What are the potential impacts of *Diorhabda* on *Tamarix* in the lower Colorado River Basin?

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Virgin River Valley 2010 – Before Biocontrol (June 1) and After (June 20)
Gateway site where there is no mortality
Beetles will defoliate *Tamarix* and the timing and frequency will be variable.
Patterns of mortality are highly variable across the landscape.

1000 tamarisk trees monitored (n = 100 / site)
No relationship between herbivory events and dieback

Hultine et al. 2015a
Patterns of mortality are highly variable across the landscape

1000 tamarisk trees monitored (n = 100 / site)

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Hultine et al. 2015
*Tamarix* response will include a depletion of carbohydrate reserves, decreased canopy cover and decreased flowering.
The plant carbon budget is a balance between sources and sinks.

- **Carbon source:** photosynthesis
- **Carbon sinks:** growth, reproduction
- **Carbon sinks:** metabolite storage, defense
Growth rate may be genotypic trait related to introgression.

Many genotypes at a site

Hultine hypothesizes that faster growing trees are killed more quickly by repeated defoliation.

Growth vs carbon storage
Tamarix root carbohydrate reserves decline in response to herbivory

Hudgeons et al 2007
Growth versus carbon storage

• Traditional hypothesis: “spillover” of available photosynthates (Chapin et al., 1990)

• Contemporary hypothesis: Allocation of photosynthates is highly regulated (Sala et al., 2012)
The high cost of salinity tolerance

- Tolerate low water potential: high construction cost
- Regulate osmotic gradients: high metabolic cost

Han et al., 2013
Adaptation to salinity can be highly expressed

- Salinity treatments conducted in greenhouse on plants from high and low salinity locations
- Plants from high salinity locations do poorly in low salinity treatments
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The hidden benefit of frost tolerance: drought tolerance

High elevation plants are subjected to regular freezing temperatures.
The hidden benefit of frost tolerance: drought tolerance

- High elevation plants maintain higher water use rates
- Higher water use: possibly a higher root area to leaf area ratio
Conclusions

- Plants adapted to salinity may be maladapted to herbivory.

- Plants adapted to freezing may be better adapted to other stresses (drought and herbivory).
Mortality percentages, including branch die-back, will be variable and will depend upon soil conditions, moisture and plant genetics. The picture is incomplete and we are still trying to define the factors that lead to mortality.

T. ramosissima  

T. parviflora

from Dudley et al 2012
Lovelock, NV

Re-growth in few weeks
Dieback gradual &
Mortality slow

Survival

First Defoliation

June 11  June 22  June 26  July 9

2003 Humboldt R, NV

0 10 20 30 40 50 60 70 80 90 100

2001 2002 2003 2004 2005 2006 2007 2008 2009
Stan Young ranch along East Salt Creek in Mesa County before and after beetles released.

Decline in green biomass and vigor

Dead biomass is brownish gray and even though most trees are still alive the canopy has opened up.
Lovelock, NV monitoring site, from Tom Dudley
Bedrock 2007 (prior to beetles)  Bedrock 2010
Mortality transects
Change in Green Tamarisk Volume at Monitored Sites in Western Colorado, 2008 and 2013
Tamarisk Mortality in Western Colorado
2010-2013
Decline in flowering/seed production

A marked tree representing the 40-60% flowering class
Inability to recover well from fire

Burned tamarisk attempting to resprout in the presence of beetles (Knowles Creek monitoring site on the Colorado River)
Knowles Canyon, CO
Burned in May of 2007, photo taken in August, 2010

burned tamarisk, now defoliated by beetles
Twenty Monitored Sites Across Colorado
Bedrock 2014-2016 = Low

Beetles

2014

2016

2017

Early June
Widespread Defoliation by Aug. 2017

Bedrock
More Damage in 2018
Tamarisk Dieback Across Sites 2008-2018

Mean Dieback Across Tamarisk Sites With Multiple Defoliations

Mean Dieback Across Six Sites

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Monitoring Results Gateway and Bedrock

Green canopy measured in 2008
Green canopy measured in 2018

Mean Tamarisk Dieback

Gateway Bedrock
As of 2018 mean canopy volume has decreased by an average of 46% at damaged sites (at least three defoliations) from measurements recorded in 2008.

Whereas we see a 50% increase at the Rattlesnake Gulch from measurements taken in 2008.
Site Level Vegetation Composition

Invaders to keep an eye on:

**Russian knapweed**
**Russian thistle**
**Cheatgrass**
**Kochia**
Flower Decline

Percent Blooms on Marked Tamarisk, Gateway Site, 2007-2018

Percent Blooms on Marked Tamarisk, Bedrock Site, 2007-2018
• Cycles of defoliation / refoliation
• Decline in green biomass and vigor
• Decline in flowering/seed production
• Mortality variable
• Inability to recover well from fire

Bedrock site on the Dolores River where beetles first defoliated in 2008
Defoliation of saltcedar by *Diorhabda elongata*
Big Spring, TX, 2005-08
Defoliation by tamarisk leaf beetle and tamarisk mortality impacts riparian soils by altering:

Litter layer
Light availability
   Linked to changes in soil temperature and moisture
Increased nutrient loading (nitrogen, phosphates, potassium)
   Nitrogen, often times at an order of magnitude greater than normal, is released to the ground in the presence of tamarisk beetle – (beetle defoliation causes pre-senescence leaf drop which provides an increase of nitrogen in the system, appearing to give advantage to exotics, according to early research results)

   50% of nitrogen and phosphate are typically returned to the plant through a process called “resorption” in the fall– though it appears the beetle impacts lead to defoliation before resorption can occur.

Salinity
   Observed short term increases in soil salinity as a result of defoliation, however, the increase in salinity is minimal compared to increased nutrient loading

Microbial communities