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2009 Monitoring Report for Treatment of Saltcedar (*Tamarix spp.*) and Other Invasive Nonnative Vegetation – Orilla Verde Recreation Area

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Environmental Services Division
Fisheries and Wildlife Resources Group
Denver, Colorado

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

2009 Monitoring Report for Treatment of Saltcedar (*Tamarix spp.*) and Other Invasive Nonnative Vegetation

Orilla Verde Recreation Area

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Introduction

The Bureau of Land Management (BLM) has implemented a program to control saltcedar (*Tamarix* spp.) and other invasive species along the Rio Grande River within the Orilla Verde Recreation Area (OVRA; USDI 2006). The Bureau of Reclamation (Reclamation) conducted baseline and post-treatment vegetation monitoring at sites within the treatment area in June 2006, October 2007, and August/October 2008 and 2009.

Reclamation has monitored five polygons in the upper reaches of the OVRA (Figure 1). Treatments began in 2007 at the northern (upstream) end and will continue south (downstream) for the next several years. Initial treatments were implemented in sites where vegetation was comprised of mostly native species and where saltcedar was fairly sparse and could be removed by hand. In 2008, saltcedar was removed at two such monitoring sites following 2 years of baseline data collection. In 2009, saltcedar was removed from a site where saltcedar was the predominate vegetation following 2 years of baseline data collection.

Methods

Monitoring was conducted within two types of polygons: treatment and reference.

Treatment Polygons (1, 3, and 5)

Treatment polygons 1 and 3 were established in 2006 and were located in those areas with sparse saltcedar as described above. In these polygons, two types of permanent transects were monitored. Two treatment transects were located in areas where the saltcedar was the most dense, and two reference transects were located in areas dominated by native species in which potential future conditions (post-treatment) existed for that polygon.

The treatment and reference transects within each polygon were statistically compared over time to determine if there were any effects to vegetation from saltcedar treatment. Saltcedar was removed in Polygons 1 and 3 in 2008 prior to monitoring in October of that year. Baseline data was collected in these polygons in June 2006 and October 2007. Because data were collected before the monsoon season in 2006 and after the monsoon season in 2007 through 2009, there were considerable differences in the amount and type of herbaceous vegetation detected. Therefore, only 2007 baseline data were used as a comparison to 2008 and 2009 post-treatment data for the herbaceous layer. Late summer monsoonal

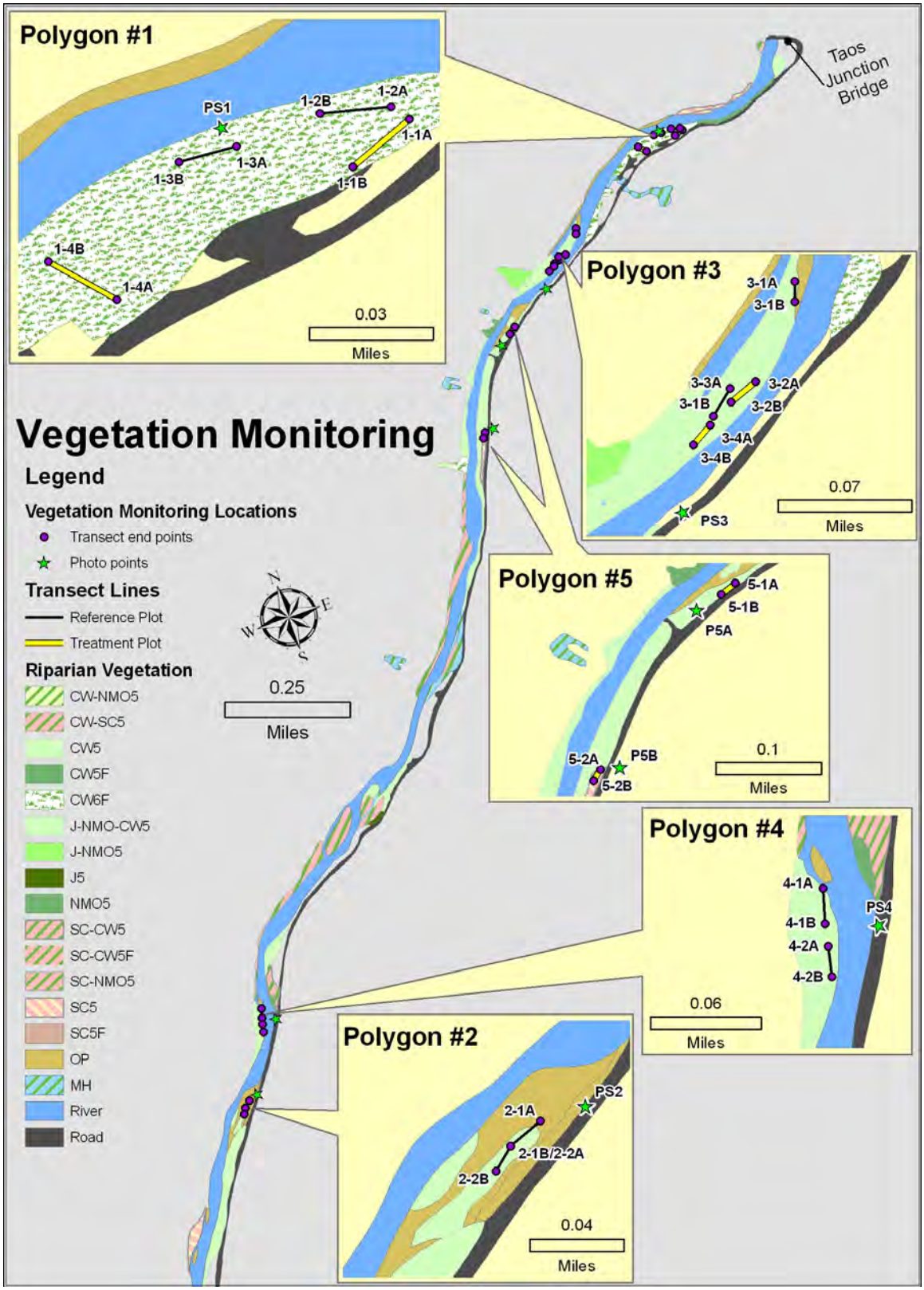


Figure 1. Vegetation monitoring locations.

rains did not appear to drastically affect the shrub cover and density. Therefore both 2006 and 2007 baseline data were used as a comparison to 2008 and 2009 post-treatment data for the overstory layer.

Polygon 5 was established in 2008. The vegetation at this site was dominated by a dense canopy of mature saltcedar. Only treatment transects were located within this polygon and baseline data were collected in late August of 2008 and 2009. Saltcedar was removed from this site in 2009 following baseline data collection.

Reference Polygons (2 and 4)

The two reference (control) polygons were located in healthy native willow communities with no saltcedar. Data from two transects in each of these polygons were collected to examine trends in untreated sites and were statistically compared over time. These sites could also potentially serve as reference areas of future desired conditions for those polygons that are dominated by saltcedar and therefore do not have reference transects available on site (e.g. Polygon 5).

Within all transects, vegetative cover and woody stem density were measured in five 1-meter square (m^2) plots along a 25-meter (m) permanent transect. The percent cover by species was estimated for the herbaceous and shrub layer, and the number of woody plant stems by species was counted within each plot. An example of the form used to record data is in Appendix A. Plots were located along the transect at 0-1 m, 5-6 m, 10-11 m, 15-16 m, and 20-21 m. The first plot was placed on the upstream (north) end of the transect; plots were alternated on each side of the tape, starting with the first plot on the right (west) of the transect, the second plot left (east), the third right, and so on. In the treatment transects within the treatment polygons, the number of saltcedar stems within 1 m of the 25-m tape on the west side was also counted. For all stem counts, every individual stem branching below 25 cm was tallied.

Statistical analyses included the relative cover of native species (i.e., the percent of native species relative to the total cover of native and introduced plant species), and the total cover of plant, litter, and bare ground within the herbaceous layer. The total shrub cover and the stem density were statistically evaluated within the overstory layer. These analyses compared data between the treatment and reference transects within the treatment polygons and compared data between years for all polygons. In comparisons between treatment and reference transects, the Student's t-test of means was used to statistically compare normally distributed data, and the Mann-Whitney nonparametric test of medians was used to compare data that were not normally distributed. In comparisons within transect types and between years, the paired t-test was used for data from normal distributions and the signed rank test was used for data that was not normally distributed.

Overall canopy cover was estimated using a densiometer by taking four readings at the end point of each of the transects —two at each direction parallel to the transect and two at each direction perpendicular to the transect. These four readings were averaged to get one value for each point, or two values per transect, which were then averaged to get a

canopy cover estimate for the transect. To avoid confusion, in this report "overall canopy cover" will be used to refer to percent canopy cover as measured with a densiometer at each end of transects and "overstory shrub cover" will be used to describe the total percent cover of shrubs (ie. all woody species) measured within 1 m^2 plots along transects, as described above.

Photographs were taken from each end of transects to visually document changes in the vegetation over time and in response to treatment. A permanent photo station was established in association with each polygon (either within the polygon or from a distance) to capture overall conditions of the site. Waypoints for photo station and transect locations are listed in Appendix B.

Results and Discussion

Treatment Polygons

Polygon 1

Saltcedar was inadvertently removed from one of two treatment transects in Polygon 1 in 2007 with no herbicide treatment, therefore data from that year does not fully represent baseline (i.e. pre-treatment). Saltcedar was removed with the cut stump method in both treatment transects in 2008 prior to monitoring in October of that year. This method of treatment entailed removing the saltcedar stem by hand cutting followed by an herbicide application to the stump.All saltcedar that were included in post-treatment monitoring measurements were resprouts.

The total percent cover by individual plant species, lifeform (i.e. native or introduced shrub seedlings, grasses, or forbs), and cover type (i.e. vegetation, litter, bare ground, or basal area of shrubs) in the herbaceous layer of treatment and reference transects in Polygon 1 are shown in Table 1 for all years of monitoring. The values listed are an average of the 10 plots measured in 2 transects within each type of transect (treatment or reference). Scientific names for the plants detected within all transects are listed in Appendix C.

Forty-four species were detected within the herbaceous layer of transects in Polygon 1 over the 4 years of monitoring. In 2007, the most abundant species based on percent cover in the treatment transects were slender wheatgrass, cheatgrass, and mullein. In 2008, the most common species were slender wheatgrass, mullein, Japanese brome, and Canada thistle and in 2009 the most common species were slender wheatgrass, Japanese brome, and Canada thistle in the same transects. In the reference transects, the most common species in 2007 were Kentucky bluegrass, slender wheatgrass, and sedge, which shifted to slender wheatgrass, sedge, and tall fescue in 2008 and to slender wheatgrass, redtop, and sedge in 2009.

Table 1. Total percent cover by plant species, lifeform, and cover type in the herbaceous layer of Treatment Polygon 1 from 2006 to 2009.

Polygon 1 - Total percent cover								
	2006		2007		2008		2009	
Herbaceous layer	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
Shrub seedlings								
Coyote willow	0.6	0.0	0.0	0.0	0.0	0.4	0.0	0.0
New Mexico olive	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0
Native shrubs	0.6	0.0	0.0	0.0	0.2	0.4	0.2	0.0
Saltcedar	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Introduced shrubs	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Graminoids								
Sedge	0.0	2.1	0.0	8.6	0.0	16.5	0.0	15.7
Canada wildrye	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0
Slender wheatgrass	9.5	2.6	47.0	19.6	39.0	25.0	37.0	32.7
Alkali muhly	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Canary reedgrass	0.0	0.0	0.0	0.2	0.0	0.3	0.0	2.3
Kentucky bluegrass	0.0	0.4	0.0	23.5	0.0	0.0	0.0	4.2
Barley foxtail	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Native grasses	9.5	5.2	47.0	53.5	39.0	41.9	37.0	54.9
Japanese brome	0.6	0.1	0.5	0.0	2.0	0.0	15.7	0.0
Cheatgrass	3.5	0.0	7.2	0.0	1.2	0.0	0.0	0.0
Redtop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8
Tall fescue	0.0	0.0	0.0	7.8	0.0	8.5	0.0	4.0
Introduced grasses	4.1	0.1	7.7	7.8	3.2	8.5	15.7	19.8
Forbs								
Annual ragweed	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.1
Dogbane	0.0	2.4	0.0	0.2	0.0	1.2	0.0	0.6
Silverweed cinquefoil	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.1
Carruth's sagewort	0.0	0.0	0.0	0.1	0.0	0.8	0.0	2.1
Spearleaf rabbitbrush	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Canadian horseweed	0.2	0.9	5.0	6.1	0.0	0.0	1.3	4.8
Smooth scouringrush	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1
Field horsetail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Mountain sneezeweed	0.0	0.0	0.0	0.1	0.0	1.5	0.0	0.1
Wild mint	0.0	1.1	0.0	0.0	0.0	1.1	0.0	0.1
Hooker's evening primrose	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.1
Cottonbatting cudweed	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.2
Geyer's aster	0.0	0.0	0.0	0.1	0.0	0.1	0.0	1.5
Thymeleaf spurge	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
Teasel	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Common yarrow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Unknown forb	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
Native forbs	0.2	4.8	5.0	7.5	0.0	8.7	1.5	11.1

Polygon 1 - Total percent cover								
	2006		2007		2008		2009	
Herbaceous layer	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
Canada thistle	3.3	2.6	0.7	3.2	2.0	2.8	8.2	1.4
Bull thistle	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Houndstongue	0.2	0.0	1.0	0.0	1.7	0.0	1.4	0.0
Perennial pepperweed	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
White sweetclover	0.0	0.0	0.0	4.4	0.1	0.0	0.0	0.0
Virginia creeper	0.2	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Narrowleaf plantain	0.0	0.0	0.6	0.8	0.0	0.0	0.0	0.0
Curly dock	0.0	0.0	0.1	0.0	0.2	0.0	0.2	0.0
Red clover	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0
Mullein	0.0	0.0	6.8	0.3	6.7	0.1	0.4	0.1
Spiny sowthistle	0.0	0.0	0.0	0.0	0.0	1.6	1.5	1.0
Common plantain	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Prickly lettuce	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Introduced forbs	4.3	2.8	11.4	8.7	10.7	4.8	11.7	2.6
Total vegetative cover	18.7	13.0	71.1	77.5	53.1	64.3	66.1	88.4
Basal area of shrubs	8.2	15.6	3.3	1.0	2.5	7.0	1.0	3.5
Litter	62.5	43.1	22.6	14.5	39.4	26.2	26.4	7.5
Bare	10.6	28.3	3.0	7.0	5.0	2.5	6.5	0.6
Total herbaceous cover	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The relative cover of plant types detected in the herbaceous layer of transects in Polygon 1 from 2006 to 2009 is listed in Table 2. These values are graphed for a visual comparison between years 2007 (pre-treatment) and 2008- 2009 (post-treatment) within the treated transects and the reference transects (Figure 2). Native grasses were the most common lifeform based on percent relative cover in both types of transects for all years of monitoring. From 2007 to 2009, the percent relative cover of native plants was statistically equal between reference and treatment transects and between years within each transect type (see Table 3 for statistical results and P-values for the herbaceous layer in Polygon 1).

Figure 3 provides a visual comparison of the total percent cover of plant, litter, and bare ground in the herbaceous layer of Polygon 1 from 2007 (pre-treatment) to 2008-2009 (post-treatment). There were no statistical differences between treatment and reference transects in total plant, litter, or bare cover in any of the years monitoring took place (Table 3). When comparing between years, the percent total plant cover was significantly lower in 2008 (53.1 percent) than in 2007 (71.1 percent) in the treatment transects. In the reference transects, total plant cover was significantly lower and total litter cover was significantly higher in 2008 than in other years. Total cover of bare ground significantly decreased from 7.0 to 0.6 percent over the monitoring period in the reference transects.

Table 2. Percent relative cover of native and introduced plants by lifeform in the herbaceous layer of transects in Treatment Polygon1 from 2006 to 2009.

	Percent Relative Cover by Lifeform							
Polygon 1	**Native shrub**	**Intro shrub**	**Native grass**	**Intro grass**	**Native forb**	**Intro forb**	**Total native spp.**	**Total intro spp.**
2006								
Treatment	3.2	0.0	50.8	21.9	1.1	23.0	55.1	44.9
Reference	0.0	0.8	36.9	3.8	36.9	21.5	73.8	26.2
2007								
Treatment	0.0	0.0	66.1	10.8	7.0	16.0	73.1	26.9
Reference	0.0	0.0	69.0	10.1	9.7	11.2	78.7	21.3
2008								
Treatment	0.4	0.0	73.4	6.0	0.0	20.2	73.8	26.2
Reference	0.6	0.0	65.0	13.2	13.5	7.5	79.2	20.7
2009								
Treatment	0.3	0.0	56.0	23.8	2.1	17.9	58.4	41.6
Reference	0.0	0.0	62.1	22.4	12.6	2.9	74.7	25.3

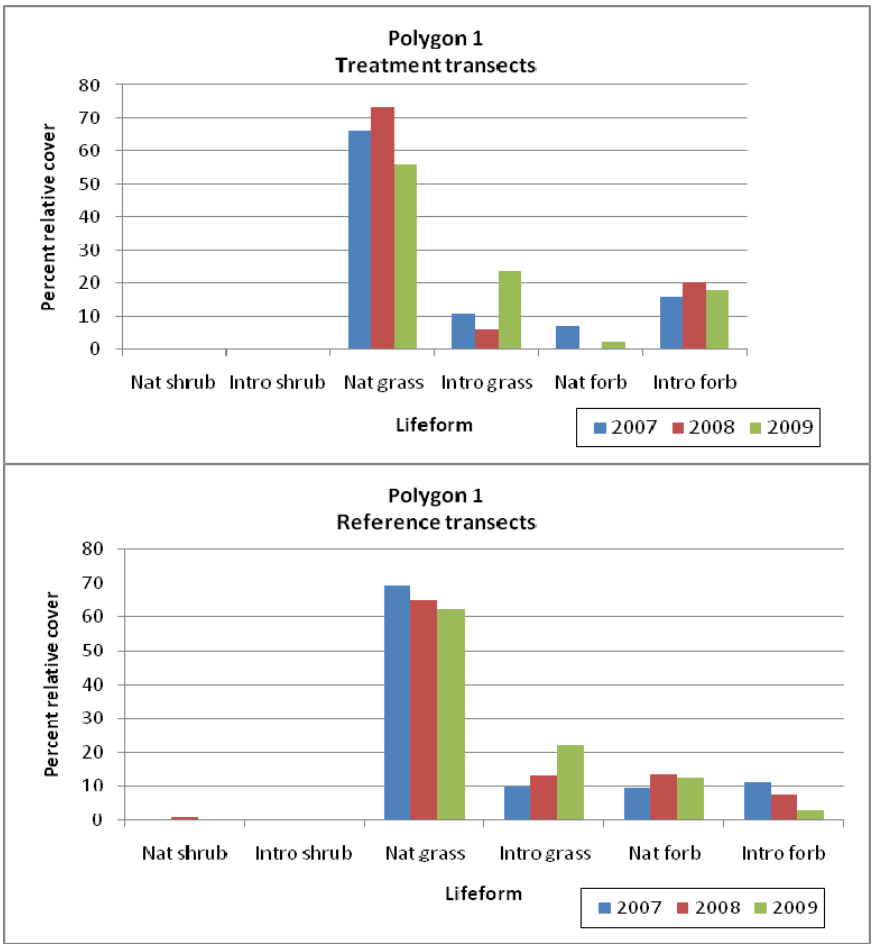


Figure 2. Percent relative cover of plants by lifeform within the treatment and reference transects in Treatment Polygon 1 in 2007 (pre-treatment) and 2008 and 2009 (post-treatment).

Table 3. Statistical comparisons between treatment and reference transects and between years for the herbaceous layer in Treatment Polygon 1; Alpha=0.05.

	Treatment vs Reference			Treatment			Reference		
Understory herbaceous layer	**2007**	**2008**	**2009**	**07 vs 08**	**08 vs 09**	**07 vs 09**	**07 vs 08**	**08 vs 09**	**07 vs 09**
Native species relative cover	T1=R1 P=0.251[1]	T1=R1 P=0.167[1]	T1=R1 P=0.091[1]	07=08 P=0.960[3]	08=09 P=0.245[3]	07=09 P=0.184[3]	07=08 P=0.415[4]	08=09 P=0.435[3]	07=09 P=0.646[3]
Plant total cover	T1=R1 P=0.507[1]	T1=R1 P=0.345[2]	T1=R1 P=0.050[1]	07>08 P=0.037[3]	08=09 P=0.052[3]	07=09 P=0.630[3]	07>08 P=0.049[3]	08<09 P=0.006[4]	07=09 P=0.191[3]
Litter total cover	T1=R1 P=0.252[2]	T1=R1 P=0.140[1]	T1=R1 P=0.263[2]	07=08 P=0.051[3]	08=09 P=0.110[3]	07=09 P=0.741[3]	07<08 P=0.016[3]	08>09 P<0.001[3]	07=09 P=0.200[3]
Bare ground total cover	T1=R1 P=0.544[2]	T1=R1 P=0.288[1]	T1=R1 P=0.065[2]	07=08 P=0.384[3]	08=09 P=1.0[4]	08=09 P=1.0[4]	07=08 P=0.105[3]	08=09 P=0.100[4]	07>09 P=0.043[3]

[1] Student's t-test; [2]Mann Whitney W test; [3]Paired t-test; [4]Signed rank test
Highlighted boxes indicate a significant difference at the 95 percent confidence level.

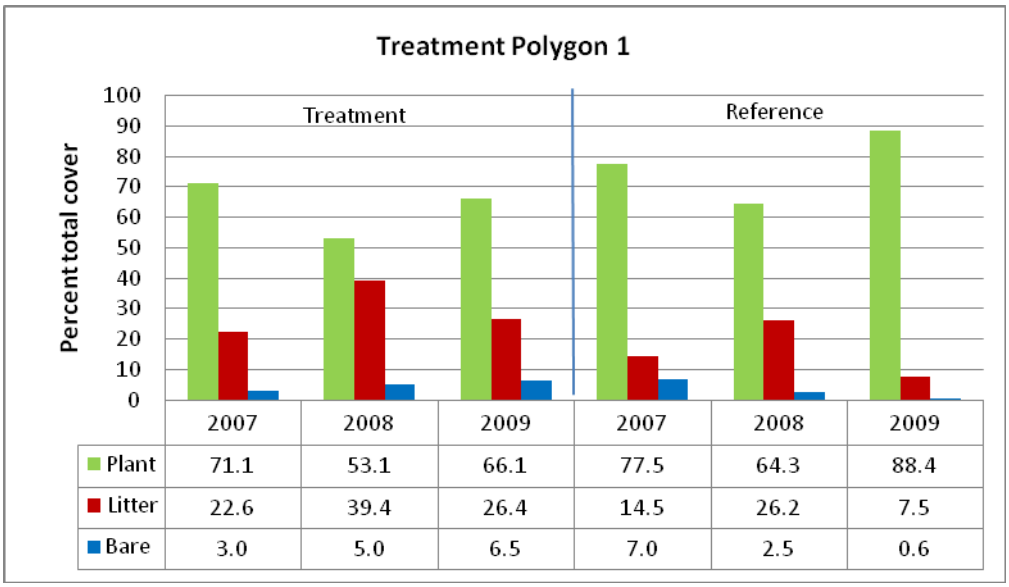


Figure 3. Total plant, litter, and bare cover within the treatment and reference transects in Treatment Polygon 1 in 2007 (pre-treatment) and 2008 and 2009 (post-treatment).

The lack of any significant differences in herbaceous cover between the treatment and reference transects suggested that saltcedar treatment did not affect herbaceous plant cover or composition in Polygon 1. Although total plant cover was greater in 2007 prior to treatment in 2008, this result was consistent between treated and untreated sites, which indicated an influence from factors other than saltcedar removal. Whatever the causes for decreased plant cover in 2008, plants in the treated transects apparently recovered less rapidly the following year than those in the reference transects where cover increased significantly in 2009.

The total percent cover of individual, native, and introduced shrub species is shown in Table 4. Four shrub species were detected in the overstory layer, of which coyote willow was the most common for all transects in all years. There were no statistically significant differences in the total percent of overstory shrub cover between the treatment and reference transects (Table 5). Total overstory shrub cover increased significantly to 64.2 percent in 2009 in the treatment transects.

Table 4. Total percent cover by individual species in the overstory shrub layer and overall canopy cover of Treatment Polygon 1 from 2006 to 2009.

	2006		2007		2008		2009	
Overstory shrub layer	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
New Mexico olive	13.5	0.2	13.7	0.0	6.5	0.1	9.5	0.0
Coyote willow	26.0	48.0	23.0	45.5	36.7	43.5	45.7	50.0
Native shrubs	39.5	48.2	36.7	45.5	43.2	43.6	55.2	50.0
Saltcedar	7.5	0.0	8.0	0.0	1.7	0.0	4.0	0.2
Siberian elm	0.0	0.0	0.0	0.0	2.5	0.0	5.0	0.0
Introduced shrubs	7.5	0.0	8.0	0.0	4.2	0.0	9.0	0.2
Total shrub cover	47.0	48.2	44.7	45.5	47.4	43.6	64.2	50.2
Canopy cover	72.1	24.2	48.2	30.6	57.3	37.0	45.9	43.2

Table 5. Statistical comparisons between treatment and reference transects and between years for the overstory layer in Treatment Polygon 1; Alpha=0.05.

	Treatment vs Reference				Treatment				Reference			
Overstory shrub layer	**2006**	**2007**	**2008**	**2009**	**06 vs 07**	**07 vs 08**	**08 vs 09**	**06 vs 09**	**06 vs 07**	**07 vs 08**	**08 vs 09**	**06 vs 09**
Total canopy cover	T1=R1 P=0.916[1]	T1=R1 P=0.952[1]	T1=R1 P=0.721[1]	T1=R1 P=0.152[1]	06=07 P=1.0[4]	07=08 P=0.821[3]	08<09 P<0.001[3]	06=09 P=0.133[3]	06=07 P=0.440[4]	07=08 P=0.613[3]	08=09 P=0.709[3]	06=09 P=0.767[3]
Total stem density	T1=R1 P=0.425[1]	T1<R1 P=0.009[2]	T1=R1 P=0.250[1]	T1=R1 P=0.397[1]	06=07 P=0.592[3]	07=08 P=0.510[3]	08=09 P=0.248[3]	06=09 P=0.498[3]	06=07 P=0.293[3]	07=08 P=0.729[3]	08=09 P=0.109[4]	06=09 P=229[3]

[1] Student's t-test; [2]Mann Whitney W test; [3]Paired t-test; [4]Signed rank test
Highlighted boxes indicate a significant difference at the 95 percent confidence level.

The overall canopy cover as measured with a densiometer is also listed in Table 4. Canopy cover of treated transects decreased considerably from 72.1 percent in 2006 to 48.2 percent in 2007, which may have been due to the cutting of saltcedar in one of the treatment transects in 2007. Canopy cover increased to 57.3 percent in 2008 despite saltcedar treatment that year. It is possible that willow cover eventually expanded following the earlier removal of saltcedar. This appeared to be the case in the overstory plot measurements as well. The cover of coyote willow increased from 23.0 percent in 2007 to 45.7 percent in 2009 in treated transects while willow cover in reference transects remained relatively stable over the same time period (Table 4). Overall canopy cover increased gradually over time within the reference transects of Polygon 1.

Table 6 shows the average number of woody stems per m^2 for both types of transects in Polygon 1. The values listed are an average of the 10 plots that were measured in each transect type. In 2007, density in treatment transects was significantly less than in

Table 6. The average number of stems per meter squared for woody species within treatment and reference transects in Treatment Polygon 1 from 2006 to 2008.

	2006		2007		2008		2009	
Shrub species	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
Coyote willow	11.2	22.8	10.3	29.8	12.6	27.9	10.6	18.3
New Mexico olive	4.3	0.1	4.1	0.0	2.6	0.1	2.7	0.0
Salt cedar	2.1	0.0	1.8	0.0	2.9	0.0	1.4	0.2
Siberian elm	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0
Total shrub	17.6	22.9	16.2	29.8	18.3	28.0	14.8	18.5

reference transects (Table 5). A slight increase in the number of willow and saltcedar stems in treatment transects in conjunction with a slight decrease in willow stems in reference transects brought density to statistically equal levels in 2008. No other statistical differences in stem density were identified from 2006 to 2009.

Table 7 shows the average number of saltcedar per 25 m^2 for the treatment transects in Polygon 1 from 2006 to 2009. The number of saltcedar stems more than doubled from 2006 to 2007, which may have been a result of cutting of saltcedar in one transect. No follow-up treatment was used and the large increase in stems was likely attributed to resprouting of saltcedar. In 2008, saltcedar removal by hand-cutting was conducted in both treatment transects, and the number of salt-cedar stems decreased slightly from 2007 but was still relatively high, also due to a high incidence of resprouting. In 2009, the number of saltcedar stems continued to decrease, but was still quite high (34.5 stems/25 m^2).

Table 7. The average number of saltcedar stems per 25 meters squared within treatment transects of Treatment Polygon 1 from 2006 to 2009.

Average number of saltcedar / 25 m^2				
Treatment transects	**2006**	**2007**	**2008**	**2009**
Polygon 1	20.0	49.5	43.0	34.5

Based on statistical analyses, there didn't appear to be large effects to the cover and density of the overstory shrub layer from saltcedar treatment in Polygon 1. There was a significant increase in the total cover of overstory shrubs in the treatment transects in 2009. This may have been due to the steady release of willow in response to the removal of saltcedar in the canopy. Some trends were observed that were not statistically tested. Changes in density of all shrubs at the 1m^2 plot level were not detected over time. However, measurements of saltcedar density in 25m^2 plots show that the number of stems doubled from 2006 to 2008 following treatment. Although the number of stems appeared to be on a decreasing trend, these results indicated that a high number of saltcedar resprouted in response to cutting and that follow-up treatment may be necessary.

Photos taken from the end points of each transect and of each polygon from 2006 to 2009 are shown in Appendix D.

Polygon 3

Saltcedar was removed using the cut stump method and herbicide application in both treatment transects in Polygon 3 in 2008 prior to monitoring in October of that year. All saltcedar that were included in post-treatment monitoring measurements were resprouts.

The total percent cover by individual plant species, lifeform (i.e. native or introduced shrub seedlings, grasses, or forbs), and cover type (i.e. vegetation, litter, bare ground, or basal area of shrubs) in the herbaceous layer of treatment and reference transects in Polygon 3 are shown in Table 8 for all years of monitoring. The values listed are an average of the 10 plots measured in 2 transects within each type of transect (treatment or reference).

Fifty-three species were detected within the herbaceous layer of transects in Polygon 3 over four years of monitoring. In 2007, the most abundant species based on percent cover in the treatment transects were cheatgrass, mullein, and Kentucky bluegrass. In 2008, the most common species were Kentucky bluegrass, Carruth's sagewort, and common yarrow and in 2009 they were Caruth's sagewort, common yarrow, and slender wheatgrass in the same transects. In the reference transects, the most common species were redtop, sedge, and smooth brome in both 2007 and 2008 and sedge, slender wheatgrass, and smooth brome in 2009.

The relative covers of plant types detected in the herbaceous layer of transects in Polygon 3 from 2006 to 2009 are listed in Table 9. These values are graphed for a visual comparison from 2007 to 2009 within the treatment transects and the reference transects (Figure 4). Introduced grasses were the most common lifeform based on percent relative cover in treatment transects in 2007, which shifted to native forbs in 2008 and 2009. In the reference transects, introduced grasses were the most common lifeform in 2007 and native grasses were the most common lifeform in 2008 and 2009. From 2007 to 2009, the percent relative cover of native plants was statistically equal between reference and treatment transects and between years within treatment transects (see Table 10 for statistical results and P-values for the herbaceous layer in Polygon 3). Within the reference transects, the relative cover of native species increased significantly over the monitoring period - from 47.1 percent in 2007 to 75.2 percent in 2009.

Figure 5 provides a visual comparison of the percent total cover of plant, litter, and bare ground in the herbaceous layer of Polygon 3 from 2007 to 2009. Total plant cover was significantly higher in treatment transects (65.5 percent) than in reference transects (40.3 percent) while litter cover was significantly lower in treatment transects (18.5 percent) than in reference transects (37.7 percent) in 2007 (Table 10). In 2008, results were opposite, with total plant cover significantly lower in treatment transects (20.0 percent) than in reference transects (50.7 percent) while litter cover was significantly higher in treatment transects (65.9 percent) than in reference transects (39.9 percent). In 2009, the trend in plant cover continued, with an average percent total cover of 11.4 percent in

Table 8. Total percent cover by plant species, lifeform, and cover type in the herbaceous layer of Treatment Polygon 3 from 2006 to 2009.

Polygon 3 - Total percent cover								
	2006		2007		2008		2009	
Herbaceous layer	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
Shrub seedlings								
Cottonwood	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Coyote willow	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
New Mexico olive	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2
Oneseed juniper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Native shrubs	0.0	0.3	0.0	0.1	0.0	0.1	0.0	0.3
Saltcedar	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siberian elm	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Introduced shrubs	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Graminoids								
Sedge	0.0	3.3	0.0	7.4	0.2	11.0	0.0	12.1
Canada wildrye	0.0	0.0	0.1	0.4	0.0	1.8	0.0	0.0
Slender wheatgrass	0.2	0.0	3.0	3.4	1.9	4.9	2.0	9.0
Alkali muhly	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.3
Marsh muhly	0.0	0.0	0.1	0.4	1.0	0.1	0.0	0.0
Canary reedgrass	0.0	1.0	0.0	3.0	0.0	3.3	0.0	3.6
Kentucky bluegrass	0.2	0.0	3.8	0.0	3.4	0.8	0.5	0.0
Sand dropseed	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0
Native grasses	0.4	4.3	7.3	14.7	6.6	22.1	2.5	25.0
Redtop	0.0	0.7	0.0	10.4	1.4	11.9	0.5	4.4
Smooth brome	0.1	0.8	0.0	4.6	2.2	7.8	0.5	4.9
Japanese brome	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0
Cheatgrass	0.6	0.0	40.4	1.2	0.5	0.0	0.0	0.0
Introduced grasses	0.7	1.5	43.4	16.2	4.1	19.7	1.0	9.3
Forbs								
Common yarrow	0.1	0.0	1.6	0.0	2.4	0.0	2.0	0.0
Dogbane	0.0	0.2	0.0	0.1	0.0	0.4	0.0	0.7
Silverweed cinquefoil	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Carruth's sagewort	0.0	0.0	2.2	0.0	2.9	1.3	4.7	0.5
White sagebrush	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3
Swamp milkweed	0.0	1.5	0.0	0.5	0.4	0.3	0.0	0.7
Spearleaf rabbitbrush	0.0	0.0	0.5	0.0	2.0	0.0	0.0	0.0
Canadian horseweed	0.2	0.2	1.5	0.5	0.0	0.0	0.0	0.0
Field horsetail	0.0	0.1	0.0	0.0	0.0	0.7	0.0	1.8
Smooth scouringrush	0.6	0.6	0.9	0.4	1.1	0.5	0.2	0.0
Curlycup gumweed	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Rough bugleweed	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Wild mint	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Hooker's evening primrose	0.0	0.0	1.9	0.0	0.0	0.0	0.1	0.0
Pricklypear cactus	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Cottonbatting cudweed	0.0	0.8	0.0	0.3	0.0	0.0	0.0	1.0
White-panicle aster	0.0	0.1	0.0	2.0	0.0	2.2	0.0	0.3

Polygon 3 - Total percent cover								
	2006		2007		2008		2009	
Herbaceous layer	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
Geyer's aster	0.0	0.0	0.1	0.4	0.0	0.1	0.0	0.0
Fleabane	0.0	0.0	0.0	0.0	0.0	0.2	0.0	2.5
Thymeleaf spurge	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
Goldenaster	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Unknown forb	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Native forbs	1.0	3.5	9.0	4.2	8.8	6.9	7.1	7.9
Canada thistle	0.0	0.6	0.0	1.8	0.0	1.0	0.2	0.9
Houndstongue	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Perennial pepperweed	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
White sweetclover	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0
Virginia creeper	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Narrowleaf plantain	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1
Dandelion	0.0	0.0	0.1	0.3	0.0	0.1	0.0	0.0
Red clover	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0
Mullein	1.1	0.0	5.5	1.4	0.3	0.6	0.1	0.1
Common plantain	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3
Spiny sowthistle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Prickly lettuce	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Teasel	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Introduced forbs	1.3	0.7	5.7	5.1	0.5	1.9	0.8	1.5
Total vegetative cover	3.5	10.3	65.5	40.3	20.0	50.7	11.4	44.0
Basal area of shrubs	13.3	14.8	13.5	7.5	3.5	1.5	2.5	0.0
Litter	58.2	36.2	18.5	37.7	65.9	39.9	68.9	51.2
Bare	25.0	38.7	2.5	14.5	10.6	7.9	17.2	4.8
Total herbaceous cover	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 9. Percent relative cover of native and introduced plants by lifeform in the herbaceous layer of transects in Treatment Polygon 3 from 2006 to 2009.

	Percent Relative Cover by Lifeform							
Polygon 3	**Native shrub**	**Intro shrub**	**Native grass**	**Intro grass**	**Native forb**	**Intro forb**	**Total nat spp.**	**Total intro spp.**
2006								
Treatment	0.0	2.9	7.1	25.7	24.3	40.0	31.4	68.6
Reference	2.9	0.0	32.0	24.3	34.0	6.8	68.9	31.1
2007								
Treatment	0.0	0.2	11.1	66.3	13.7	8.7	24.9	75.1
Reference	0.2	0.0	36.5	40.2	10.4	12.7	47.1	52.9
2008								
Treatment	0.0	0.0	33.0	20.5	44.0	2.5	77.0	23.0
Reference	0.2	0.0	43.6	38.9	13.6	3.7	57.4	42.6
2009								
Treatment	0.0	0.0	21.9	8.8	62.3	7.0	84.2	15.8
Reference	0.7	0.0	56.8	21.1	17.7	3.4	75.2	24.5

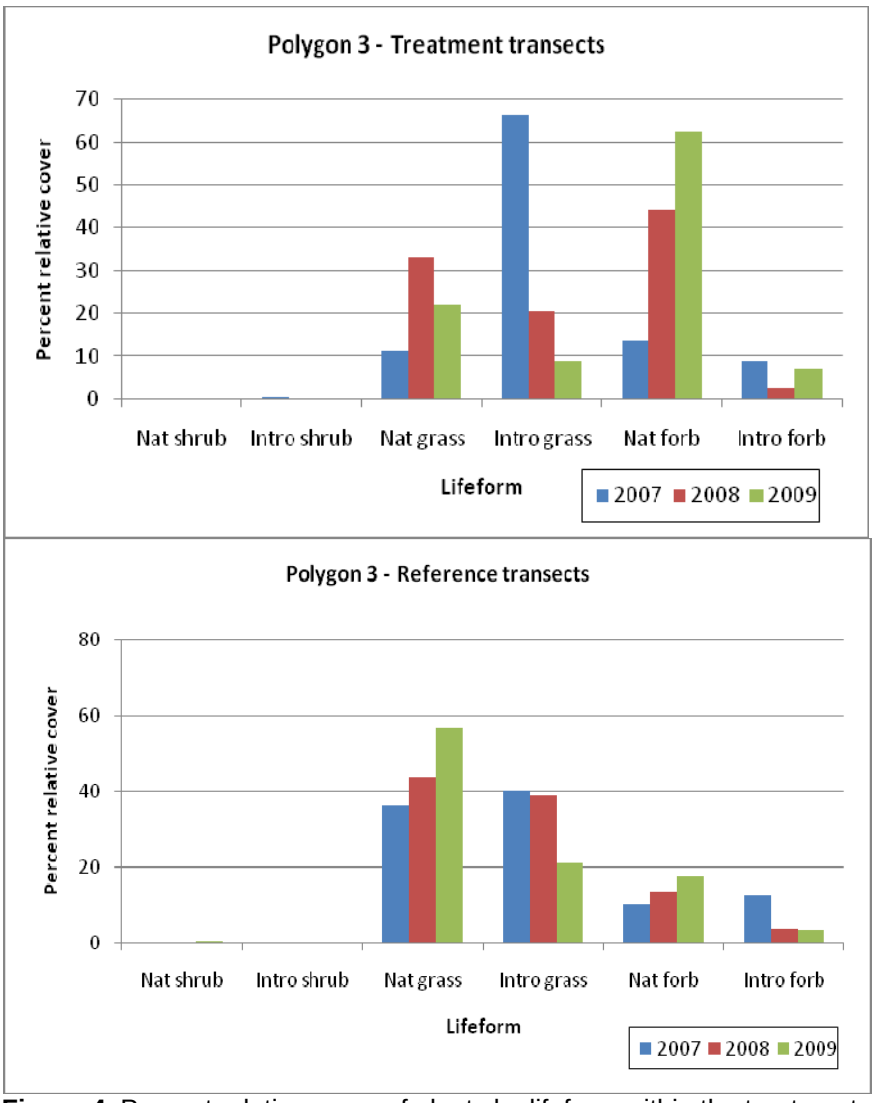
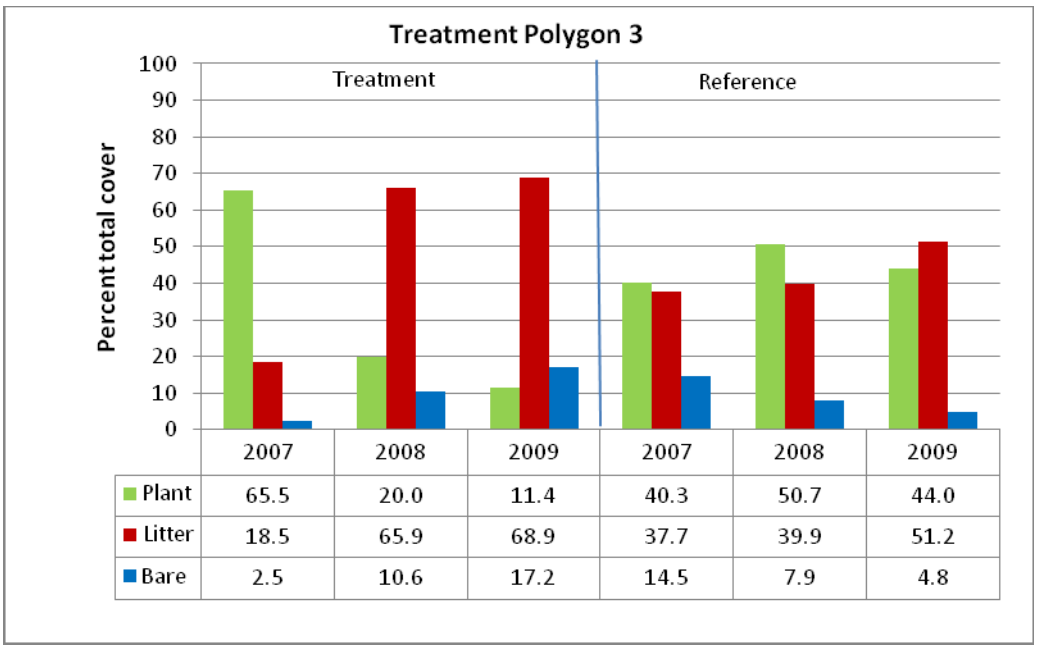


Figure 4. Percent relative cover of plants by lifeform within the treatment and reference transects in Treatment Polygon 3 in 2007 (pre-treatment) and 2008 and 2009 (post-treatment).

Table 10. Statistical comparisons between treatment and reference transects and between years for the herbaceous layer in Treatment Polygon 3; Alpha=0.05.

	Treatment vs Reference			Treatment			Reference		
Understory herbaceous layer	**2007**	**2008**	**2009**	**07 vs 08**	**08 vs 09**	**07 vs 09**	**07 vs 08**	**08 vs 09**	**07 vs 09**
Native species relative cover	T3=R3 P=0.186[1]	T3=R3 P=0.940[1]	T3=R3 P=0.965[1]	07=08 P=0.132[3]	08=09 P=0.271[3]	07=09 P=0.692[3]	07=08 P=0.145[3]	08=09 P=0.103[4]	07<09 P=0.018[3]
Plant total cover	T3>R3 P=0.029[1]	T3<R3 P=0.006[2]	T3<R3 P=0.004[2]	07>08 P<0.001[3]	08=09 P=0.079[3]	07>09 P<0.001[3]	07<08 P=0.010[3]	08=09 P=0.331[3]	07=09 P=0.638[3]
Litter total cover	T3<R3 P=0.023[1]	T3>R3 P=0.017[1]	T3=R3 P=0.113[1]	07<08 P=0.008[4]	08=09 P=0.614[3]	07<09 P<0.001[3]	07=08 P=0.505[3]	08=09 P=0.094[3]	07=09 P=0.104[3]
Bare ground total cover	T3=R3 P=0.125[2]	T3=R3 P=0.729[2]	T3=R3 P=0.132[2]	07=08 P=0.169[3]	08=09 P=0.051[4]	07=09 P=0.095[3]	07=08 P=0.190[4]	08=09 P=0.553[4]	07=09 P=0.205[4]

[1] Student's t-test; [2]Mann Whitney W test; [3]Paired t-test; [4]Signed rank test
Highlighted boxes indicate a significant difference at the 95 percent confidence level.



	2007	2008	2009	2007	2008	2009
Plant	65.5	20.0	11.4	40.3	50.7	44.0
Litter	18.5	65.9	68.9	37.7	39.9	51.2
Bare	2.5	10.6	17.2	14.5	7.9	4.8

Figure 5. Total plant, litter, and bare cover within the treatment and reference transects in Treatment Polygon 3 in 2007 (pre-treatment) and 2008 and 2009 (post-treatment).

treatment transects being significantly less than 44.0 percent cover in reference transects. There was not a statistical difference in litter cover between the two transect types in 2009, however. When comparing between years, in 2007 plant cover was significantly higher while litter cover was significantly less than in other years in treatment transects. Total plant cover in reference transects significantly increased from 40.3 percent in 2007 to 50.7 percent in 2008.

These changes in herbaceous plant and litter cover were related to saltcedar treatment and the methods of removal that were used in this polygon. Saltcedar was hand cut and the plant material was left on site. The slash left on the ground was categorized as litter, and its abundant cover inhibited the growth of understory herbaceous species. Thus, even though treatment transects had higher plant cover than reference transects prior to treatment, once the site was treated plant cover fell below the untreated transects. And although plant cover in untreated reference transects showed no change from 2007 to 2009, it decreased in the treatment transects as litter increased post-treatment.

A shift in the common lifeforms in treatment but not reference transects may have also been a result of saltcedar control at this site. The introduced cheatgrass was the predominate species in treatment transects in 2007 and was barely detected in 2008 and not detected at all in 2009, which would be a desirable effect if it was in fact caused by the removal of saltcedar. It should be noted, however, that total plant cover in general decreased significantly post-treatment, so very few plants of any species were detected at all.

The total percent cover of individual, native, and introduced shrub species is shown in Table 11. Three shrub species were detected in the overstory layer. Coyote willow and

Table 11. Total percent cover by individual species in the overstory shrub layer and overall canopy cover of Treatment Polygon 3 from 2006 to 2009.

	2006		2007		2008		2009	
Overstory shrub layer	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
New Mexico olive	0.0	0.0	0.0	0.2	1.5	0.7	1.5	1.5
Coyote willow	20.5	53.5	19.5	48.5	12.7	57.0	18.7	64.0
Native shrubs	20.5	53.5	19.5	48.7	14.2	57.7	20.2	65.5
Saltcedar	19.3	0.0	23.1	0.0	6.3	0.0	6.3	0.0
Introduced shrubs	19.3	0.0	23.1	0.0	6.3	0.0	6.3	0.0
Total shrub cover	39.8	53.5	42.6	48.7	20.5	57.7	26.5	65.5
Canopy cover	62.2	0.7	66.4	22.5	52.6	36.8	54.0	49.8

saltcedar were the most common shrubs in treatment transects and coyote willow was the most common in reference transects in all years. Prior to treatment, the percent total shrub cover was statistically equal between the two types of transects, while total cover in treatment transects was significantly less than reference transects post-treatment (Table 12). In comparing years, total shrub cover in 2008 (post-treatment) was significantly less than in 2007 (pre-treatment) in treated transects. These results suggested that saltcedar removal decreased shrub cover, which is logical because saltcedar was a relatively large component of the overstory in these transects prior to treatment. However in 2009 shrub cover was on an increasing trend and no statistical differences were indicated between years.

Table 12. Statistical comparisons between treatment and reference transects and between years for the overstory layer in Treatment Polygon 3; Alpha=0.05.

	Treatment vs Reference				Treatment				Reference			
Overstory shrub layer	**2006**	**2007**	**2008**	**2009**	**06 vs 07**	**07 vs 08**	**08 vs 09**	**06 vs 09**	**06 vs 07**	**07 vs 08**	**08 vs 09**	**06 vs 09**
Total canopy cover	T3=R3 P=0.195[1]	T3=R3 P=0.637[1]	T3<R3 P=0.003[1]	T3<R3 P=0.003[1]	06=07 P=0.620[3]	07>08 P=0.045[3]	08=09 P=0.216[3]	06=09 P=0.117[3]	06=07 P=0.566[3]	07=08 P=0.171[4]	08=09 P=0.357[4]	06=09 P=0.085[3]
Total stem density	T3<R3 P=0.009[1]	T3<R3 P=0.032[1]	T3<R3 P=0.001[1]	T3<R3 P=0.003[1]	06=07 P=0.448[3]	07>08 P=0.030[3]	08=09 P=0.616[3]	06>09 P=0.008[4]	06=07 P=0.383[3]	07=08 P=0.847[3]	08=09 P=0.125[3]	06=09 P=0.148[3]

[1] Student's t-test; [2]Mann Whitney W test; [3]Paired t-test; [4]Signed rank test
Highlighted boxes indicate a significant difference at the 95 percent confidence level.

Overall canopy cover of treatment transects remained relatively stable, decreasing somewhat post-treatment (Table 11). Canopy cover within reference transects increased considerably, however, from 0.7 percent in 2006 to 49.8 percent in 2009. Although no height measurements were taken, growth in willow within the reference transects was apparent based on photographs (see Polygon 3, Reference transects 1A and B and 3A and B in Appendix C). Since the actual percent cover of coyote willow changed very little from year to year within overstory plots in reference transects (Table 11), it is likely that willow reached heights that were captured in the densiometer starting in 2007.

Table 13 shows the average number of woody stems per m^2 for both types of transects in Polygon 3. The values listed are an average of the 10 plots that were measured in each transect type. Stem density in treatment transects was significantly less than in reference transects both pre- and post-treatment (Table 12). Treatment transects were comprised of coyote willow and saltcedar, while reference transects were comprised primarily of coyote willow. Saltcedar in treatment transects had a larger diameter than willow in this stand. This would explain fewer stems than the reference transects which were dominated by willow of smaller diameter. Comparisons between years did show significantly greater stem densities in pre-treatment years (2006 and 2007) than in post-treatment years (2008 and 2009) in the treatment transects, which appeared to be due to a decrease in the number of willow stems since saltcedar densities did not change considerably. The decrease in willow density may have been a result of disturbance caused by the mechanical removal of saltcedar. Resprouting of saltcedar did occur even though an herbicide was applied following cutting (Figure 6), as was indicated by the average number of saltcedar stems in 2009 (6.0 stems/ m^2).

Table 13. The average number of stems per meter squared for woody species within treatment and reference transects in Treatment Polygon 3 from 2006 to 2009.

Polygon 3 - Average number of stems / m^2								
	2006		2007		2008		2009	
Shrub species	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**	**Treatment**	**Reference**
Coyote willow	11.2	37.0	10.5	31.7	5.6	31.2	5.9	27.7
New Mexico olive	0.0	0.0	0.2	0.5	0.5	0.4	0.6	0.5
Salt cedar	7.9	0.0	6.6	0.0	5.8	0.0	6.0	0.0
Total shrub	19.1	37.0	17.3	32.2	11.9	31.6	12.5	28.2

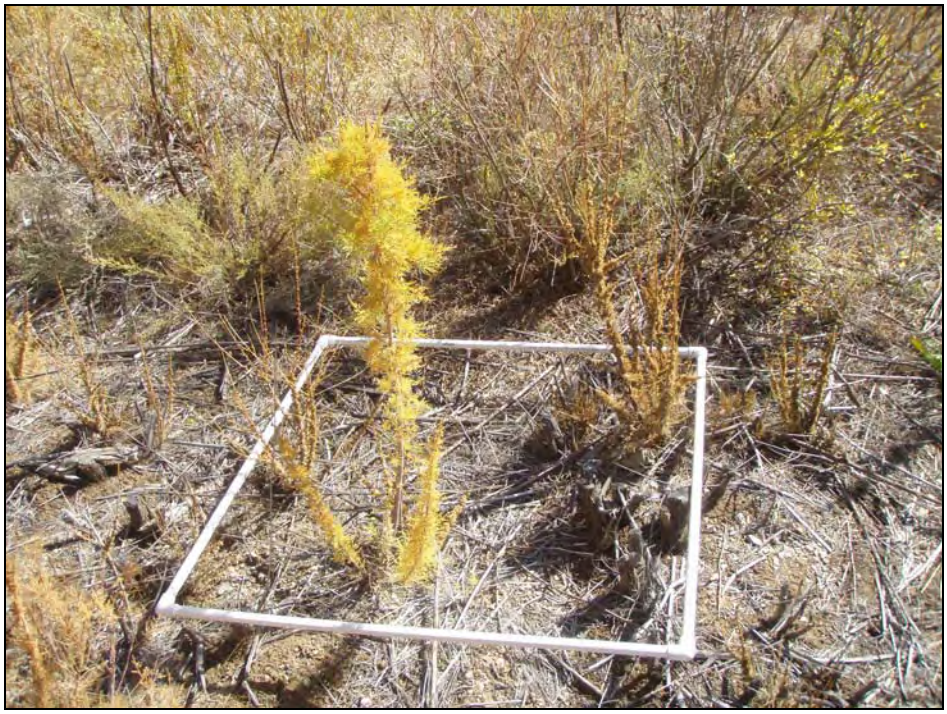


Figure 6. Post-treatment resprouting of saltcedar in Transect 3-1, October, 2009.

Table 14 shows the average number of saltcedar per 25 m^2 for the treatment transects in Polygon 3 from 2006 to 2009. The number of saltcedar stems decreased to 54.0 post-treatment, from an average of 84.8 prior to treatment, a result of saltcedar removal. The number of saltcedar stems was still quite high following removal, however, which was due to the relatively high incidence of resprouting.

Table 14. The average number of saltcedar stems per 25 meters squared within treatment transects of Treatment Polygon 3 from 2006 to 2008.

Average number of saltcedar / 25 m^2				
Treatment transects	**2006**	**2007**	**2008**	**2009**
Polygon 3	86.5	83	57.5	54.0

Polygon 5

Baseline data was collected in Polygon 5 in 2008 and 2009, therefore only two years of pre-treatment data is statistically compared. Saltcedar was removed from this plot in late August of 2009. Photos of both pre- and post-treatment were taken in August and October, respectively, for this polygon and are shown in Appendix C.

The total percent cover by individual plant species, lifeform (i.e. native or introduced shrub seedlings, grasses, or forbs), and cover type (i.e. vegetation, litter, bare ground, or basal area of shrubs) in the herbaceous layer of treatment transects in Polygon 5 are shown in Table 15. The values listed are an average of the 10 plots measured in 2 transects.

Sixteen species were detected within the herbaceous layer of transects in Polygon 5 in two years of monitoring. In 2008, the most abundant species based on percent cover were slender wheatgrass, perennial pepperweed, houndstongue, and virgin's bower. In 2009, the most common species were slender wheatgrass, Virginia creeper, and perennial pepperweed. Both pepperweed and houndstongue are nonnative invasive species. They should be monitored closely to determine if their cover increases with saltcedar control.

The relative cover of plant types detected in the herbaceous layer of transects in Polygon 5 is listed in Table 16. These values are graphed for a visual comparison between 2008 and 2009 in Figure 7. Introduced forbs were the most common lifeform in both years based on percent relative cover. No statistical differences were identified in the percent relative cover of native species between 2008 and 2009 (see Table 17 for statistical results and P-values for the herbaceous layer in Polygon 5).

Figure 8 provides a visual comparison of the percent total cover of plant, litter, and bare ground in the herbaceous layer of Polygon 5 in 2008 and 2009. No statistical differences were found in the percentage of total plant, litter or bare cover between 2008 and 2009 (Table 17).

Table 15. Total percent cover by plant species, lifeform, and cover type in the herbaceous layer of Treatment Polygon 5 in 2008 and 2009.

Polygon 5 - Total percent cover		
Herbaceous layer	**2008**	**2009**
Shrub seedlings		
Coyote willow	0.2	0.0
New Mexico olive	0.1	0.1
Native shrubs	0.3	0.1
Graminoids		
Slender wheatgrass	12.3	12.4
Canada wildrye	0.0	0.1
Native grasses	12.3	12.5
Japanese brome	1.0	0.0
Cheatgrass	0.0	0.5
Introduced grasses	1.0	0.5
Forbs		
Dogbane	0.1	
Virgin's bower	4.6	2.0
Native forbs	4.7	2.0
Bull thistle	0.2	0.2
Houndstongue	4.6	3.1
Perennial pepperweed	4.9	4.0
Virginia creeper	4.5	11.5
Mullein	0.5	0.2
Prickly lettuce	0.2	0.2
Canada thistle	0.0	0.4
Lambsquarters	0.0	0.1
Introduced forbs	14.9	19.7
Total vegetative cover	33.2	34.8
Basal area of shrubs	5.1	4.0
Litter	61.7	61.2
Bare	0.0	0.0
Total herbaceous cover	100.0	100.0

Table 16. Percent relative cover of native and introduced plants by lifeform in the herbaceous layer of transects in Treatment Polygon 5 in 2008 and 2009.

	Percent Relative Cover by Lifeform							
Polygon 5	**Native shrub**	**Intro shrub**	**Native grass**	**Intro grass**	**Native forb**	**Intro forb**	**Total nat spp.**	**Total intro spp.**
2008	0.9	0.0	37.0	3.0	14.2	44.9	52.1	47.9
2009	0.3	0.0	35.9	1.4	5.7	56.6	42.0	58.0

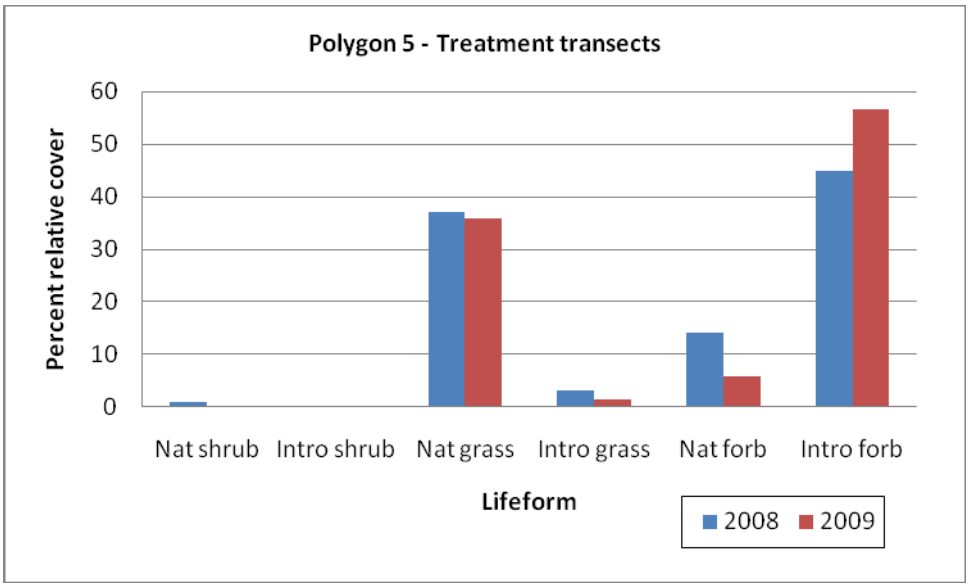


Figure 7. Percent relative cover of plants by lifeform within treatment transects in Treatment Polygon 5 in 2008 and 2009 (pre-treatment).

Table 17. Statistical comparisons between treatment and reference transects and between years for the herbaceous layer in Treatment Polygon 5; Alpha=0.05.

Understory herbaceous layer	**08 vs 09**
Native species relative cover	08=09 P=0.097[2]
Plant total cover	08=09 P=0.789[1]
Litter total cover	08=09 P=0.927[1]
Bare ground total cover	No bare ground

[1] Paired t-test; [2]Signed rank test

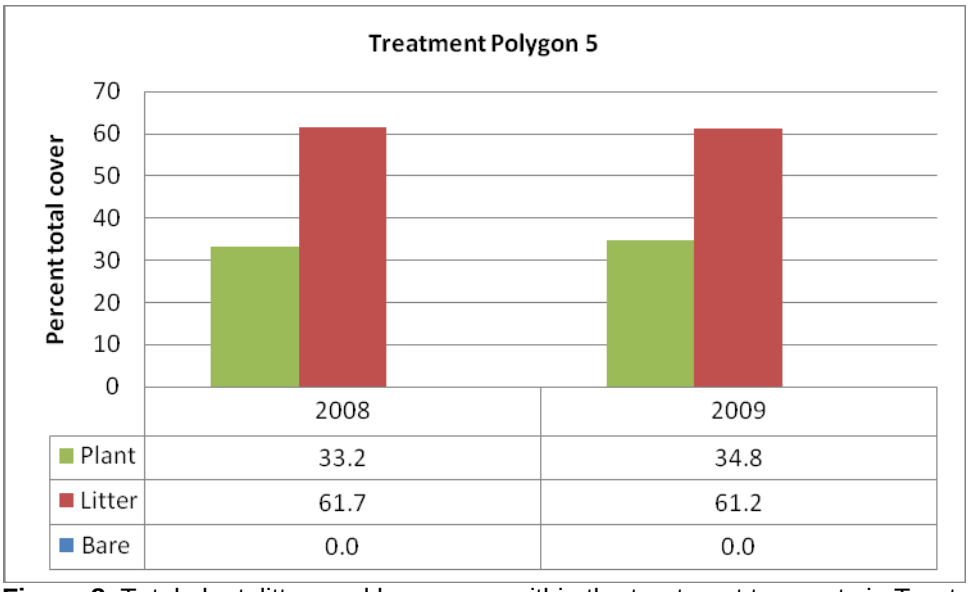


Figure 8. Total plant, litter, and bare cover within the treatment transects in Treatment Polygon 5 in 2008 and 2009 (pre-treatment).

The total percent cover of individual, native, and introduced shrub species is shown in Table 18. Saltcedar was the most common shrub species detected in the overstory layer within 1 m^2 transect plots. There was not a statistical difference in the percent of overstory cover between 2008 and 2009 (Table 19). The overall canopy cover, as measured with a densiometer, was almost complete at 97.7 percent and 97.4 percent in 2008 and 2009, respectively.

Table 18. Total percent cover by individual species in the overstory shrub layer and overall canopy cover of Treatment Polygon 5 in 2008 and 2009.

Overstory shrub layer	**2008**	**2009**
New Mexico olive	1.5	1.5
Coyote willow	3.2	0.5
Native shrubs	4.7	2.0
Saltcedar	31.9	26.3
Introduced shrubs	31.9	26.3
Total shrub cover	36.6	28.3
Canopy cover	97.7	97.4

Table 19. Statistical comparisons between treatment and reference transects and between years for the overstory layer in Treatment Polygon 5; Alpha=0.05.

Overstory shrub layer	**08 vs 09**
Total canopy cover	08=09 P=0.899[4]
Total stem density	08=09 P=1.0[3]

Table 20 shows the average number of woody stems per m^2 and Table 21 shows the average number of saltcedar stems per 25 m^2 in Polygon 5. Stem density was quite low compared to the other treatment polygons due to the dominance and large diameter of saltcedar in this stand.

Table 20. The average number of stems per meter squared for woody species within treatment transects in Treatment Polygon 5 in 2008 and 2009.

Polygon 5 - Average number of stems/m^2		
Shrub species	**2008**	**2009**
Coyote willow	1.0	0.9
New Mexico olive	0.3	0.4
Salt cedar	2.3	2.3
Total shrub	3.6	3.6

Table 21. The average number of saltcedar stems per 25 meters squared within treatment transects of Treatment Polygon 5 in 2008 and 2009.

Average number of saltcedar / 25 m^2		
	2008	**2009**
Polygon 5	32	29.5

Reference Polygons

Polygons 2 and 4

The total percent cover by individual plant species, lifeform (i.e. native or introduced shrub seedlings, grasses, or forbs), and cover type (i.e. vegetation, litter, bare ground, or basal area of shrubs) in the herbaceous and overstory layers of transects in Polygons 2 and 4 are shown in Table 22 for all years of monitoring. The values listed are an average of the 10 plots measured in 2 transects within each polygon.

Forty-one species were detected within the herbaceous layers of Reference Polygons 2 and 4 over four years of monitoring. In 2007, the most abundant species based on percent cover in Polygon 2 were redtop, sedge, and smooth scouring rush. In 2008, the most common species were sedge, field horsetail, and redtop and in 2009 they were sedge, redtop, and dogbane in the same polygon. In Polygon 4, the most common species were redtop, sedge, and spearleaf rabbitbrush in all years 2007 through 2009.

The relative covers of plant types detected in the herbaceous layer of transects in Polygons 2 and 4 from 2006 to 2009 are listed in Table 23. These values are graphed for a visual comparison between years 2007 through 2009 (Figure 9). Introduced grasses were the most common lifeform based on percent relative cover in Polygon 2 in 2007, which shifted to native forbs in 2008 and 2009. In Polygon 4, introduced grasses were the most common lifeforms in 2007 and 2008, and native forbs were the most abundant lifeform in 2009. The percent relative cover of native plant species was significantly less in 2007 (44.9 percent) than in 2008 (81.8 percent) and 2009 (80.2 percent) in Polygon 2.

Table 22. Total percent cover by plant species, lifeform, and cover type in the herbaceous and overstory layers of Reference Polygons 2 and 4 from 2006 to 2009.

	Polygon 2				Polygon 4			
Herbaceous layer	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
Shrub seedlings								
Coyote willow	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Native shrubs	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Graminoids								
Sedge	5.3	10.7	11.2	17.3	16.4	16.0	15.8	19.0
Canada wildrye	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Slender wheatgrass	0.0	0.5	0.5	0.1	3.4	0.0	0.0	0.0
Canary reedgrass	0.2	1.8	3.8	2.6	2.8	4.8	3.2	6.5
Witchgrass	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Kentucky bluegrass	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Native grasses	5.5	13.1	15.7	20.0	22.7	20.8	19.0	25.5
Redtop	3.7	20.3	5.5	7.7	0.0	20.8	30.7	25.7
Tall fescue	0.0	0.0	0.0	0.0	5.4	13.4	2.5	0.0
Introduced grasses	3.7	20.3	5.5	7.7	5.4	34.2	33.2	25.7
Forbs								
Dogbane	1.5	2.6	1.5	5.2	0.2	0.5	1.0	1.0
Silverweed cinquefoil	0.8	0.4	1.5	1.1	0.0	0.0	0.0	0.0
Carruth's sagewort	0.0	0.3	0.0	0	0.0	0.0	0.0	0.0
Spearleaf rabbitbrush	0.0	0.2	2.5	2	21.2	15.3	21.7	37.1
Canadian horseweed	0.2	0.7	0.0	2.2	0.0	0.0	0.0	0.0
Field horsetail	0.2	0.1	10.4	3.5	0.0	0.0	0.0	0.0
Smooth scouringrush	1.0	3.6	1.4	1.6	0.0	0.0	0.1	0.0
Wild licorice	0.0	0.0	0.0	0	0.1	0.0	0.0	0.0
Mountain sneezeweed	0.0	0.2	0.2	0.6	0.0	0.0	0.1	0.1
Rough bugleweed	0.0	0.0	0.0	0	0.0	0.0	0.4	0.5
Wild mint	0.3	0.0	0.1	0.4	0.0	0.0	1.0	1.1
Hooker's evening primrose	0.0	0.3	0.0	2.1	0.0	0.0	0.0	0.0
Norwegian cinquefoil	0.7	0.0	0.6	0.7	0.0	0.0	0.0	0.0
Cottonbatting cudweed	0.0	0.9	0.6	1	0.0	0.0	0.0	0.0
White-panicle aster	0.0	0.0	0.0	0	0.2	0.0	0.0	0.0
Geyer's aster	0.0	0.0	0.2	0.3	0.0	0.1	0.2	0.0
Swamp milkweed	0.0	0.0	0.1	0.1	0.0	0.0	0.3	0.2
Fringed willowherb	0.0	0.0	0.2	0.2	0.0	0.0	0.1	0.0
Spotted water hemlock	0.0	0.0	0.0	0	0.0	0.0	0.0	0.1
Unknown forb	0.0	0.2	0.0	0	0.0	0.0	0.0	0.0
Native forbs	4.6	9.5	19.3	21.0	21.7	15.9	24.9	40.1
Canada thistle	1.3	2.9	0.9	0.7	0.9	7.8	4.3	0.5
Bull thistle	0.0	0.0	0.1	0	0.0	0.0	0.0	0.0
Prickly lettuce	0.0	0.1	0.1	0.3	0.0	0.0	0.0	0.1
White sweetclover	0.0	1.0	0.1	0.3	0.0	0.0	0.0	0.0
Narrowleaf plantain	0.0	1.3	0.0	0	0.0	0.0	0.0	0.0
Common plantain	0.0	0.0	0.9	0.6	0.0	0.0	0.0	0.0

	Polygon 2				Polygon 4			
Herbaceous layer	**2006**	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
Dandelion	0.0	0.3	0.1	0	0.0	0.0	0.0	0.0
Red clover	0.1	0.2	0.1	0	0.0	0.0	0.0	0.0
Virginia creeper	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Spiny sowthistle	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Curly dock	0.0	0.0	0.0	0	0.0	0.0	0.0	0.1
Mullein	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Introduced forbs	1.4	7.4	2.3	2.4	0.9	7.8	4.3	0.7
Total vegetative cover	15.4	50.3	42.8	51.1	50.8	78.7	81.5	92.0
Basal area of shrubs	9.2	7.7	14.5	10.0	11.9	7.5	10.7	1.5
Litter	49.7	42.0	25.6	27.0	32.3	13.3	7.3	6.0
Bare	25.7	0.0	17.1	11.9	5.0	0.5	0.5	0.5
Total herbaceous cover	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 23. Percent relative cover of native and introduced plants by lifeform in the herbaceous layer of transects in Reference Polygons 2 and 4 from 2006 to 2009.

	Percent Relative Cover by Lifeform							
Transects	**Native shrub**	**Intro shrub**	**Native grass**	**Intro grass**	**Native forb**	**Intro forb**	**Total nat spp.**	**Total intro spp.**
Polygon 2								
2006	1.3	0.0	34.4	25.3	29.9	9.1	65.6	34.4
2007	0.0	0.0	26.0	40.4	18.9	14.7	44.9	55.1
2008	0.0	0.0	36.7	12.9	45.1	5.4	81.8	18.2
2009	0.0	0.0	39.1	15.1	41.1	4.7	80.2	19.8
Polygon 4								
2006	0.2	0.0	49.6	5.7	42.7	1.8	92.5	7.5
2007	0.0	0.0	26.4	43.5	20.2	9.9	46.6	53.4
2008	0.1	0.0	23.3	40.7	30.6	5.3	54.0	46.0
2009	0.0	0.0	27.7	27.9	43.6	0.8	71.3	28.7

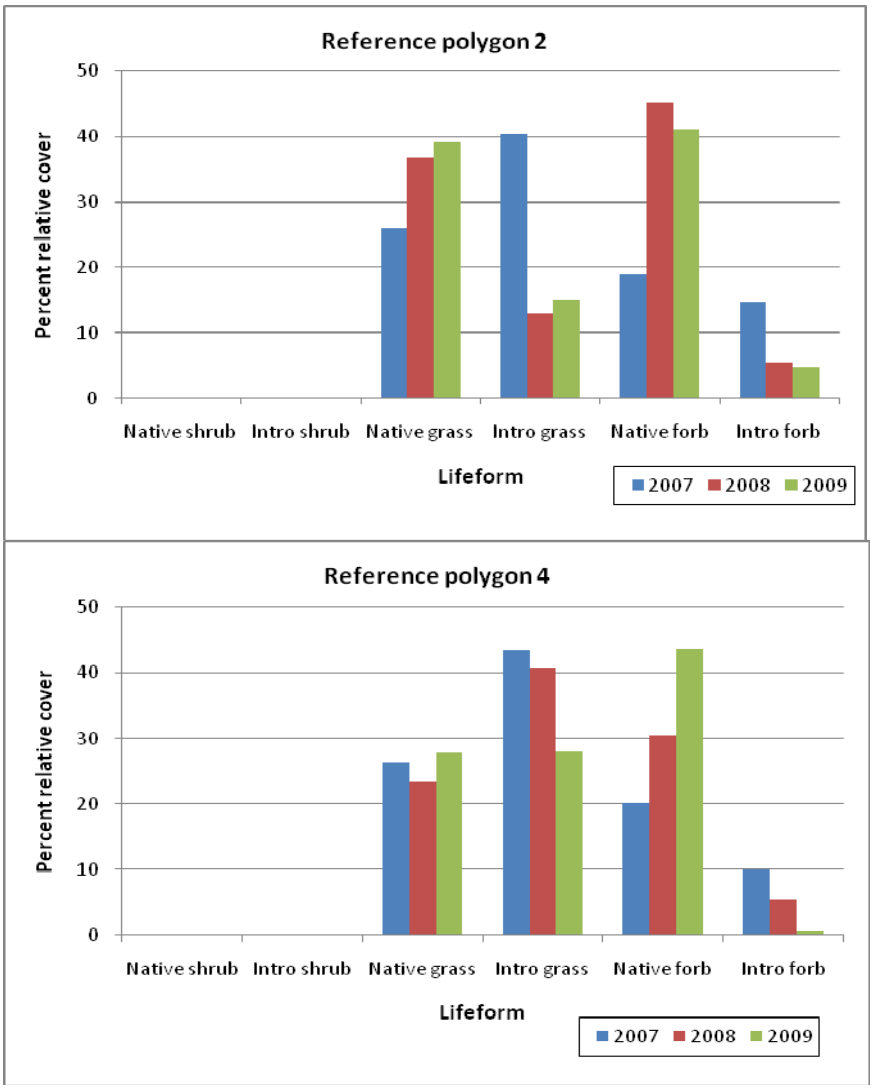


Figure 9. Percent relative cover of plants by lifeform within Reference Polygons 2 and 4 from 2007 to 2009.

The percent relative cover of native plants was statistically equal between all years within Polygon 4 (see Table 24 for statistical results and P-values for the herbaceous layer in Polygons 2 and 4).

Figure 10 provides a visual comparison of the percent total cover of plant, litter, and bare ground in the herbaceous layer of Polygons 2 and 4 from 2007 to 2009. Total plant cover was statistically less in 2008 (42.8 percent) than in 2009 (51.1 percent) in Reference Polygon 2 (Table 24). In Polygon 2, total litter cover was significantly higher and total bare cover was significantly less in 2007 than in 2008 and 2009. The increase in total cover of bare ground was due to scouring floods in 2008 and 2009. Total plant cover increased significantly in 2009 in the herbaceous layer in Polygon 4. Total litter cover gradually decreased to significant levels in 2009 in this polygon as well.

Coyote willow was the only species detected in the overstory shrub layer in both polygons throughout 4 years of monitoring (Table 25). No statistical differences in the

Table 24. Statistical comparisons between 2007 and 2008 for the herbaceous layer in Reference Polygons 2 and 4; Alpha=0.05.

	Polygon 2			Polygon 4		
Understory herbaceous layer	**07 vs 08**	**08 vs 09**	**07 vs 09**	**07 vs 08**	**08 vs 09**	**07 vs 09**
Native species relative cover	07<08 P=0.008[3]	08=09 P=0.939[3]	07<09 P=0.002[3]	07=08 P=0.264[3]	08=09 P=0.082[3]	07=09 P=0.065[3]
Plant total cover	07=08 P=0.285[3]	08<09 P=0.038[3]	07=09 P=0.892[3]	07=08 P=0.622[3]	08<09 P=0.014[3]	07<09 P=0.010[3]
Litter total cover	07>08 P=0.006[3]	08=09 P=0.723[3]	07>09 P=0.026[3]	07=08 P=0.134[3]	08=09 P=0.579[3]	07>09 P=0.045[3]
Bare ground total cover	07<08 P=0.001[3]	08=09 P=0.180[3]	07<09 P=0.008[3]	07=08 P=1.0[3]	08=09 P=1.0[4]	07=09 P=1.0[4]

[1] Paired t-test; [2]Signed rank test
Highlighted boxes indicate a significant difference at the 95 percent confidence level.

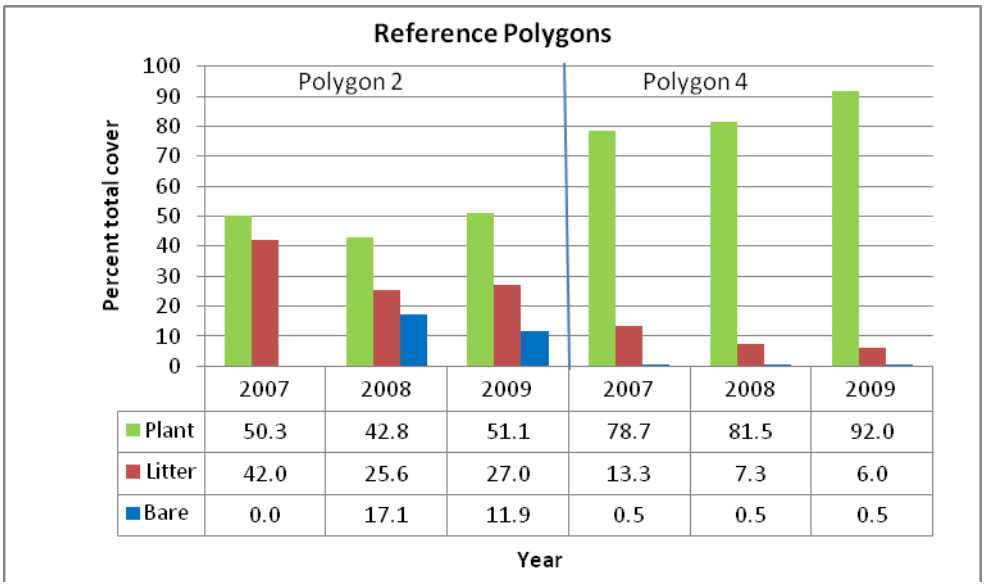


Figure 10. Total plant, litter, and bare cover within Reference Polygons 2 and 4 from 2007 to 2009.

Table 25. Total percent cover of coyote willow in the overstory shrub layer and overall canopy cover of Reference Polygons 2 and 4 from 2006 to 2009.

	Polygon 2				Polygon 4			
	2006	**2007**	**2008**	**2009**	**2006**	**2007**	**2008**	**2009**
Coyote willow	61.5	68.5	72.0	75.0	64.5	52.5	67.5	61.5
Total shrub cover	61.5	68.5	72.0	75.0	64.5	52.5	67.5	61.5
Canopy cover	63.3	72.1	63.5	88.40	*	72.9	62.2	81.8

*too windy to get accurate readings

total cover of willow were detected between years in either polygon (Table 26). Overall canopy cover in reference transects remained relatively stable until 2009, when it increased by about 20 percent in both polygons (Table 26).

Table 26. Statistical comparisons between years for the overstory layer in Reference Polygons 2 and 4; Alpha=0.05.

	Polygon 2				Polygon 4			
Overstory shrub layer	**06 vs 07**	**07 vs 08**	**08 vs 09**	**06 vs 09**	**06 vs 07**	**07 vs 08**	**08 vs 09**	**06 vs 09**
Total canopy cover	06=07 P=0.200[3]	07=08 P=0.680[3]	08=09 P=0.594[3]	06=09 P=0.070[3]	06=07 P=0.406[3]	07=08 P=0.315[3]	08=09 P=0.609[4]	06=09 P=0.774[3]
Total stem density	06=07 P=0.160[3]	07<08 P=0.004[4]	08>09 P=0.001[3]	06=09 P=0.122[3]	06=07 P=0.742[3]	07<08 P=0.020[3]	08>09 P=0.003[3]	06=09 P=0.108[3]

[1] Paired t-test; [2]Signed rank test
Highlighted boxes indicate a significant difference at the 95 percent confidence level.

Table 27 shows the average number of woody stems per m^2 (i.e. coyote willow) for Polygons 2 and 4 from 2006 to 2009. The values listed are an average of the 10 plots that were measured in each transect type. Stem density in both polygons was significantly higher in 2008 than in other years (Table 26), the reasons for which are unknown. Willow stem density within reference transects in treatment polygons did not undergo such drastic increases during this same time period.

Table 27. The average number of coyote willow stems per meter squared within transects in Reference Polygons 2 and 4 from 2006 to 2009.

Average # of coyote willow stems/m^2				
	2006	**2007**	**2008**	**2009**
Polygon 2	32.1	36.1	58.1	38.5
Polygon 4	21.0	19.5	49.0	29.4

The majority of willow stems that were counted within transects originated from one base with many shoots. Therefore the increase in stem counts in 2008 was more related to resprouting of old plants than to regeneration of new plants. Evidence of beaver damage was prevalent along this section of the Rio Grande, and in 2007 it was noted that transects were heavily browsed by beaver in Polygon 4. This would explain an increase in the number of stems – in the form of resprouts- the following year. The hydrology within these polygons was clearly favorable for the growth of willow, which was the only overstory species present at these sites. Polygon 2 is located along a sandbar and often experiences flooding. Polygon 4 is characterized by side channels and depressions, which provide a source of available water. The combination of beaver browsing in 2007 and high discharges in 2008 (Figure 10) likely contributed to the significant increase in willow stem density in the Reference polygons that year.

In 2009, heavy beaver damage was again noted and discharge rates were again high (Figure 11). However, willow stem counts returned to values documented in years prior to 2008. It was observed that many of the bases from which shoots of willow plants emerged had reached heights above 25 cm in 2009. In this situation, only one stem was counted since protocol for stem density involved tallying only individual stems that branched below 25 cm. So although there may have been many stems arising from one

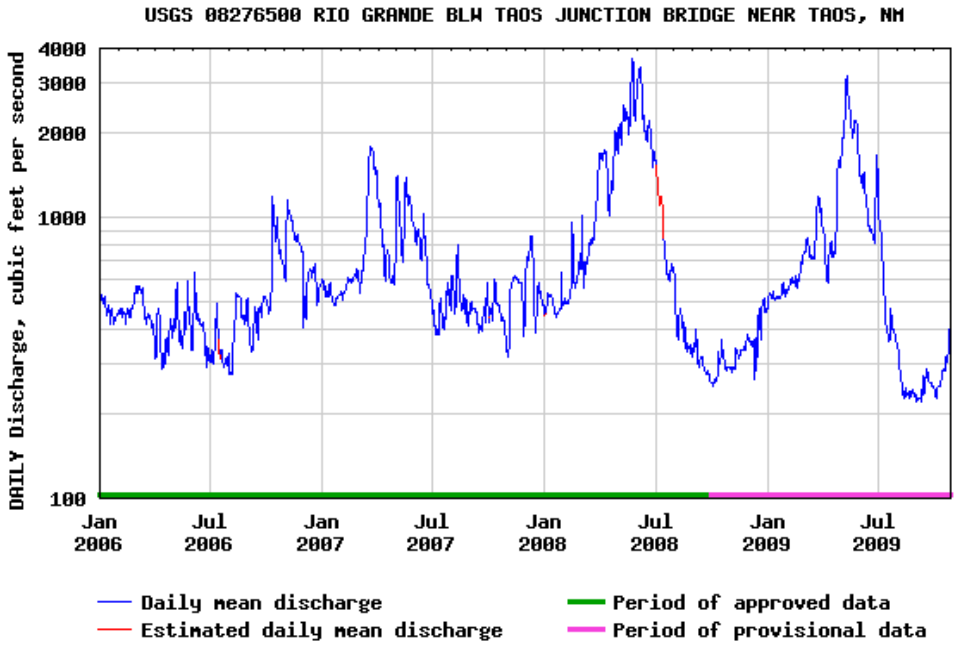


Figure 11. Discharge in CFS of the Rio Grande at Taos Junction Bridge, New Mexico. Source: United States Geological Survey

base, only one stem was counted. Factors that caused the increases in willow base heights may have been repeated beaver browsing that led to resprouting of shoots at continually higher points on the plant and/or scouring floods that lowered the ground level. The increases in willow base heights would have affected stem density by decreasing the number of stems measured below 25 cm this year.

Conclusions and Recommendations

In summary, saltcedar was removed from 2 treatment polygons in 2008 after two years of baseline data were collected. Analyses of post-treatment data collected in 2008 and 2009 identified possible effects from saltcedar control in Treatment Polygons 1 and 3.

In Polygon 1, native grasses continued to be the dominant herbaceous lifeform after saltcedar was removed, which indicated that disturbance at the site did not appear to cause a measurable increase in weedy species. Total overstory cover increased significantly from 2008 to 2009, which was primarily a result of an increase in the cover of coyote willow. Total cover of coyote willow increased from 26.0 percent to 45.7 percent over the monitoring period, which was most likely due to a release in the growth of willow following saltcedar removal. During this same time period, total cover of saltcedar decreased slightly from 7.5 percent to 4.0 percent. Saltcedar density increased from 20 stems/25m^2 in 2006 to 34.5 stems/25m^2 that had resprouted by 2009.

In Polygon 3, total herbaceous plant cover decreased significantly from 65.5 percent prior to saltcedar control to 11.4 percent post-treatment, while total litter cover increased significantly from 18.5 percent to 68.9 percent during the same period. These changes in herbaceous plant and litter cover were most likely related to saltcedar removal. Saltcedar was hand cut and the plant material was left on site as litter. The high litter cover inhibited the growth of understory herbaceous species. Although the total plant cover decreased, the proportion of native plants that made up the vegetation increased. This outcome indicated that treatment did not result in an increase in introduced weedy species at the site. Both overstory cover and density decreased statistically in the treated sites in 2008. These results suggest that saltcedar removal decreased shrub cover, which is logical because saltcedar was a relatively large component of the overstory at this site prior to treatment. In 2009, total overstory cover was on an upward trend, which was linked to an increase in the percentage of coyote willow cover. Saltcedar density decreased but was still quite high following treatment (54.0 stems/25m^2).

Saltcedar densities recorded in 2008 indicated that saltcedar resprouted at a relatively high rate following treatment. In 2009, these number decreased somewhat. In order to sustain some level of success in saltcedar control, Reclamation recommends conducting follow-up treatments in Polygons 1 and 3 using the same methods of control that were originally applied.

Baseline data was collected for the first year in 2008 in Treatment Polygon 5 and again in 2009. Besides saltcedar, the invasive species perennial pepperweed and houndstoungue were recorded in somewhat high proportions. These herbaceous species should be observed closely following treatment to determine if they have spread and if control is necessary. Polygon 5 was treated using the cut stump method - including herbicide application and removal of slash - in 2009 following baseline data collection. Reclamation will collect post-treatment data at this site in the future.

In Reference Polygons 2 and 4, stem density of coyote willow increased significantly in 2008 but returned to initial levels in 2009. These results probably suggest that hydrologic conditions in 2008 were conducive to willow productivity at these sites. It was also likely that intensive browsing by beaver stimulated resprouting of willow stems. The large increase in stem density in 2008 should be taken into consideration when using data for comparison purposes over time. In 2009, it was observed that many of the bases from which shoots of willow plants emerged had reached heights above 25 cm. In this situation, only one stem was counted since protocol for stem density involved tallying only individual stems that branched below 25 cm. This caused the total number of stems to decrease. Beaver browsing continued to be intensive throughout the project area in 2009.

Reclamation recommends that vegetation monitoring continue at the established sites to document effects and success of saltcedar treatment within the OVRA. Based on the results of the sampling effort thus far, some issues that may be important to monitor over time include 1) long-term inhibition of herbaceous species due to saltcedar material that was left on site after cutting, 2) reestablishment of willow and other native woody species

in the absence of saltcedar, 3) resprouting rates of treated saltcedar, and 4) invasion of other troublesome species following saltcedar removal.

Literature Cited

USDI - BLM, August 2006. Treatment of Saltcedar (Tamarix sp) and Other Invasive Non-Native Vegetation in Orilla Verde Recreation Area. NM-220-05-054.

Appendix A

Data Collection Form

Orilla Verde Recreation Area
Saltcedar Removal Vegetation Monitoring

Date:	
Observers:	
Polygon ID:	
Height class verification:	
Transect #:	
Waypoints:	
Photo #s:	
Densiometer readings:	

Plot #	Life Form*	Species Code	% Cover	Stem count**	Plot #	Life Form	Species Code	% Cover	Stem count

*H=Herbaceous and woody seedlings S=shrubs and saplings (<20 ft) T=tree (>20 ft) **Woody spp. Only

Appendix B

Waypoints for Photo Station and Transect Locations

Polygons

Polygon	Transect	X	Y
1	1A	433773	4021290
1	1B	433746	4021280
1	2A	433768	4021297
1	2B	433741	4021304
1	3A	433706	4021303
1	3B	433683	4021305
1	4A	433642	4021263
1	4B	433622	4021286
2	1A	431400	4018834
2	1B	431380	4018817
2	2A	431380	4018817
2	2B	431370	4018800
3	1A	433344	4021108
3	1B	433338	4021092
3	2A	433284	4021040
3	2B	433259	4021031
3	3A	433262	4021042
3	3B	433241	4021025
3	4A	433236	4021019
3	4B	433217	4021008
4	1A	431537	4019100
4	1B	431528	4019070
4	2A	431524	4019051
4	2B	431518	4019025
5	1A	433051	4020878
5	1B	433034	4020858
5	2A	432845	4020593
5	2B	432834	4020576

Photo Stations

Photo Station	x	y	Notes
PS1	433703	4021312	1 photo upstream; 1 photo downstream
PS2	431431	4018844	1 photo downstream
PS3	433189	4020958	No marker; rock next to elm, across river on downstream end of polygon
PS4	431571	4019053	Taken at culvert from road post w/ reflectors
PS5-1	433002	4020829	Fence post west side of road near transect 1
PS5-2	432875	4020596	Big rock upslope from transect 2, east side of road, upstream side of polygon

Datum NAD83
Zone 13

Appendix C

Common and Scientific Names of Plants
Detected in Treatment and Reference Transects

Code	Scientific name	Common name	Lifeform*
Trees/shrubs			
FOPU	*Foresteria pubescens*	New Mexico olive	NS
JUMO	*Juniperus monosperma*	Oneseed juniper	NS
PODE	*Populus deltoides*	Cottonwood	NS
SAEX	*Salix exigua*	Coyote willow	NS
TARA	*Tamarix ramosissima*	Saltcedar	IS
ULPU	*Ulmus pumila*	Siberian elm	IS
Grasses			
AGGI	*Agrostis gigantea*	Redtop	IG
BRIN	*Bromus inermis*	Smooth brome	IG
BRJA	*Bromus japonicus*	Japanese brome	IG
BRTE	*Bromus tectorum*	Cheatgrass	IG
CAEM	*Carex emoryi*	Sedge	NG
ELCA	*Elymus canadensis*	Canada wildrye	NG
ELTR	*Elymus trachycaulus*	Slender wheatgrass	NG
FEAR	*Festuca arundinacea*	Tall fescue	IG
HOJU	*Hordeum jubatum*	Barley foxtail	NG
MUAS	*Muhlenbergia asperifolia*	Alkali muhly	NG
MURA	*Muhlenbergia racemosa*	Marsh muhly	NG
PACA	*Panicum capillare*	Witchgrass	NG
PHAR	*Phalaris arundinacea*	Canary reedgrass	NG
POPR	*Poa pratensis*	Kentucky bluegrass	NG
SPCR	*Sporobolus cryptandrus*	Sand dropseed	NG
Forbs			
ACMI	*Achillea millefolium*	Common yarrow	NF
AMAR	*Ambrosia artemisifolia*	Annual ragweed	NF
APCA	*Apocynum cannabinum*	Clasping-leaf dogbane	NF
ARAN	*Argentina anserina*	Silverweed cinquefoil	NF
ARCA	*Artemisia carruthii*	Carruth’s sagewort	NF
ARLU	*Artemisia ludoviciana*	White sagebrush	NF
ASIN	*Asclepias incarnata*	Swamp milkweed	NF
CHLI	*Chrysothamnus linifolius*	Spearleaf rabbitbrush	NF
CHSE	*Chamaesyce serpyllifolia*	Thymeleaf spurge	NF
CHAL	*Chenopodium album*	Lambsquarters	IF
CIAR	*Cirsium arvense*	Canada thistle	IF
CIMA	*Cicuta maculata*	Spotted water hemlock	NF
CIVU	*Cirsium vulgare*	Bull thistle	IF
CLLI	*Clematis ligusticifolia*	Virgin's bower	NF
COCA	*Conyza canadensis*	Horseweed	NF
CYOF	*Cynoglossum officianale*	Houndstongue	IF
DIFU	*Dipsacus fullonum*	Teasel	IF
EPCI	*Epilobium ciliatum*	Fringed willowherb	NF
ERSP	*Erigeron* sp.	Fleabane	NF
EQAR	*Equisetum arvense*	Field horsetail	NF
EQLA	*Equisetum laevigatum*	Smooth scouringrush	NF

Code	Scientific name	Common name	Lifeform*
GLLE	*Glycyrrhiza lepidota*	Wild licorice	NF
GRSQ	*Grindelia squarrosa*	Curlycup gumweed	NF
HEAU	*Helenium autumnale*	Mountain sneezeweed	NF
HESP	*Heterotheca* sp,	Goldenaster	NF
LASE	*Lactuca serriola*	Prickly lettuce	IF
LELA	*Lepidium latifolium*	Perrenial pepperweed	IF
LYAS	*Lycopus asper*	Rough bugleweed	NF
MEAL	*Melilotus albus*	White sweetclover	IF
MEAR	*Mentha arvensis*	Wild mint	NF
OEEL	*Oenothera elata*	Hooker's evening primrose	NF
OPSP	*Opuntia* sp.	Pricklypear cactus	NF
PAQU	*Parthenocissus quinquefolia*	Virginia creeper	IF
PLLA	*Plantago lanceolata*	Narrowleaf plantain	IF
PLMA	*Plantago major*	Common plantain	IF
PONO	*Potentilla norvegica*	Norwegian cinquefoil	NF
PSST	*Pseudognaphalium stramineum*	Cottonbatting cudweed	NF
RUCR	*Rumex crispis*	Curly dock	IF
SOAS	*Sonchus asper*	Spiny sowthistle	IF
SYLAG	*Symphyotrichum laeve var. geyeri*	Geyer's aster	NF
SYLAH	*Symphyotrichum lanceolatum ssp. hesperium*	White-panicle aster	NF
TAOF	*Taraxacum officinale*	Dandelion	IF
TRPO	*Tragopogon porrifolius*	Salsify	IF
TRPR	*Trifolium pratense*	Red clover	IF
VETH	*Verbascum thapsus*	Mullein	IF

*IS=Introduced shrub; NS=Native shrub; IG=Introduced grass; NG=Native grass; IF=Introduced forb; NF=Native forb

Appendix D

Photo Stations
June 2006 through October 2009

Polygon 1 - Treatment Transects

1A


2006 Pre-treatment


2007 Post-treatment

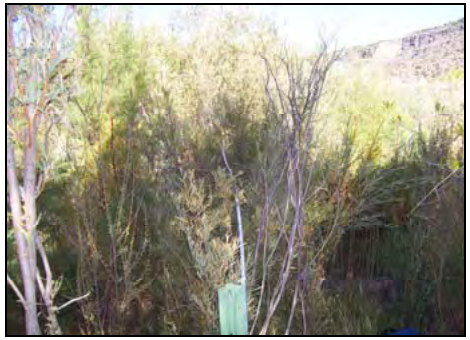

2008 Post-treatment


2009 Post-treatment

1B


2006 Pre-treatment


2007 Post-treatment


2008 Post-treatment


2009 Post-treatment

4A


2006 Pre-treatment


2007 Pre-treatment


2008 Post-treatment


2009 Post-treatment

4B


2006 Pre-treatment


2007 Pre-treatment


2008 Post-treatment


2009 Post-treatment

Polygon 1 - Reference Transects

2A


2006


2007

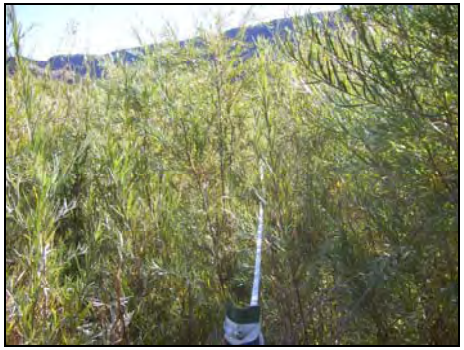

2008


2009

2B

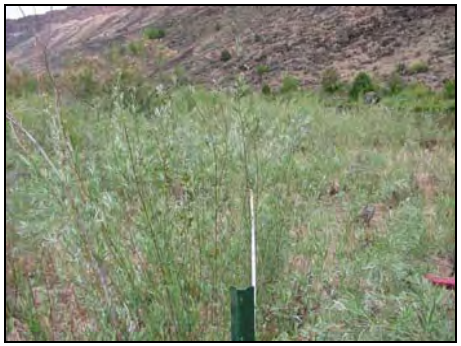

2006


2007


2008


2009

3A


2006

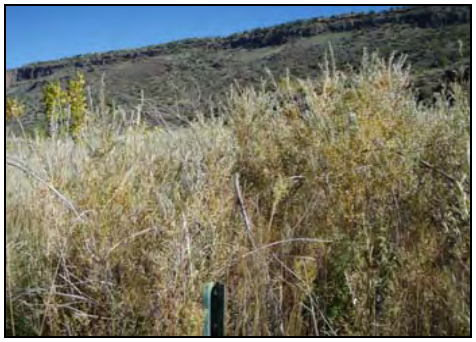

2007


2008


2009

3B


2006


2007

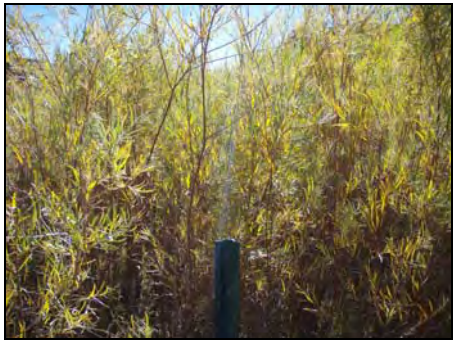

2008


2009

Polygon 2 – Reference Transects

1A


2006


2007


2008


2009

1B


2006


2007


2008


2009

2A


2006


2007


2008


2009

2B


2006


2007


2008


2009

Polygon 3 – Treatment Transects

2A


2006 Pre-treatment


2007 Pre-treatment


2008 Post-treatment


2009 Post-treatment

2B


2006 Pre-treatment


2007 Pre-treatment


2008 Post-treatment


2009 Post-treatment

4A


2006 Pre-treatment


2007 Pre-treatment


2008 Post-treatment


2009 Post-treatment

4B


2006 Pre-treatment


2007 Pre-treatment

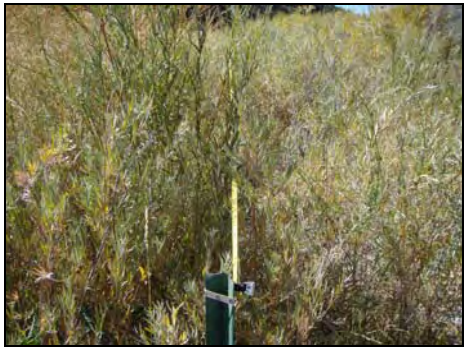

2008 Post-treatment


2009 Post-treatment

Polygon 3 – Reference Transects

1A

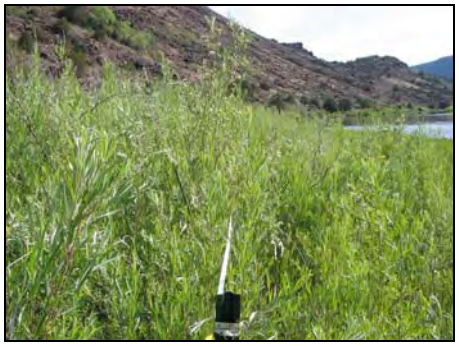

2006


2007


2008


2009

1B


2006


2007


2008


2009

3A


2006


2007


2008

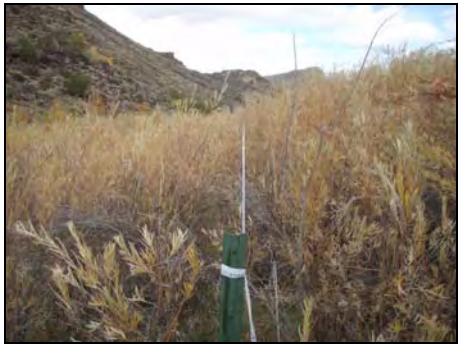

2009

3B


2006


2007


2008


2009

Polygon 4 – Reference Transects

1A


2006


2007


2008


2009

1B


2006


2007


2008


2009

2A


2006


2007


2008


2009

2B


2006


2007


2008


2009

Polygon 5 – Treatment Transects

1A


2008 Pre-treatment


2009 Pre-treatment


2009 Post-treatment

1B


2008 Pre-treatment


2009 Pre-treatment


2009 Post-treatment

2A


2008 Pre-treatment


2009 Pre-treatment


2009 Post-treatment

2B

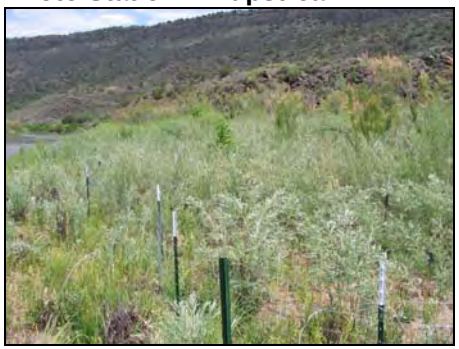

2008 Pre-treatment


2009 Pre-treatment


2009 Post-treatment

Photo Stations

Photo Station 1 – upstream


2006


2007


2008


2009

Photo Station 1 – downstream


2006


2007


2008


2009

Photo Station 2


2006


2007


2008


2009

Photo Station 3


2006


2007


2008


2009

Photo Station 4 – upstream


2006


2007


2008


2009

Photo Station 4 – across


2006


2007


2008


2009

Photo Station 4 – downstream


2006


2007


2008


2009

Photo Station 5-1


2008 Pre-treatment


2009 Pre-treatment


2009 Post-treatment

Photo Station 5-2

2008 Pre-treatment

2009 Pre-treatment

2009 Post-treatment