Potential for Water Salvage by Release of the Biocontrol Beetle, *Diorhabda elongata*, on Tamarisk (*Tamarix ramosissima*) Dominated Western U.S. Rivers

Photo: Greg Joder

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ABSTRACT

The biocontrol beetle, *Diorhabda elongata*, has been widely released in the upper basin of the Colorado River to control Tamarisk in the western U.S. A primary motivation for beetle release is to salvage water that would otherwise be lost to transpiration by Tamarisk. We summarize preliminary findings of our assessment of water usage. We used the Enhanced Vegetation Index (EVI) from the MODIS sensors on the Terra satellite to evaluate the prospects for water salvage at 15 riparian release sites in Utah, Colorado, Nevada and Wyoming. EVI was combined with meteorological data to estimate evapotranspiration (ET) at the release sites and in adjacent sites to which the beetle might have spread. ET was estimated at 16-day intervals from 2000 to 2008, encompassing pre-release and post-release periods at each site. Baseline ET rates tended to be low, from 2-6 mm d-1 in summer (less than half of potential ET). Ground observations confirmed that beetles were active at all sites following release, defoliating stands of Tamarisk over areas as large as 200 ha. At four of the sites, ET rates estimated by MODIS EVI decreased markedly one to two years after release. At other sites, however, no decrease in ET was detected, and ET tended to recover to pre-release levels at affected sites. Ground data collected at four sites on the Dolores River include vegetation structure, composition and phenology as well as bird monitoring and productivity. The four sites are dominated by saltcedar, with components of willow and cottonwood. For the last 3 years, monthly monitoring of 100 trees at each site were observed for percent flower and leaf, coupled with ratios of green-to-brown needle observations, done from spring green-up to senescence. Bird census data were collected at 100 m radius circular plot stations (n=20) and birds were captured in mist-nets, in which the type and number of birds were reported as birds per net hour. At each location, the results support our past 3 years of findings for the ET seasonally and annually time-series curves as the beetle came into the area and defoliated saltcedar. This study supports phenological observations showing that beetle damage is spotty and localized at most sites, and reduction in ET is confined mainly to July when beetles are actively feeding. However, beetles are still spreading and the eventual fate of Tamarisk stands remains to be determined.

Rationale for Study

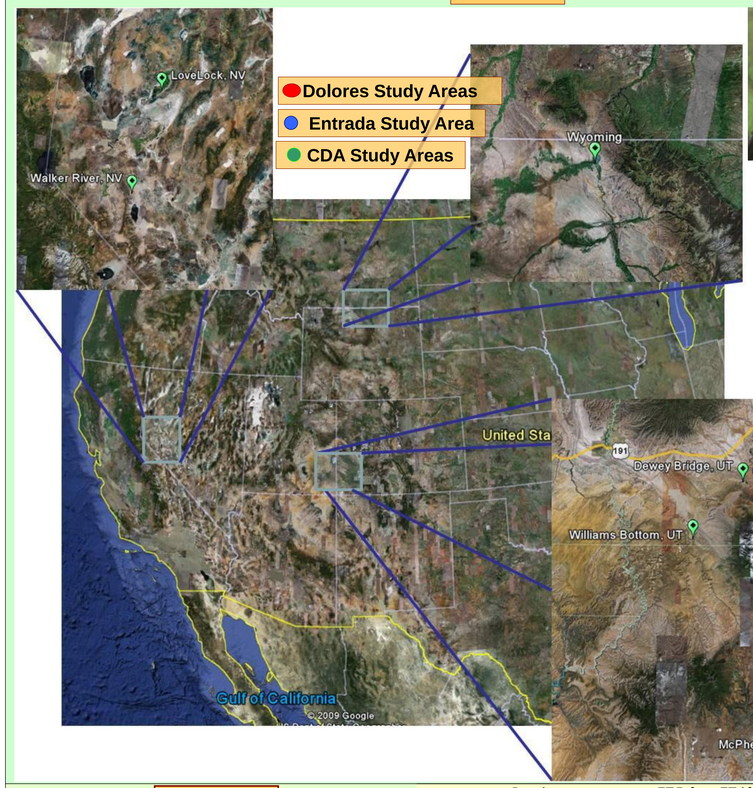
The control of tamarisk (*Tamarix* spp) trees and shrubs near rivers, streams, and wetlands in the western US is now a high priority among many local, state, and federal agencies. Recent releases of the saltcedar leaf beetle have shown considerable promise for controlling tamarisk over large areas, but may also have many unintended negative impacts on highly valued riparian ecosystems. Intensive monitoring of ecosystem services in these riparian zones, including sediment & nutrient export, water usage, distribution of noxious weeds, habitat quality, and socioeconomic factors, to improve remediation efforts in tamarisk-invaded riparian ecosystems is needed. Restoration and future control efforts would benefit from the timely establishment of a comprehensive policy and research framework to address potential impacts of biocontrol agents, through collaborations with scientists, land managers, and stakeholders.

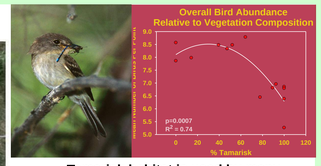
Objectives

- To determine baseline values of riparian evapotranspiration (ET) for each river reach
- To estimate the percent reduction in ET that can be attributed to defoliation of Tamarisk by beetles.

Tamarisk stand on the Dolores River, near Moab, UT,
(a) before and (b) after defoliation by the saltcedar leaf beetle *(Diorhabda elongata).*

Methods



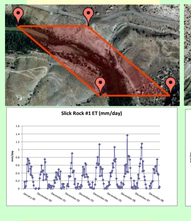


Tamarisk habitat is used by many migrant and breeding birds, including the Endangered Southwestern Willow Flycatcher. The species that nest and breed in it were found to prefer a composition of 30% tamarisk to 70% native. Tamarisk control has the potential to negatively influence certain bird species. There is no single tamarisk management action that is suitable for ALL bird species. The defoliation period by the tamarisk beetle coincides with the highest nest productivity (80% occurs after defoliation).

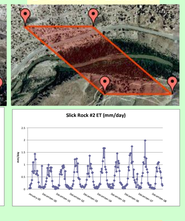
Dolores Study Areas

Slick Rock, CO

1 = 38.03092 – 108.86885



2 = 38.03173 – 108.87348

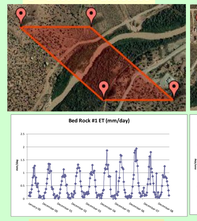


5 = 38.03281 – 108.88636

10= 38.04390 - 108.89185

Bed Rock, CO

1 = 38.30705 – 108.89308



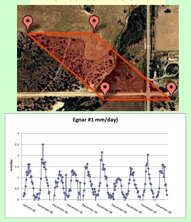
2 = 38.30934 – 108.88721

9 = 38.32590 – 108.85992

10 = 38.33062 – 108.85494

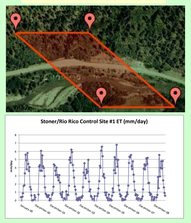
Egnar, CO

1 = 37.85290 – 108.94249



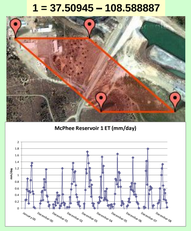
Stoner/Rio Rico, CO

1 = 37.578780 – 108.211475



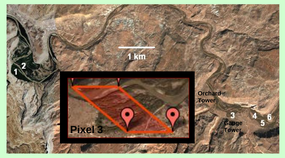
McPhee Reservoir, CO

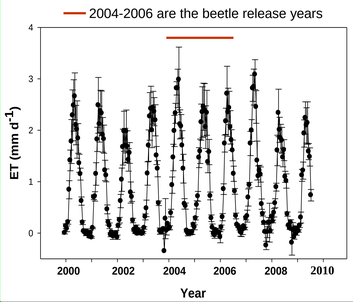
1 = 37.50945 – 108.588887



We used MODIS imagery to attempt to quantify potential water savings through defoliaiton of Tamarisk. We obtained before-beetle-release and after-beetle release imagery for sixteen sites where ground surveys have confirmed that beetles have established and are actively defoliating Tamarisk. The sites represent seven river reaches on the Upper Colorado, Walker, Upper Dolores, Lower Dolores, Wyoming, and Humbolt rivers.

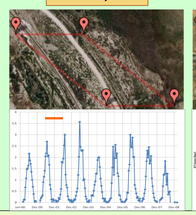
Entrada Study Area





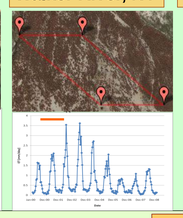
CDA Study Areas

Lovell, WY



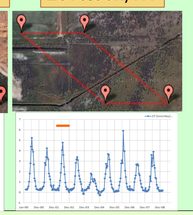
Dewey Bridge, UT

Walker River, NV



Williams Bottom, UT

Lovelock, NV



RESULTS

ET in mm d-1 was calculated for each site from MODIS Enhanced Vegetation Index (EVI) values and potential ET for each site using methods described in Nagler et al. (2009). The figures above show 16-day composite ET values for each site from 2000 to 2009, with an indication of when beetles were released and noted to be active at each site. Baseline ET values differed among sites, with peak summer values ranging from < 1 to 6 mm d^{-1}. Values at some sites were artificially low because the MODIS pixel footprint encompassed adjacent sparse vegetation as well as riparian vegetation. For those pixels that fell completely within the riparian zone, mean ET was 3.7 mm d^{-1} in summer, about 60% of potential ET of 6.6 mm d^{-1} across these sites.

Location	ET Before (mm yr^{-1})	ET After (mm yr^{-1})	F	P
Lower Dolores R. UT	359 (28)	347 (42)	0.051	0.822
Upper Dolores R. UT	181 (14)	206 (26)	0.909	0.341
Walker R. NV	306 (38)	254 (24)	1.428	0.233
Upper Colorado R. At Dewey Bridge UT	849 (70)	560 (49)	10.7	0.001**
Wyoming R. At Lovell WY	290 (42)	224 (29)	0.006	0.937
Humbolt R. At Lovelock NV	537 (69)	412 (38)	2.911	0.089
Upper Colorado R. At Williams Bottom UT	371 (27)	272 (34)	3.81	0.052
All Sites	400 (17)	340 (14)	7.402	0.007**

Annual evapotranspiration (ET) before and after beetle release for riparian sites on western U.S. rivers. ** Denotes significant difference between before and after means at P < 0.01. Numbers in parentheses after means are standard errors. Mean values across sites within a reach were used so that each reach had equal weight in the statistical analysis. Release years were counted in the Before (pre-release) group because there was a lag of 1-2 years following release before defoliation was noted in ground surveys.

Annual ET rates before beetle release ranged from 290 to 840 mm yr^{-1}, and from 224 to 560 mm yr^{-1} post-release. When analyzed separately, only the Dewey Bridge site showed a significant reduction in ET following beetle release. When all sites were combined, ET decreased significantly, from 400 mm yr^{-1} to 340 mm yr^{-1} ($P < 0.01$), a 15% reduction following beetle release. This results in a net reduction of 60 mm yr^{-1} of water use. However, this is an underestimate because some pixels were not totally within the riparian zone and contained sparse adjacent vegetation. Based on analyses of land cover classes within individual pixels, riparian vegetation represented 60% of pixel contents across sites. Hence, the potential ET reduction in the riparian zone was about 100 mm yr^{-1}. As noted, results varied among sites, with no significant reduction observed at most sites.

Conclusions

Based on these results, the potential water savings from Tamarisk defoliation appear to be limited. Several factors contribute to the minimal reduction in ET noted at these sites: (i) Defoliation is temporary, affecting shrubs for 6-8 weeks over their 30 week growing season. (ii) Defoliation is patchy within an affected river reach. Dennison et al. (2009) reported that about 25% of riparian areas showed defoliation on the Lower Dolores River. Tamarisk only accounted for 40% of land cover in those Tamarisk-dominated riparian zones, due to the presence of bare soil and other vegetation types, and beetles did not attack all Tamarisk plants within a reach. (iii) Base levels of riparian ET are relatively low, no greater than 60% of potential ET, which limits the maximum possible ET reduction even if defoliation was to be complete.

However, this situation could change in the future. Beetles are still increasing their range, and it is possible that as niches become full, they will more effectively defoliate Tamarisk stands at a given location. Tamarisk stands might also be weakened and eventually killed through repeated years of defoliation. At present, Tamarisk is thought to dominate some 400,000 to 640,000 ha of western U.S. riparian habitat. Based on a projected water savings of 100 mm yr^{-1}, beetles might eventually result in an ET reduction of 4 – 6.4 x 10^8 m^3 yr^{-1} (340,000 – 544,000 acre-ft) of water if it spreads to all possible locations and its pattern of defoliation remains the same. Actual water savings would be less because the beetle might not be adapted to the climatic extremes in the southwestern U.S., and because the calculation assumes no replacement vegetation with defoliated reaches. Now that it is part of the riparian ecosystem, careful monitoring will be needed to detect effects of the beetle on riparian hydrology and ecology.

References

Nagler, P.L., Morino, K., Murray, R.S., Osterberg, J. and Glenn, Edward P. 2009. An Empirical Algorithm for Estimating Agricultural and Riparian Evapotranspiration Using MODIS Enhanced Vegetation Index and Ground Measurements of ET. I. Description of Method. *Remote Sensing*: Special Issue: Global Croplands. In press.

Murray, R.S., Nagler. P.L. and Glenn. E.P. 2009. An Empirical Algorithm for Estimating Agricultural and Riparian Evapotranspiration Using MODIS Enhanced Vegetation Index and Ground Measurements of ET. II. Application to the Lower Colorado River, U.S. *Remote Sensing*: Special Issue: Global Croplands 1125-1138.

Dennison, P. E., Nagler, P.L., Hultine, K.R., Glenn, E.P. and Ehleringer, J. 2009. Remote Monitoring of Tamarisk Defoliation and Evapotranspiration Following Saltcedar Leaf Beetle Attack. Special Issue of *Remote Sensing of Environment* (RSE) focused on Monitoring Parks and Protected Areas 113: 1462-1472.