Diorhabda carinulata and Tamarisk Control

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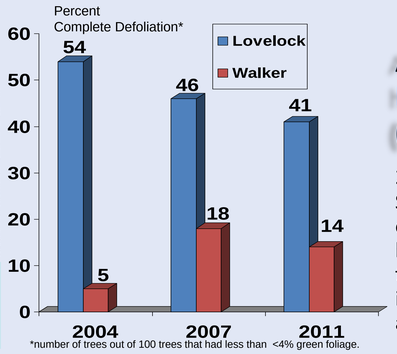
Introduction

Saltcedar (*Tamarix ramosissima*), a small tree native to Central Asia has invaded more than 1.9 million hectares in the western United States. Planted in the early 1800s as an ornamental and later for windbreaks and soil stabilization, it escaped cultivation, infesting riparian and adjacent communities.

In an effort to control saltcedar, the USDA-Agricultural Research Service investigated a number of potential control insects in the 1970s. By the 1990s a foreign leaf eating beetle (Diorhabda carinulata formerly D. elongata), was released by USDA.

Figure 2. Saltcedar defoliation at both the Lovelock and Walker Lake sites for 2004, 2007 and 2011. Visual reference above of maximum defoliation and re-growth.



Results

After measuring defoliation for a decade, complete defoliation (>96% tree) reached a high of 54% in 2004 at the Lovelock site and a high of 18% at the Walker site in 2007 **(Figure 2)**. By 2011, complete defoliation was recorded at 41% and 14%, respectfully.

2001 vegetation cover was 10.51% **(Table1)(Figure 3)**. Saltgrass occurred in 47% of the quadrats with an average cover of 9.26%. Tall whitetop was also present in 47% of the quadrats beneath the canopy with an average cover of 12.68%. By 2011 tall whitetop was not present in the quadrats and saltgrass had increased to a presence of 50% beneath the canopy with an average cover of 48.46%.

Primary Species	Year	% Presence Below	% Presence Edge	Ave. % Cover below	Ave. % Cover Edge
Saltgrass	2001	47	26	9	6
Tall Whitetop	2001	47	28	13	10
Annual Kochia	2001	2	3	6	4
Russian Knapweed	2001	1	3	5	16
Total all plots (n100)	**2001**	**62**	**46**	**10**	**6**
Saltgrass	2004	39	36	6	8
Tall Whitetop	2004	7	4	4	3
Annual Kochia	2004	1	0	2	0
Russian Knapweed	2004	0	7	0	4
Total all plots (n100)	**2004**	**43**	**42**	**3**	**3**
Saltgrass	2007	10	21	15	17
Tall Whitetop	2007	6	0	20	0
Annual Kochia	2007	86	82	82	81
Russian Knapweed	2007	2	1	40	1
Total all plots (n100)	**2007**	**93**	**89**	**76**	**71**
Saltgrass	2011	50	54	48	45
Tall Whitetop	2011	0	0	0	0
Annual Kochia	2011	36	40	28	21
Russian Knapweed	2011	7	5	11	16
Total all plots (n100)	**2011**	**59**	**66**	**35**	**33**

Table 1. Primary vegetation cover below and at the edge of saltcedar canopies at the Lovelock site from 2001 to 2011. * percent rounded to nearest whole number

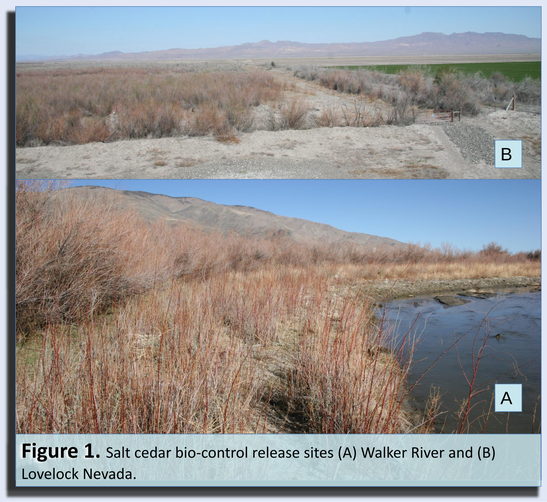


Figure 1. Salt cedar bio-control release sites (A) Walker River and (B) Lovelock Nevada.

In 1999 we constructed three bio-control quarantine cages in North-western Nevada; Lovelock (40º01.219'N 118º31.389'E) Stillwater (39º31.493'N 118º30.823'E) Walker, (38º53.529'N 118º46.780'E). Beetle reproduction in the wild was to be observed in the cages before full release. Five other states also constructed cages. In 2001 the leaf beetle was released. At two of the three release sites (Walker and Lovelock) the beetle initially established.

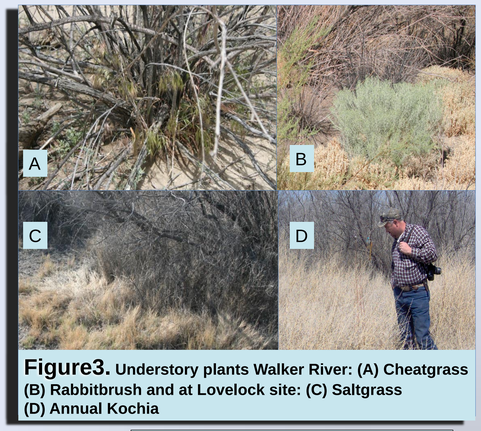


Figure3. **Understory plants Walker River: (A) Cheatgrass (B) Rabbitbrush and at Lovelock site: (C) Saltgrass (D) Annual Kochia**

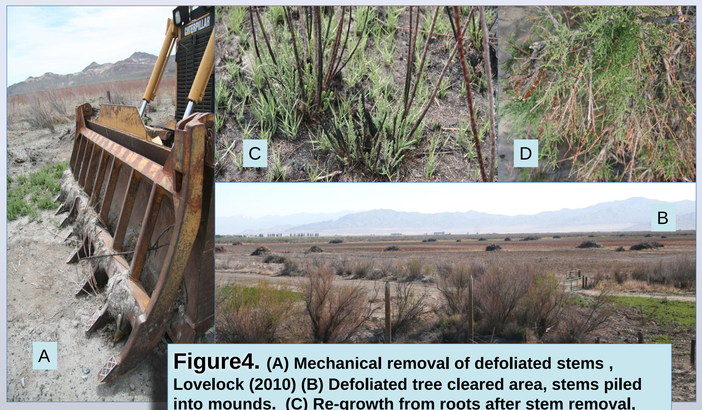


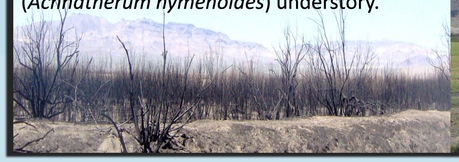
Figure4. **(A) Mechanical removal of defoliated stems , Lovelock (2010) (B) Defoliated tree cleared area, stems piled into mounds. (C) Re-growth from roots after stem removal, Lovelock (D) Significantly cattle browsed stems re-sprouted At the Walker site**

Discussion

Our question is whether the release of the leaf beetle resulted in death or defoliation of the trees and does the aftermath of the bio-control lead to improved habitat. Previous reports suggest rapid beetle defoliation is significant and death can occur within 3-5 years. We observed a high percent of re-growth of near completely defoliated trees after removing the defoliated-stem overstory **(Figure 4 & 5)**. In 2011 the beetle was absent, which along with the nature of salt cedar; deep rooted, re-spouting (after fire or flood), drought tolerant, long-lived, makes control unlikely. However, there still seems to be debate over the effectiveness of the beetle to control saltcedar. The interpretation of a dead saltcedar tree further clouds this reality. We follow the guidelines that "dead trees do not grow" in our assessment of true senescence. A defoliated saltcedar tree that may look dead and gray actually has tremendous potential to re-grow. Removal of defoliated standing biomass (a necessity for revegetation and wildlife use), stimulates re-growth **(Figure 5)**. Based on our observations we find it most probable that heavy equipment and herbicides will continue to be the tools that will ultimately control saltcedar.

Walker River

The site was under lake level as recent as 1928. Up-stream diversion resulted in a dramatic Lake level drop. As the lake receded the exposed muddy delta provided opportunity for saltcedar establishment **(Figure 1a)**. Willows and cottonwood (*Populus fremontii*) are abundant on the rivers edge. The adjacent rivers edge is dominated by an *Atriplex/Sarcobatus* salt desert community with a saltgrass (*Distichlis spicata*) or sparse Indian ricegrass (*Achnatherum hymenoides*) understory.



Lovelock

The site is adjacent to production agricultural fields **(Figure 1b)**. Before the rapid invasion of saltcedar following the flood of 1985, the site was dominated by black greasewood (*Sarcobatus vermiculatus*) with saltgrass (*Distichlis spicata*) understory. Occasional willows (*Salix* sps.) line the Humboldt river and diversion ditches. Cottonwood trees historically never occurred at the Humboldt River delta. The site flooded for most of the growing season in 2006.

Vegetation Monitoring

In May 2001 at each site, we began annual saltcedar measurements of plant morphology of 100 marked trees [e.g. height, diameter, densitometer (percent), foliage/stem status (green, defoliated (dead leaf /stem), re-growth, and flowering]. We measured nearest shrub and primary vegetation under the canopy along with presence or absence of beetles. These measurements were taken (last week in May) from 2001 through 2011. Vegetation monitoring was cancelled at the Stillwater site after a few years because of lack of beetle presence, likely due to a dense saltgrass understory and annual flooding which eliminate the habitat for soil over wintering for the beetle.

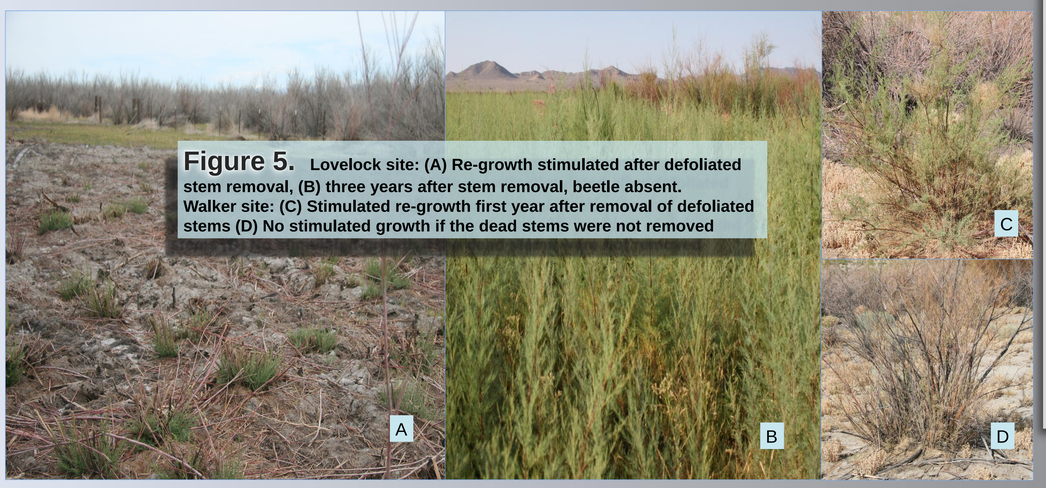


Figure 5. **Lovelock site: (A) Re-growth stimulated after defoliated stem removal, (B) three years after stem removal, beetle absent. Walker site: (C) Stimulated re-growth first year after removal of defoliated stems (D) No stimulated growth if the dead stems were not removed**

The Walker site has much more vegetation diversity **(Table 2)**. Cheatgrass **(Figure 3)** and Tansy mustard were the most frequently recorded species with cheatgrass occurring in 42% of the quadrats with an average cover of 7.14%. Tansy mustard was present in 19% of the quadrats with an average cover of 1.95%. By 2011 there had been a significant decrease in vegetation presence (2001-49% vs. 2011-2%) and average cover for vegetative present plots (2001-5.38% vs. 2011-0.01%).

Primary Species	Year	% of Plots Presence Below	% of Plots Presence Edge	Ave % Cover Below	Ave % Cover Edge	Year	% of Plots Presence Below	% of Plots Presence Edge	Ave % Cover Below	Ave % Cover Edge
Cheatgrass	*2001*	42	65	7	6	*2004*	4	7	9	4
Saltgrass	*2001*	7	7	4	2	*2004*	5	12	4	3
Tansy Mustard	*2001*	19	22	2	1	*2004*	3	3	4	2
Russian Thistle	*2001*	4	0	1	0	*2004*	5	25	1	4
Rabbitbrush	*2001*	0	0	0	0	*2004*	0	0	0	0
Indian ricegrass	*2001*	0	3	0	1	*2004*	1	1	2	1
Total	***2001***	**49**	**71**	**5**	**6**	***2004***	**14**	**34**	**1**	**2**
Cheatgrass	*2007*	1	2	5	3	*2011*	0	3	0	13
Saltgrass	*2007*	2	6	5	6	*2011*	0	4	0	7
Tansy Mustard	*2007*	0	3	0	2	*2011*	0	2	0	6
Russian Thistle	*2007*	9	15	10	6	*2011*	1	5	2	5
Rabbitbrush	*2007*	5	7	41	23	*2011*	1	12	7	48
Indian ricegrass	*2007*	0	3	0	3	*2011*	0	0	0	0
Total	***2007***	**13**	**19**	**3**	**4**	***2011***	**2**	**28**	**0**	**7**

Table 2. Primary Vegetation cover below and at the edge of saltcedar canopies at the Walker Lake site from 2001 to 2011. Total = percent of all (n100) plots with any vegetative presence and the average cover of all vegetative present plots.

* percent rounded to nearest whole number