickly Russian thistle	I	0.012	0.112	0.062	0.063	0.437
Schkuhria multiflora	manyflower false threadleaf	N	0.013				
Scorzonera laciniata	cutleaf vipergrass	I	0.212				
Sisymbrium spp.	hedgemustard				0.062		
Sisyrinchium demissum	dwarf blue-eyed grass	N		0.062	0.125		
Solanum elaeagnifolium	silverleaf nightshade	N	0.012			0.275	1.493
Sonchus asper	spiny sowthistle	I		0.025			
Taraxacum officinale	common dandelion	I	0.837	0.312	0.187	0.05	
Tribulus terrestris	puncturevine	I	0.045			0.025	0.138
Trifolium pratense	red clover	I	0.312	0.165	0.15		
unidentified forb	unidentified forb		0.002				
unidentified forb - seedling	unidentified forb - seedling					0.026	0.008
unidentified spp.	unidentified plant						0.012
Xanthium strumarium	rough cocklebur	N	0.012	1.725	0.001	0.112	0.043

Appendix D

Inclusive species list from all transects across all years.

Scientific Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Trees				
Celtis laevigata var. reticulata	netleaf hackberry	CELLAER	CELAR	N
Elaeagnus angustifolia	Russian olive	ELAANG	ELAN	I
Juniperus monosperma	oneseed juniper	JUNMON	JUMO	N
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	POPDELW	PODEW	N
Salix amygdaloides	peachleaf willow	SALAMY	SAAM2	N
Salix gooddingii	Goodding's willow	SALGOO	SAGO	N
Tamarix chinensis	saltcedar	TAMCHI	TACH2	I
Ulmus pumila	Siberian elm	ULMPUM	ULPU	I
Shrubs				
Atriplex canescens	fourwing saltbush	ATRCAN	ATCA2	N
Brickellia californica	California brickellbush	BRICAL	BRCA3	N
Cylindropuntia imbricata	tree cholla	CYLIMB	CYIM2	N
Ericameria nauseosa	rubber rabbitbrush	ERINAU	ERNA10	N
Fallugia paradoxa	Apacheplume	FALPAR	FAPA	N
Forestiera pubescens var. pubescens	New Mexico olive	FORPUBP	FOPUP	N
Ptelea trifoliata	common hoptree	PTETRI	PTTR	N
Rhus trilobata	skunkbush sumac	RHUTRI	RHTR	N
Ribes leptanthum	trumpet gooseberry	RIBLEP	RILE	N
Salix exigua	coyote willow	SALEXI	SAEX	N
Sub-shrubs				
Baccharis wrightii	Wright's baccharis	BACWRI	BAWR	N
Gutierrezia sarothrae	broom snakeweed	GUTSAR	GUSA2	N
Opuntia phaeacantha	tulip pricklypear	OPUPHA	OPPH	N
Graminoids				
Achnatherum hymenoides	Indian ricegrass	ACHHYM	ACHY	N
Agrostis gigantea	redtop	AGRGIG	AGGI2	I
Agrostis scabra	rough bentgrass	AGRSCA	AGSC5	N
Agrostis spp.	bentgrass	AGROST	AGROS2	
Agrostis stolonifera	creeping bentgrass	AGRSTO	AGST2	I
Bothriochloa laguroides ssp. torreyana	silver beardgrass	BOTLAGT	BOLAT	N
Bouteloua barbata	sixweeks grama	BOUBAR	BOBA2	N
Bouteloua curtipendula	sideoats grama	BOUCUR	BOCU	N
Bouteloua eriopoda	black grama	BOUERI	BOER4	N
Bouteloua gracilis	blue grama	BOUGRA	BOGR2	N
Bromus catharticus	rescuegrass	BROCAT	BRCA6	I
Bromus inermis	smooth brome	BROINE	BRIN2	I
Bromus japonicus	Japanese brome	BROJAP	BRJA	I
Bromus tectorum	cheatgrass	BROTEC	BRTE	I

Scientific Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Graminoids - cont.				
Carex praegracilis	clustered field sedge	CARPRA	CAPR5	N
Cenchrus spinifex	sandbur	CENSPI	CESP4	N
Chloris verticillata	tumble windmill grass	CHLVER	CHVE2	N
Cynodon dactylon	bermudagrass	CYNDAC	CYDA	I
Cyperus esculentus	chufa flatsedge	CYPESC	CYES	I
Cyperus niger	black flatsedge	CYPNIG	CYNI2	N
Cyperus spp.	flatsedge	CYPERU	CYPER	
Distichlis spicata	inland saltgrass	DISSPI	DISP	N
Echinochloa crus-galli	barnyardgrass	ECHCRU	ECCR	I
Eleocharis palustris	common spikerush	ELEPAL	ELPA3	N
Eleocharis parishii	Parish's spikerush	ELEPAR	ELPA4	N
Eleocharis spp.	spikerush	ELEOCH	ELEOC	
Elymus elymoides	bottlebrush squirreltail	ELYELY	ELEL5	N
Elymus lanceolatus ssp. riparius	streambank wheatgrass	ELYLANR	ELLAR	N
Elymus repens	quackgrass	ELYREP	ELRE4	I
Elymus x pseudorepens	false quackgrass	ELYPSE	ELPS	N
Eragrostis pectinacea	tufted lovegrass	ERAPEC	ERPE	N
Festuca arundinacea	tall fescue	FESARU	FEAR3	I
Hordeum brachyantherum	meadow barley	HORBRA	HOBR2	N
Hordeum jubatum	foxtail barley	HORJUB	HOJU	N
Hordeum jubatum ssp. intermedium	intermediate barley	HORJUBI	HOJUI	N
Hordeum murinum	mouse barley	HORMUR	HOMU	I
Hordeum murinum ssp. glaucum	smooth barley	HORMURG	HOMUG	I
Juncus arcticus var. balticus	Baltic rush	JUNARCB	JUARB5	N
Juncus torreyi	Torrey's rush	JUNTOR	JUTO	N
Muhlenbergia asperifolia	alkali muhly	MUHASP	MUAS	N
Munroa squarrosa	false buffalograss	MUNSQU	MUSQ3	N
Pascopyrum smithii	western wheatgrass	PASSMI	PASM	N
Paspalum distichum	knotgrass	PASDIS	PADI6	N
Poa annua	bluegrass	POAANN	POAN	I
Poa compressa	Canada bluegrass	POACOM	POCO	I
Poa pratensis	Kentucky bluegrass	POAPRA	POPR	I
Polypogon interruptus	ditch rabbitsfoot grass	POLINT	POIN7	I
Polypogon monspeliensis	annual rabbitsfoot grass	POLMON	POMO5	I
Schedonnardus paniculatus	tumblegrass	SCHPAN	SCPA	N
Schoenoplectus pungens	common threesquare	SCHPUN	SCPU10	N
Schoenoplectus tabernaemontani	softstem bulrush	SCHTAB	SCTA2	N
Setaria pumila	yellow bristlegrass	SETPUM	SEPU8	I
Setaria viridis	green bristlegrass	SETVIR	SEVI4	I
Sporobolus airoides	alkali sacaton	SPOAIR	SPAI	N
Sporobolus contractus	spike dropseed	SPOCON	SPCO4	N
Sporobolus cryptandrus	sand dropseed	SPOCRY	SPCR	N
Sporobolus flexuosus	mesa dropseed	SPOFLE	SPFL2	N
unidentified graminoid	unidentified graminoid	UNIDG	2GRAM	
Vulpia octoflora	sixweeks fescue	VULOCT	VUOC	N

Scientific Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Forbs				
Almutaster pauciflorus	alkali marsh aster	ALMPAU	ALPA14	N
Alyssum simplex	alyssum	ALYSIM	ALSI8	I
Amaranthus hybridus	slim amaranth	AMAHYB	AMHY	N
Ambrosia acanthicarpa	flatspine burr ragweed	AMBACA	AMAC2	N
Ambrosia psilostachya	Cuman ragweed	AMBPSI	AMPS	N
Anemopsis californica	yerba mansa	ANECAL	ANCA10	N
Argentina anserina	silverweed cinquefoil	ARGANS	ARAN7	N
Artemisia dracunculus	tarragon	ARTDRA	ARDR4	N
Artemisia ludoviciana	white sagebrush	ARTLUD	ARLU	N
Asclepias latifolia	broadleaf milkweed	ASCLAT	ASLA4	N
Asclepias subverticillata	whorled milkweed	ASCSUB	ASSU2	N
Atriplex prostrata	triangle orache	ATRPRO	ATPR	N
Berula erecta	cutleaf waterparsnip	BERERE	BEER	N
Bidens cernua	nodding beggarstick	BIDCER	BICE	N
Boerhavia spicata	creeping spiderling	BOESPI	BOSP	N
Brassicaceae	mustard family	BRASSI2	BRASSI	
Calibrachoa parviflora	seaside petunia	CALPAR	CAPA47	N
Chamaesyce serpyllifolia	thymeleaf sandmat	CHASER2	CHSE6	N
Chamaesyce serrula	sawtooth sandmat	CHASER3	CHSE7	N
Chenopodiaceae	goosefoot family	CHENOP2	CHENOP	
Chenopodium atrovirens	pinyon goosefoot	CHEATR	CHAT	N
Chenopodium fremontii	Fremont's goosefoot	CHEFRE	CHFR3	N
Chenopodium graveolens	fetid goosefoot	CHEGRA	CHGR2	N
Chenopodium incanum	mealy goosefoot	CHEINC	CHIN2	N
Chenopodium spp.	goosefoot	CHENOP	CHENO	
Cirsium ochrocentrum	yellowspine thistle	CIROCH	CIOC2	N
Cirsium vulgare	bull thistle	CIRVUL	CIVU	I
Cleome serrulata	Rocky Mountain beeplant	CLESER	CLSE	N
Convolvulus arvensis	field bindweed	CONARV	COAR4	I
Conyza canadensis	Canadian horseweed	CONCAN	COCA5	N
Croton texensis	Texas croton	CROTEX	CRTE4	N
Cryptantha minima	little cryptantha	CRYMIN	CRMI5	N
Cucurbita foetidissima	buffalo gourd	CUCFOE	CUFO	N
Dalea candida var. oligophylla	white prairieclover	DALCANO	DACAO	N
Descurainia obtusa	blunt tansymustard	DESOBT	DEOB	N
Dyssodia papposa	fetid marigold	DYSPAP	DYPA	N
Equisetum laevigatum	smooth horsetail	EQULAE	EQLA	N
Erigeron divergens	spreading fleabane	ERIDIV	ERDI4	N
Erigeron flagellaris	trailing fleabane	ERIFLA	ERFL	N
Erodium cicutarium	redstem stork's bill	EROCIC	ERCI6	I
Euphorbia davidii	David's spurge	EUPDAV	EUDA5	I
Euphorbia exstipulata	squareseed spurge	EUPEXS	EUEX4	N
Gaura coccinea	scarlet beeblossom	GAUCOC	GACO5	N
Gaura mollis	velvetweed	GAUMOL	GAMO5	N

Grindelia squarrosa	curlycup gumweed	GRISQU	GRSQ	N

Scientific Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Forbs - cont.				
Heterotheca villosa	hairy goldenaster	HETVIL	HEVI4	N
Ipomoea cristulata	transpecos morningglory	IPOCRI	IPCR	N
Ipomoea spp.	morning glory	IPOMOE	IPOMO	
Ipomopsis longiflora	flaxflowered ipomopsis	IPOLON	IPLO2	N
Kallstroemia parviflora	warty caltrop	KALPAR	KAPA	N
Kochia scoparia	common kochia	KOCSCO	BASC5	I
Lactuca serriola	prickly lettuce	LACSER	LASE	I
Lappula occidentalis	flatspine stickseed	LAPOCC	LAOC3	N
Machaeranthera tanacetifolia	tanseyleaf aster	MACTAN	MATA2	N
Malva neglecta	common mallow	MALNEG	MANE	I
Marrubium vulgare	horehound	MARVUL	MAVU	I
Medicago lupulina	black medick	MEDLUP	MELU	I
Medicago sativa	alfalfa	MEDSAT	MESA	I
Melilotus officinalis	yellow sweetclover	MELOFF	MEOF	I
Mentzelia multiflora	manyflowered mentzelia	MENMUL	MEMU3	N
Mimulus glabratus	roundleaf monkeyflower	MIMGLA	MIGL	N
Mirabilis linearis	narrowleaf four o'clock	MIRLIN	MILI3	N
Mirabilis oxybaphoides	smooth spreading four o'clock	MIROXY	MIOX	N
Nasturtium officinale	watercress	NASOFF	NAOF	I
Persicaria maculosa	spotted ladysthumb	PERMAC	PEMA24	I
Physalis hederifolia var. fendleri	Fendler's groundcherry	PHYHEDF	PHHEF	N
Physalis longifolia var. longifolia	longleaf groundcherry	PHYLONL	PHLOL3	N
Plantago lanceolata	english plantain	PLALAN	PLLA	I
Plantago major	common plantain	PLAMAJ	PLMA2	I
Polygonum aviculare	prostrate knotweed	POLAVI	POAV	I
Portulaca oleracea	common purslane	POROLE	POOL	N
Ranunculus cardiophyllus	heartleaf buttercup	RANCAR	RACA4	N
Ranunculus cymbalaria	alkali buttercup	RANCYM	RACY	N
Ratibida tagetes	green prairie coneflower	RATTAG	RATA	N
Rorippa sinuata	spreading yellowcress	RORSIN	ROSI2	N
Rumex crispus	curly dock	RUMCRI	RUCR	I
Salsola tragus	prickly Russian thistle	SALTRA	SATR12	I
Salvia reflexa	lanceleaf sage	SALREF	SARE3	N
Sanvitalia abertii	Albert's creeping zinnia	SANABE	SAAB	N
Schkuhria multiflora	manyflower false threadleaf	SCHMUL	SCMU6	N
Scorzonera laciniata	cutleaf vipergrass	SCOLAC	SCLA6	I
Sisymbrium spp.	hedgemustard	SISYMB	SISYM	
Sisyrinchium demissum	dwarf blue-eyed grass	SISDEM	SIDE4	N
Solanum elaeagnifolium	silverleaf nightshade	SOLELA	SOEL	N
Sonchus asper	spiny sowthistle	SONASP	SOAS	I
Sphaeralcea angustifolia	copper globemallow	SPHANG	SPAN3	N
Sphaeralcea coccinea	scarlet globemallow	SPHCOC	SPCO	N

Sphaeralcea fendleri	Fendler's globemallow	SPHFEN	SPFE	N
Stephanomeria pauciflora	brownplume wirelettuce	STEPAU	STPA4	N

Scientific Name	Common Name	NHNM Acronym	USDA Plant Database Symbol	Origin
Forbs - cont.				
Symphyotrichum ericoides var. ericoides	heath aster	SYMERIE	SYERE	N
Symphyotrichum spp.	aster	SYMPHY	SYMPH4	N
Taraxacum officinale	common dandelion	TAROFF	TAOF	I
Thelesperma megapotamicum	Hopi tea greenthread	THEMEG	THME	N
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	
Verbascum thapsus	common mullein	VERTHA	VETH	I
Verbena bracteata	bigbract verbena	VERBRA	VEBR	N
Verbesina encelioides	golden crownbeard	VERENC	VEEN	N
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
Algae/Cyanobacteria	algae/cyanobacteria	ALGAE	2ALGA	