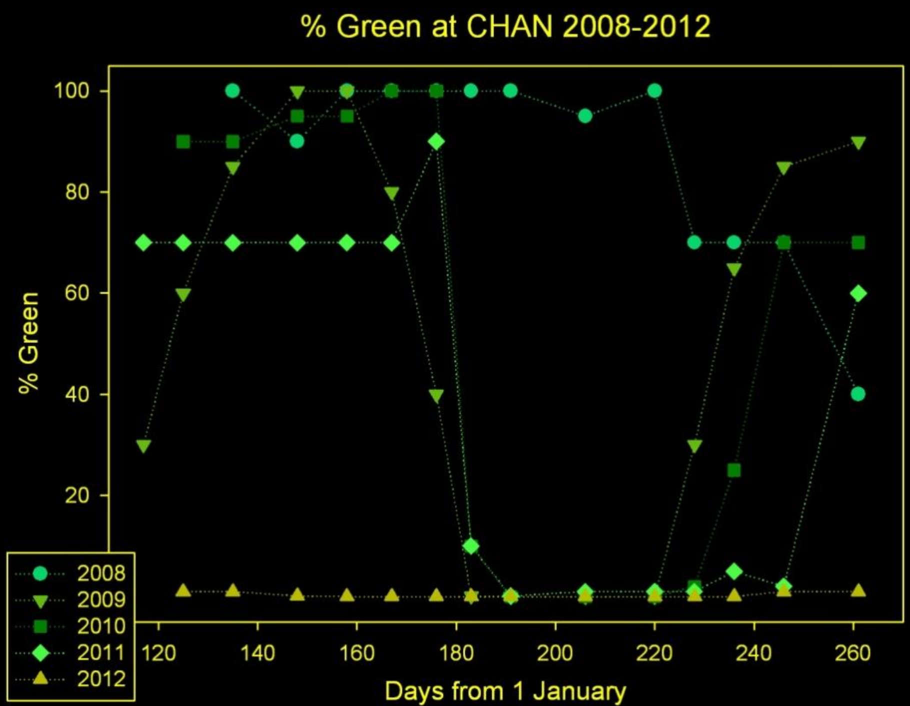
What are the potential impacts of *Diorhabda* on *Tamarix* in the lower Colorado River Basin?

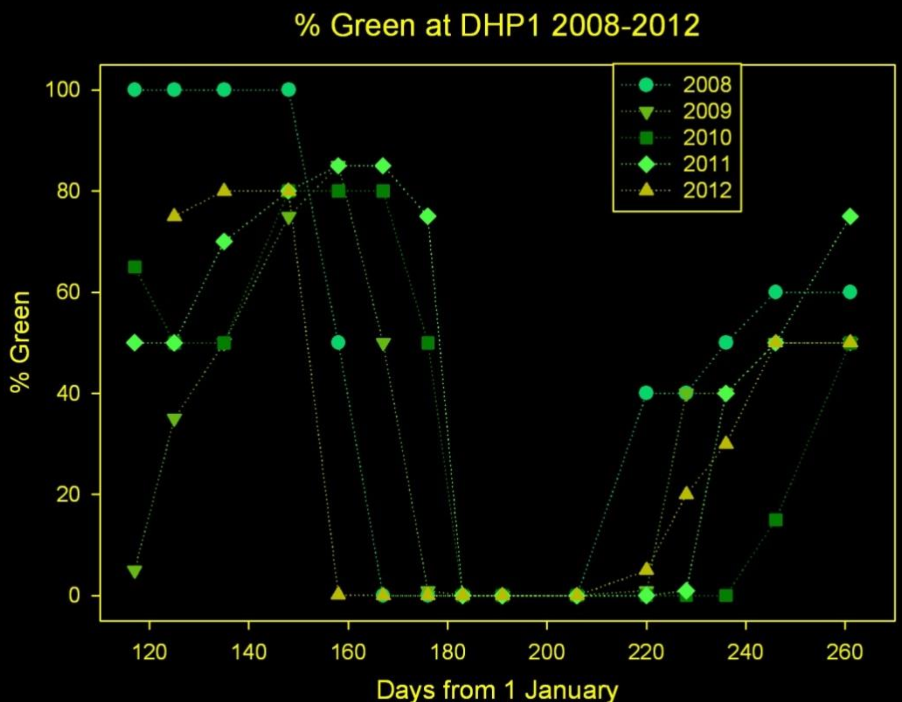
Dan Bean
Colorado Department of Agriculture, Palisade Insectary
Kevin Hultine
Desert Botanical Gardens, Phoenix, AZ
Tim Graham
Grand County, Utah
Anna Sher
Denver University
Gail Drus
St. Francis University

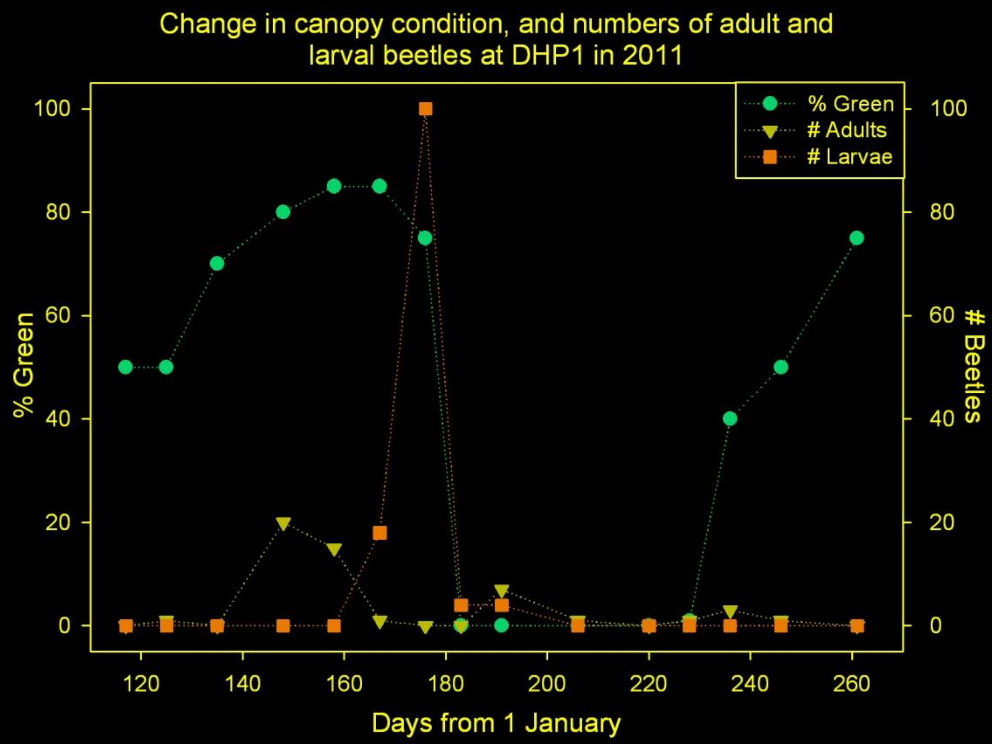
Virgin River Valley 2010 – Before Biocontrol (June 1) and After (June 20)

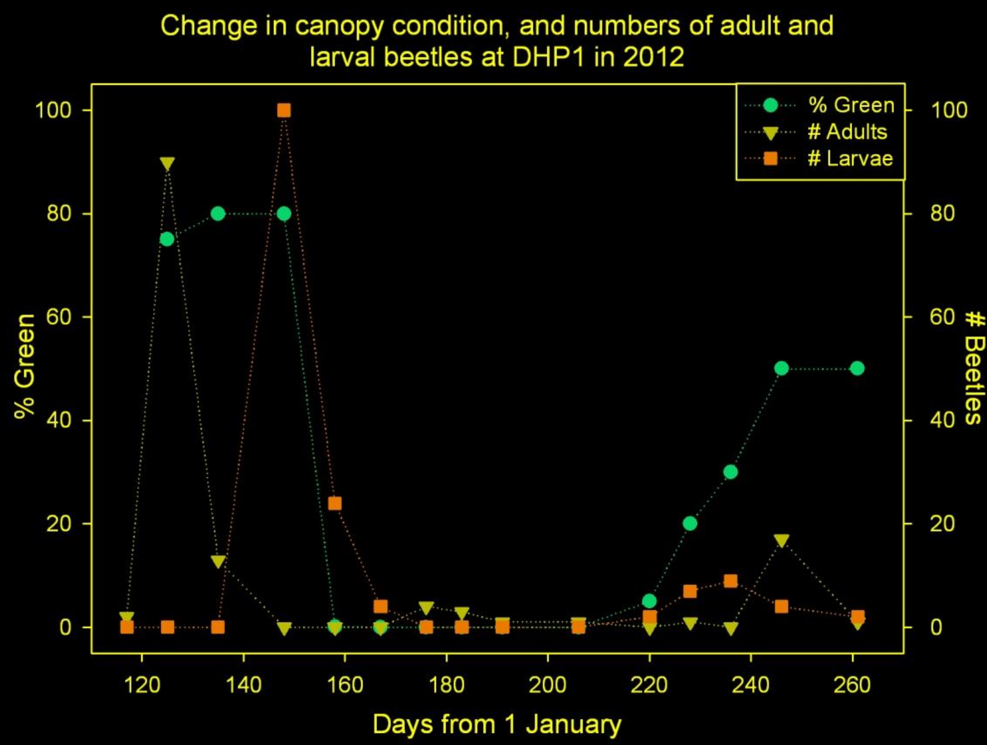

Gateway site where there is no mortality

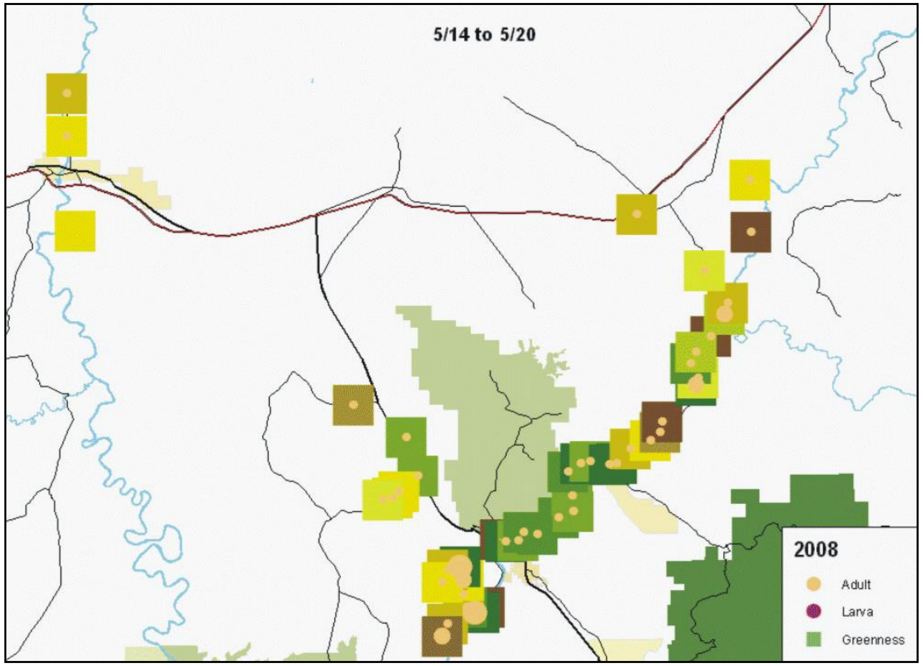
Beetles will defoliate *Tamarix* and the timing and frequency will be variable.

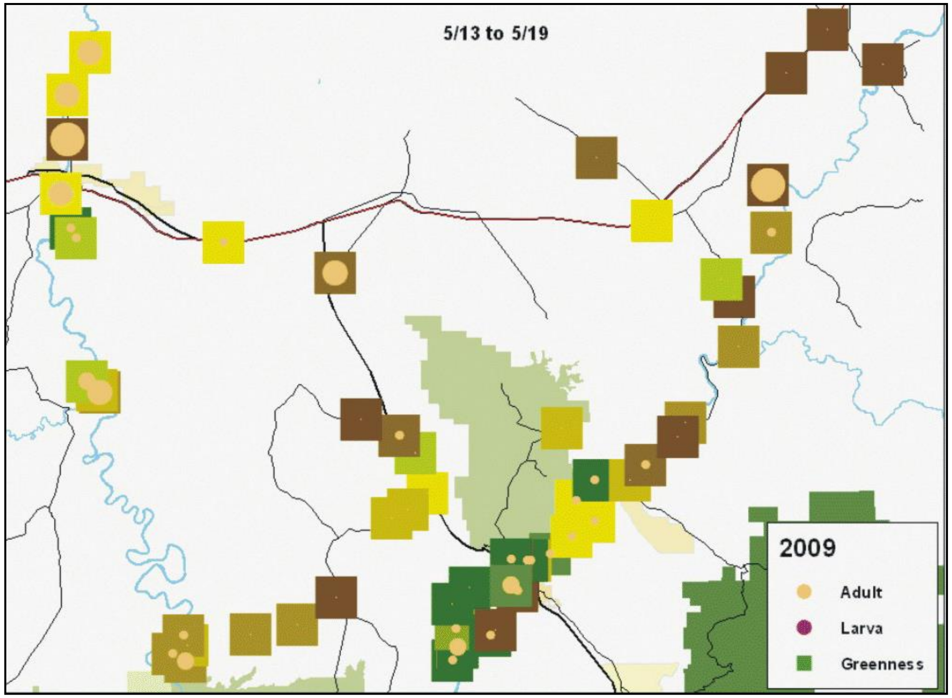

% Green at CHAN 2008-2012
% Green
Days from 1 January
2008
2009
2010
2011
2012

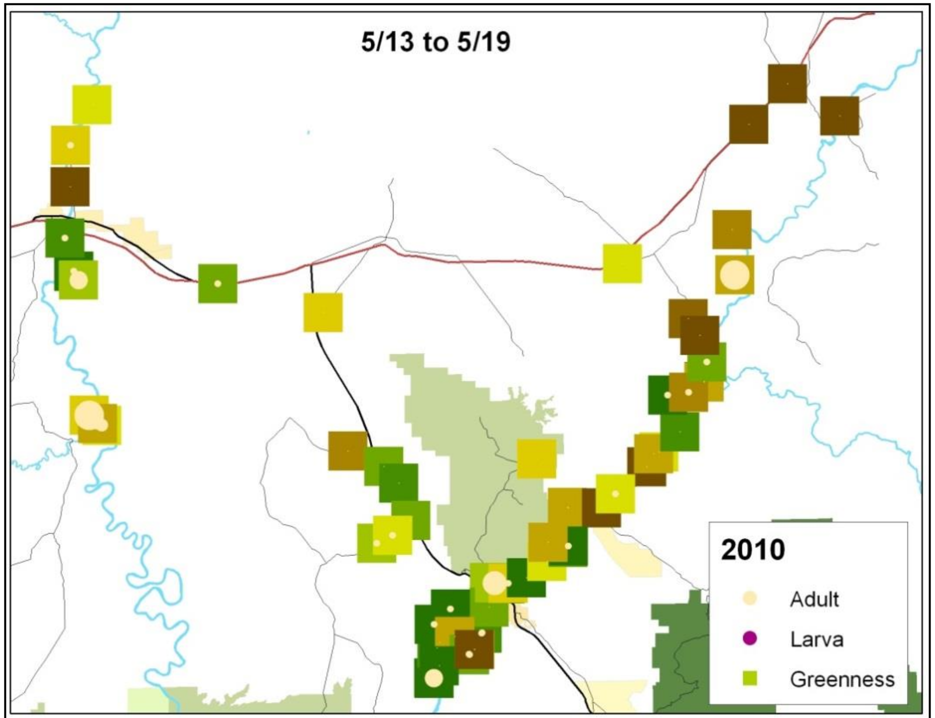

% Green at DHP1 2008-2012
% Green
Days from 1 January
2008
2009
2010
2011
2012


Change in canopy condition, and numbers of adult and larval beetles at DHP1 in 2011
% Green
# Adults
# Larvae
% Green
# Beetles
Days from 1 January
0
20
40
60
80
100
120
140
160
180
200
220
240
260


Change in canopy condition, and numbers of adult and larval beetles at DHP1 in 2012
% Green
# Adults
# Larvae
% Green
# Beetles
Days from 1 January
0
20
40
60
80
100
120
140
160
180
200
220
240
260

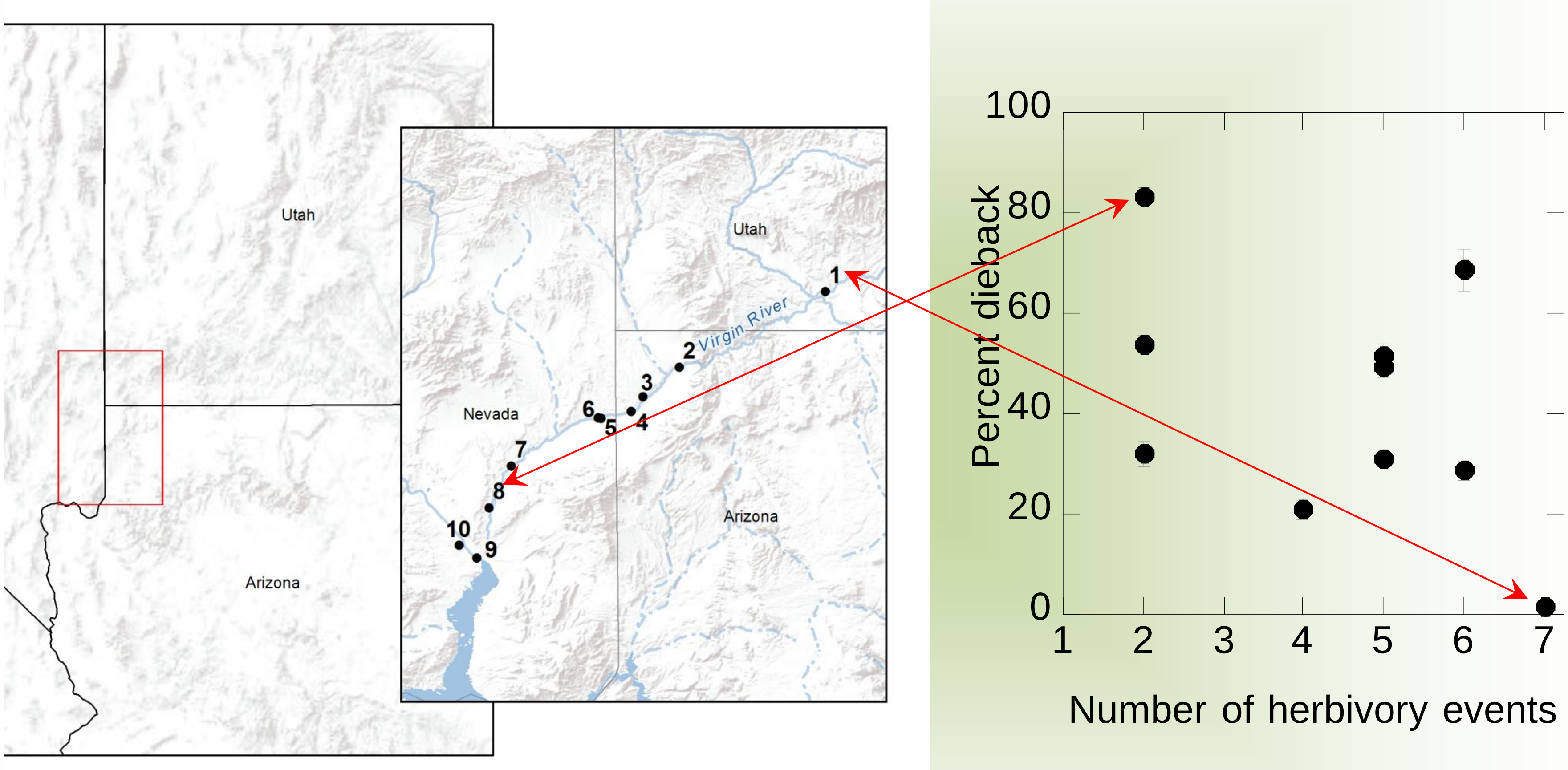






2012Vids.avi

Patterns of mortality are highly variable across the landscape

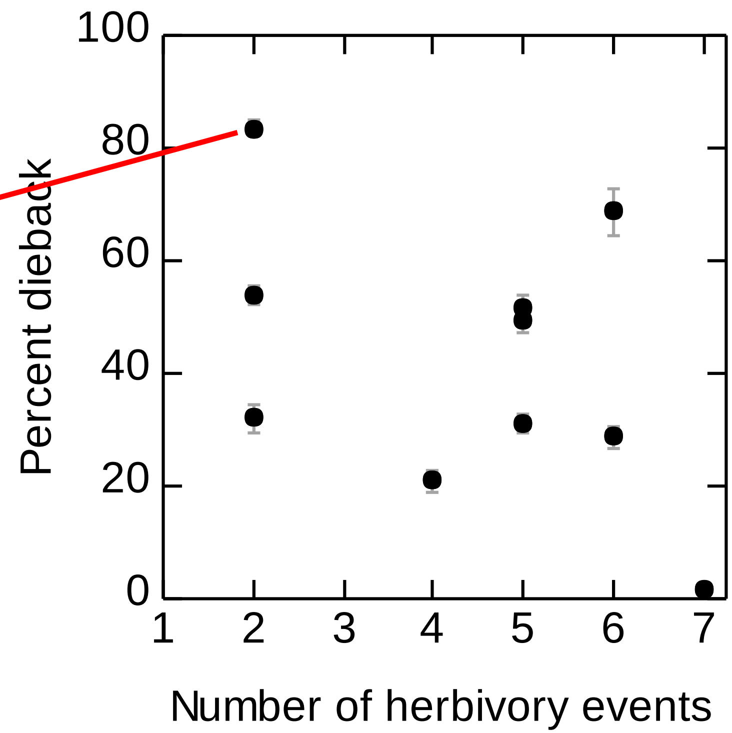


1000 tamarisk trees monitored (n = 100 / site)

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)

No relationship between herbivory events and dieback

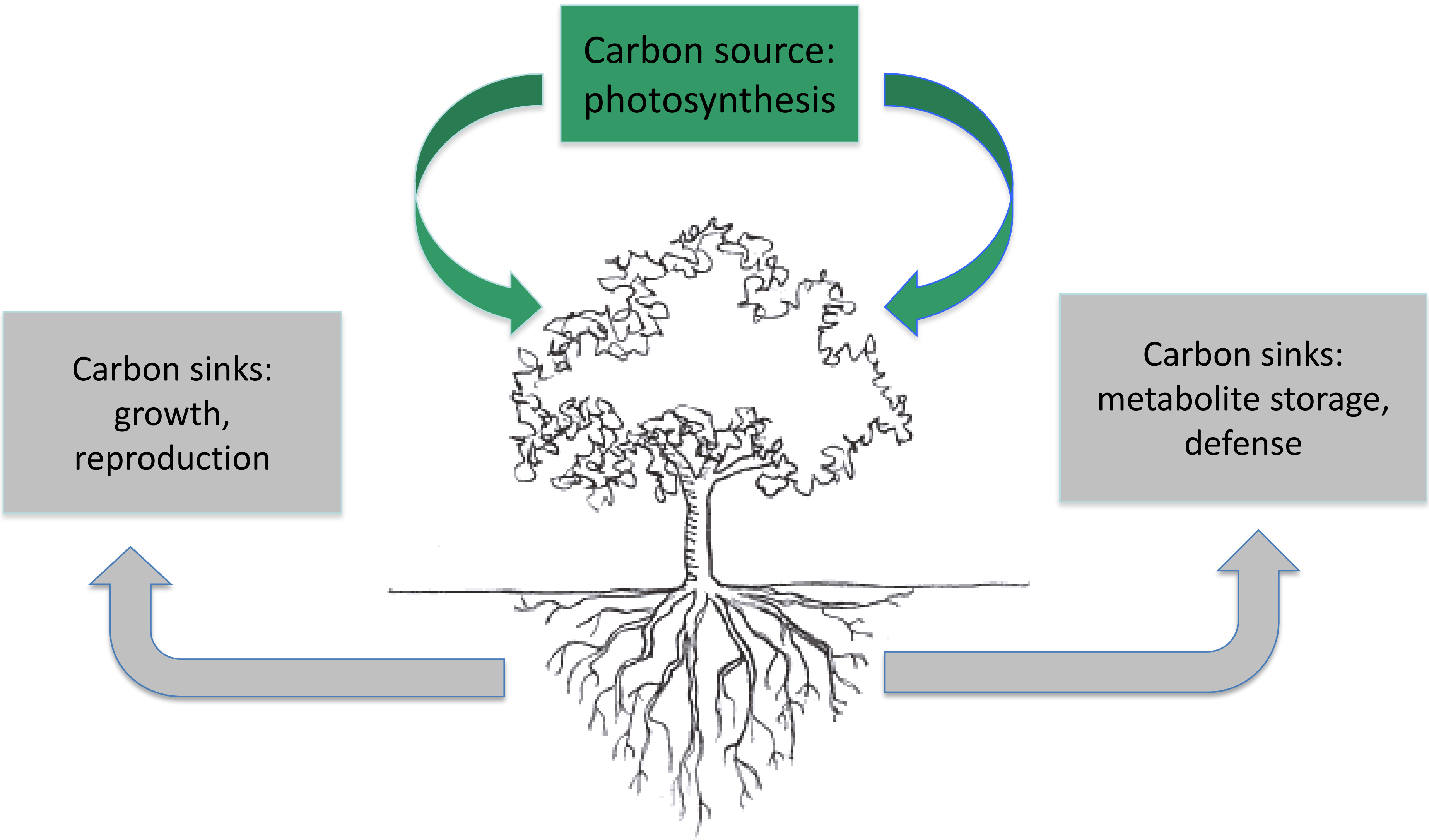
Hultine et al. 2015

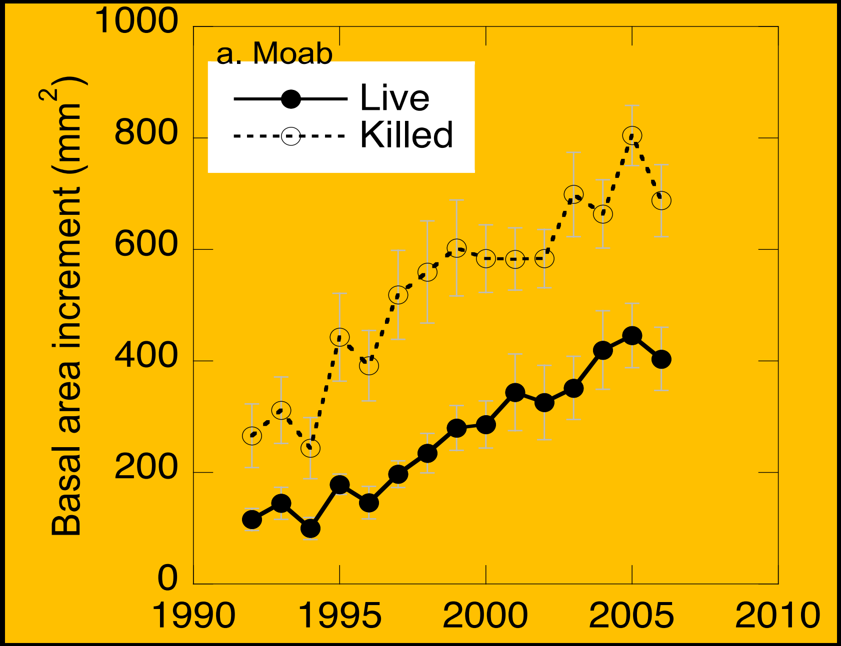
Tamarix response will include a depletion of carbohydrate reserves, decreased canopy cover and decreased flowering

Owl Draw, Utah

Dolores River, Utah

The plant carbon budget is a balance between sources and sinks





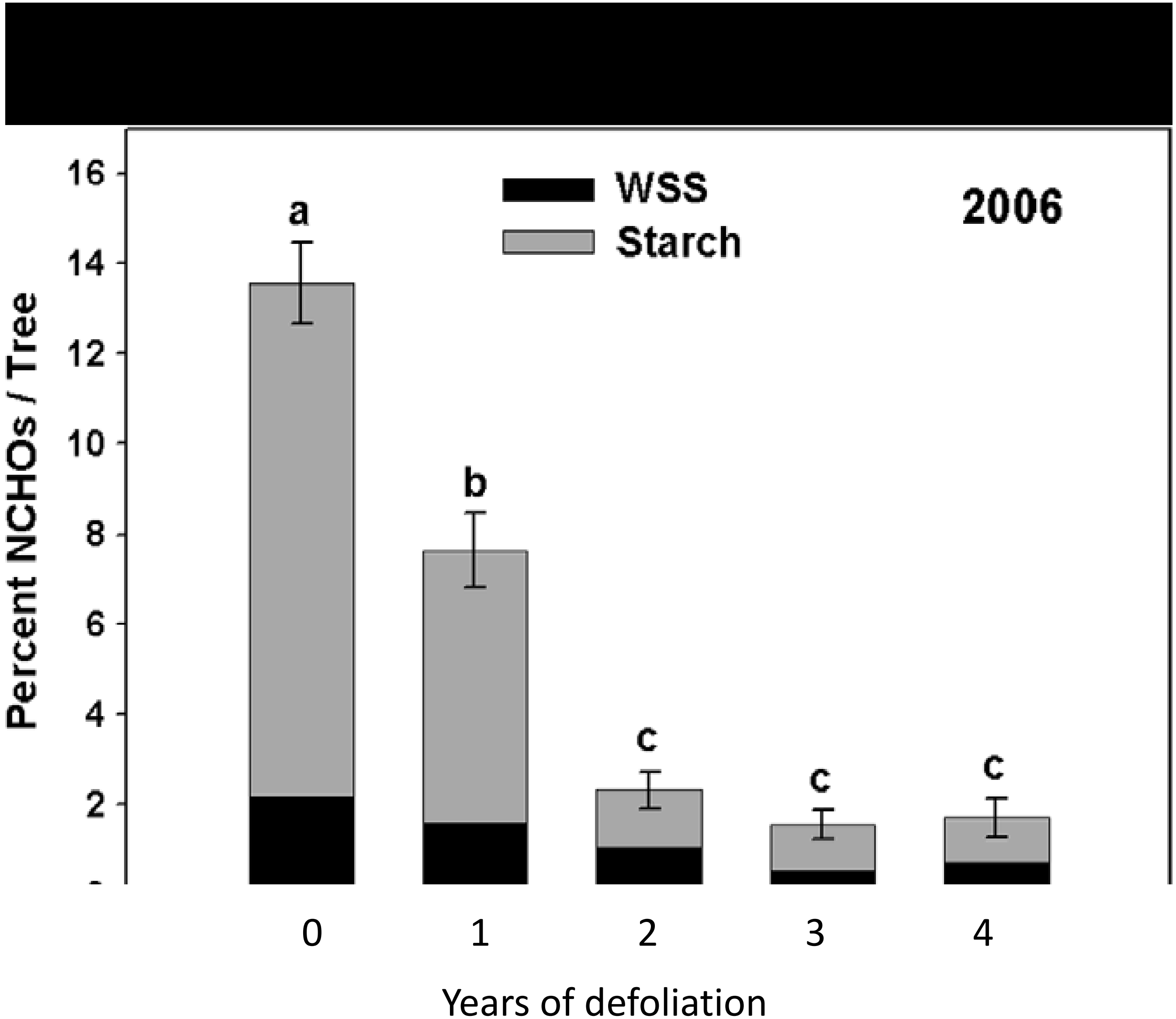
Growth rate may be genotypic trait related to introgression

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

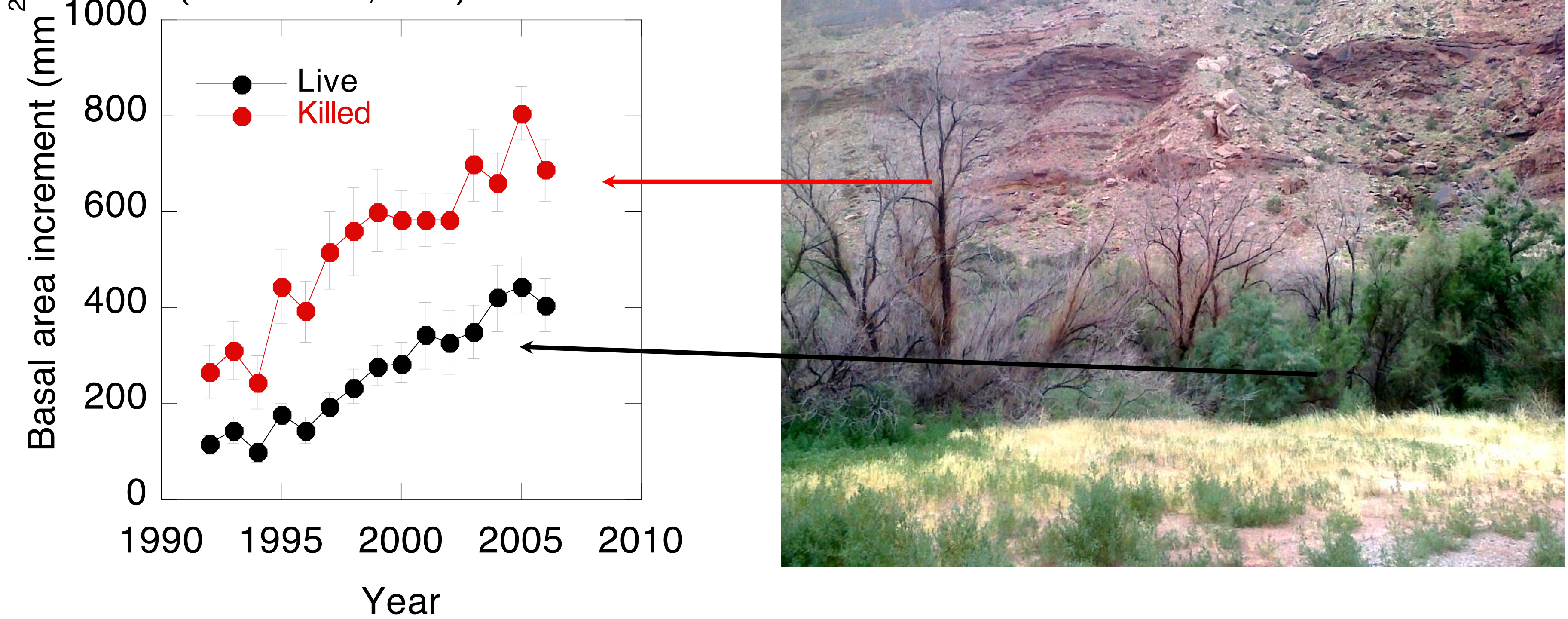


Hudgeons et al 2007

Growth versus carbon storage

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

BAI 2x higher in killed vs live trees (Hultine et al., 2013)

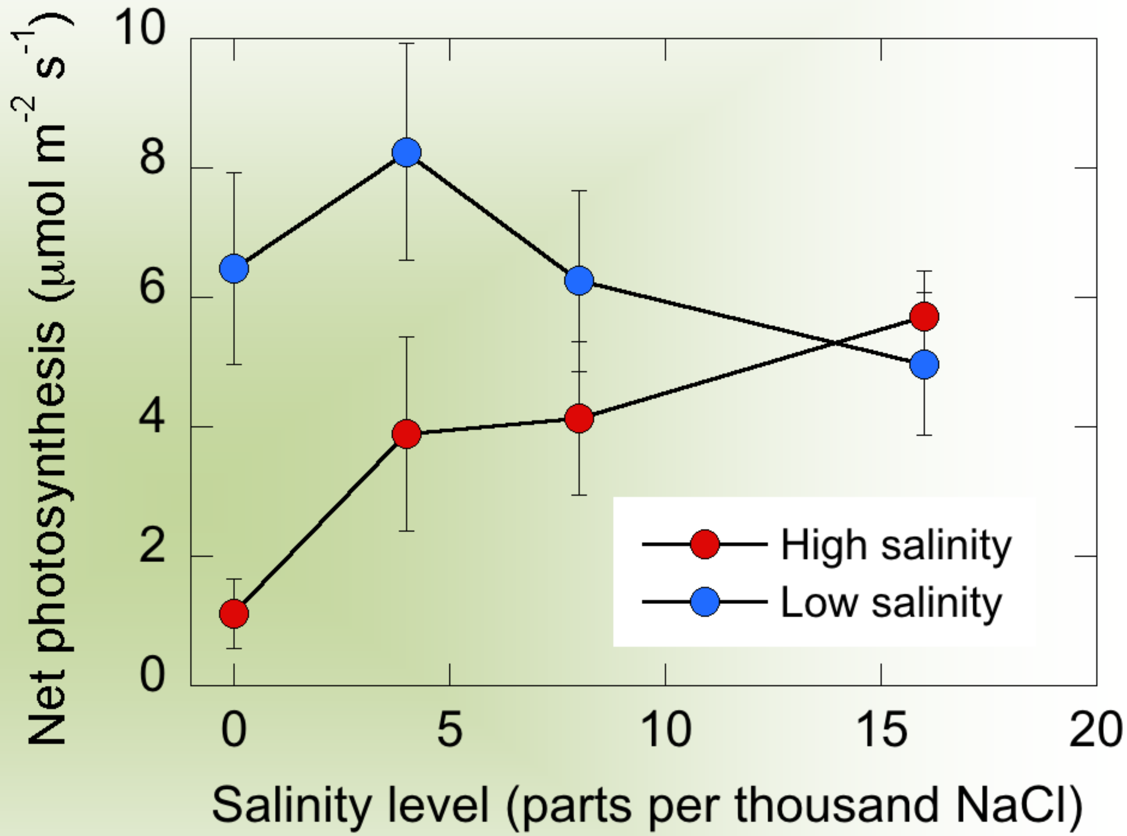


- Contemporary hypothesis: Allocation of photosynthates is highly regulated (Sala et al., 2012)

The high cost of salinity tolerance

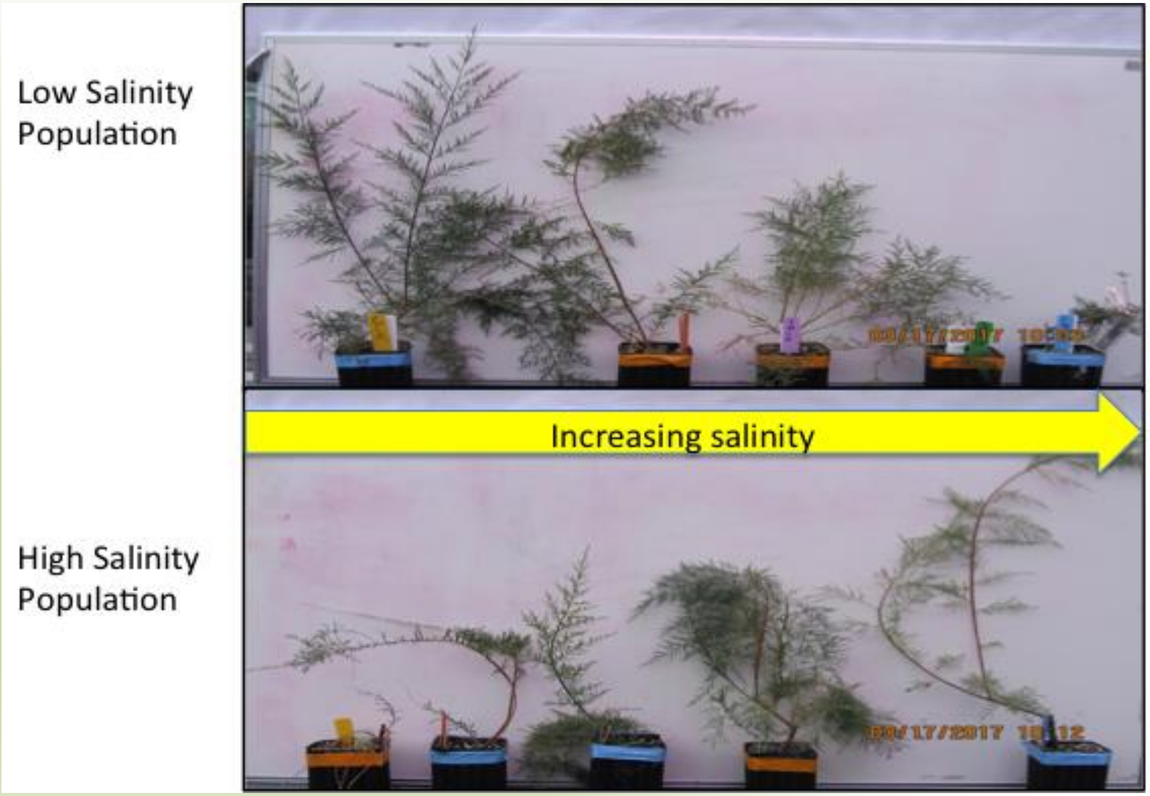
- Tolerate low water potential: high construction cost
- Regulate osmotic gradients: high metabolic cost

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

Adaptation to salinity can be highly expressed



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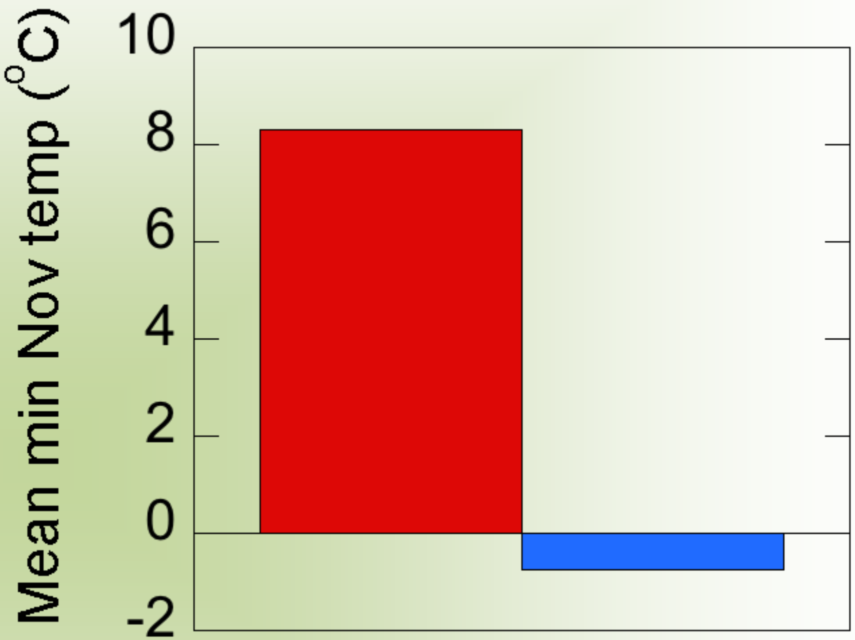
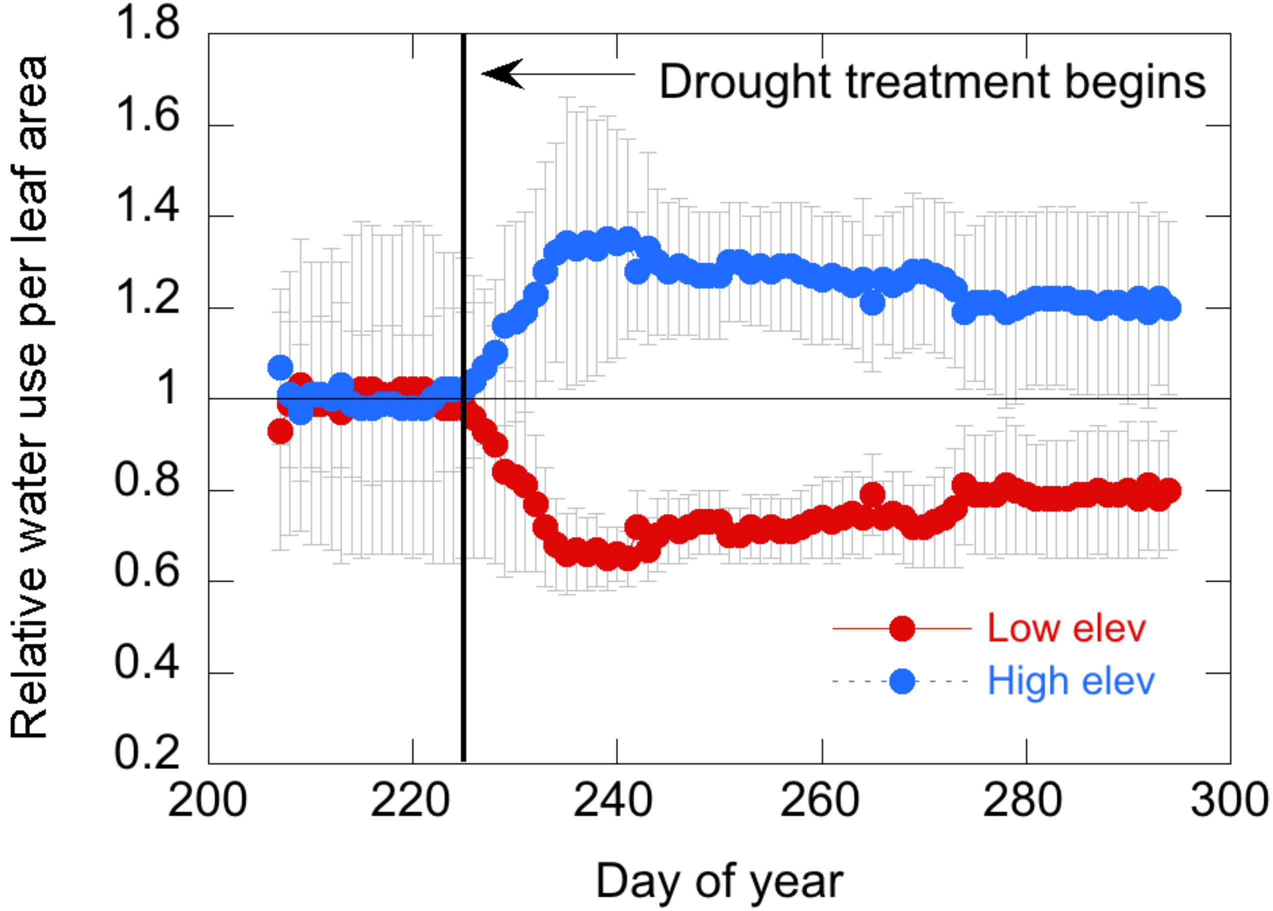
The hidden benefit of frost tolerance: drought tolerance



High elevation plants are subjected to Regular freezing temperatures

The hidden benefit of frost tolerance: drought tolerance

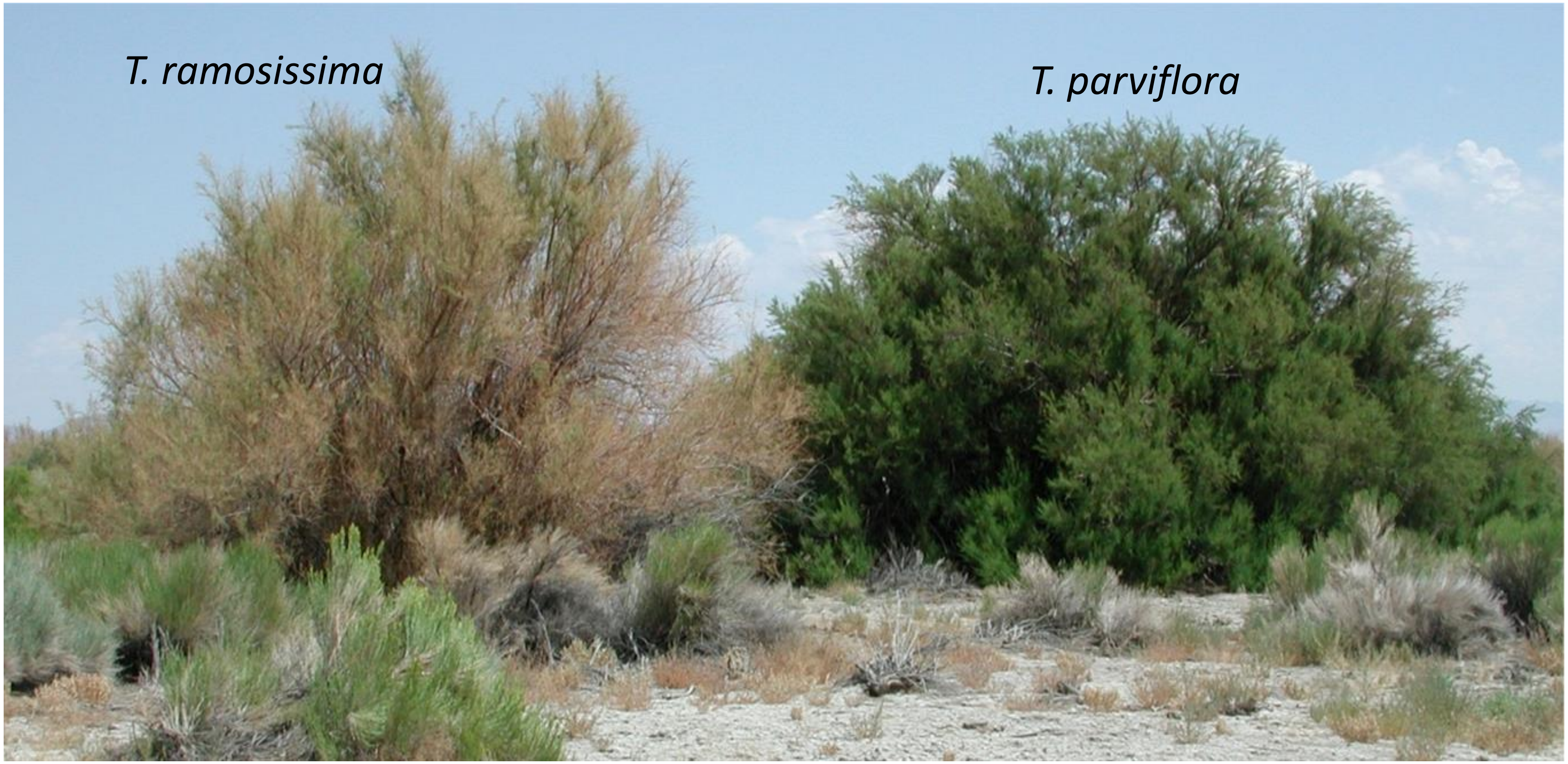


- High elevation plants maintain higher water use rates
- Higher water use: possibly a higher root area to leaf area ratio

Conclusions

- Plants adapted to salinity may be maladapted to herbivory
- Plants adapted to freezing may be better adapted to other stresses (drought and herbivory)

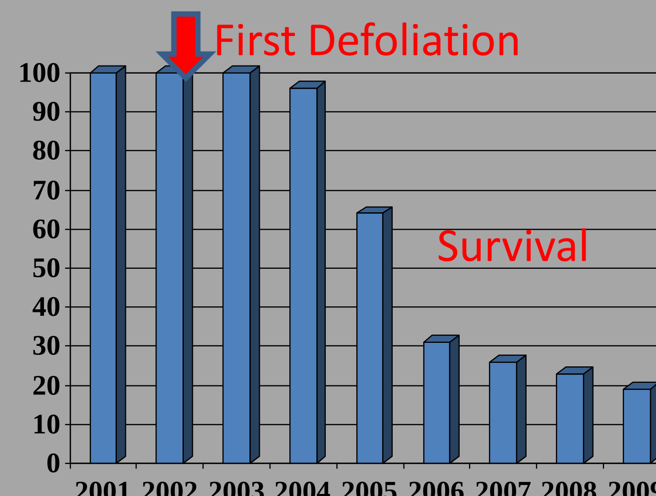
Mortality percentages, including branch die-back, will be variable and will depend upon soil conditions, moisture and plant genetics. The picture is incomplete and we are still trying to define the factors that lead to mortality.



from Dudley et al 2012

Lovelock, NV

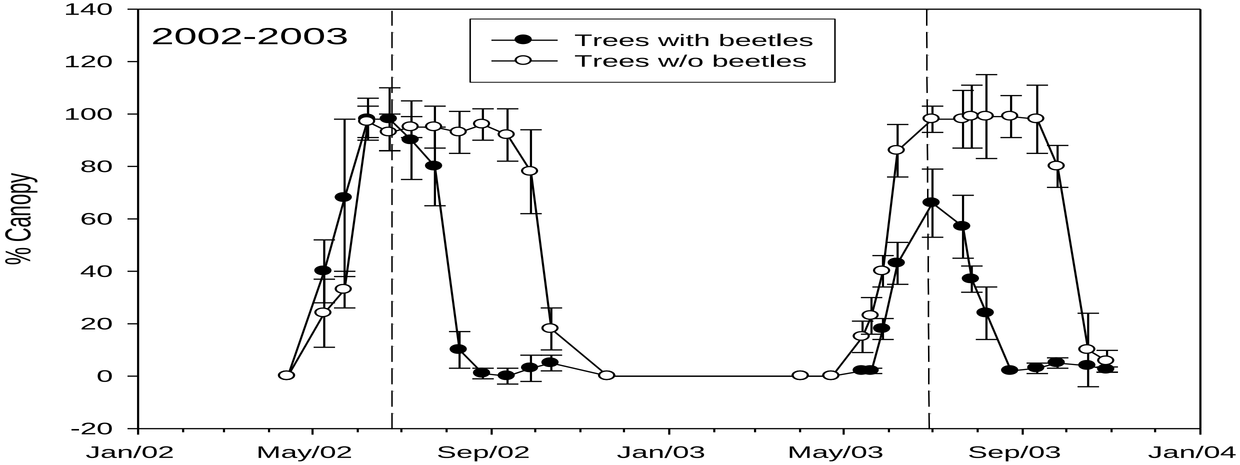
Re-growth in few weeks
Dieback gradual &
Mortality slow



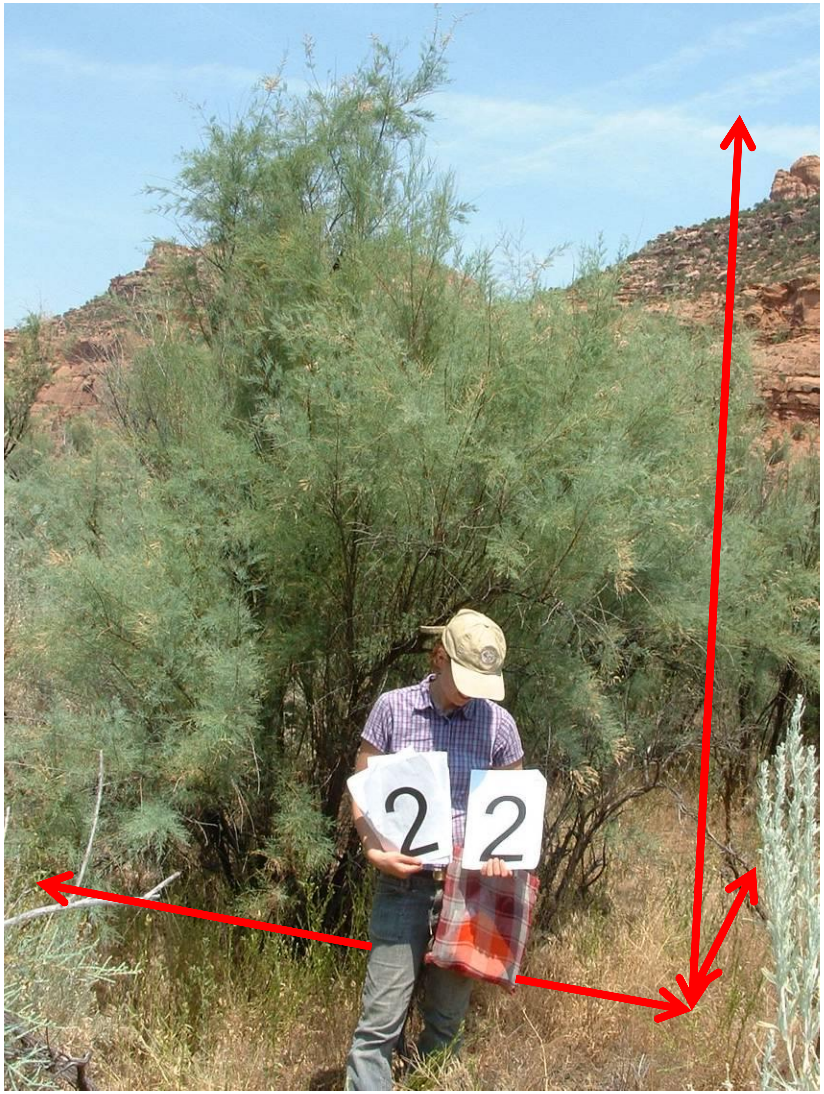
Decline in green biomass and vigor

Dead biomass is brownish gray and even though most trees are still alive the canopy has opened up

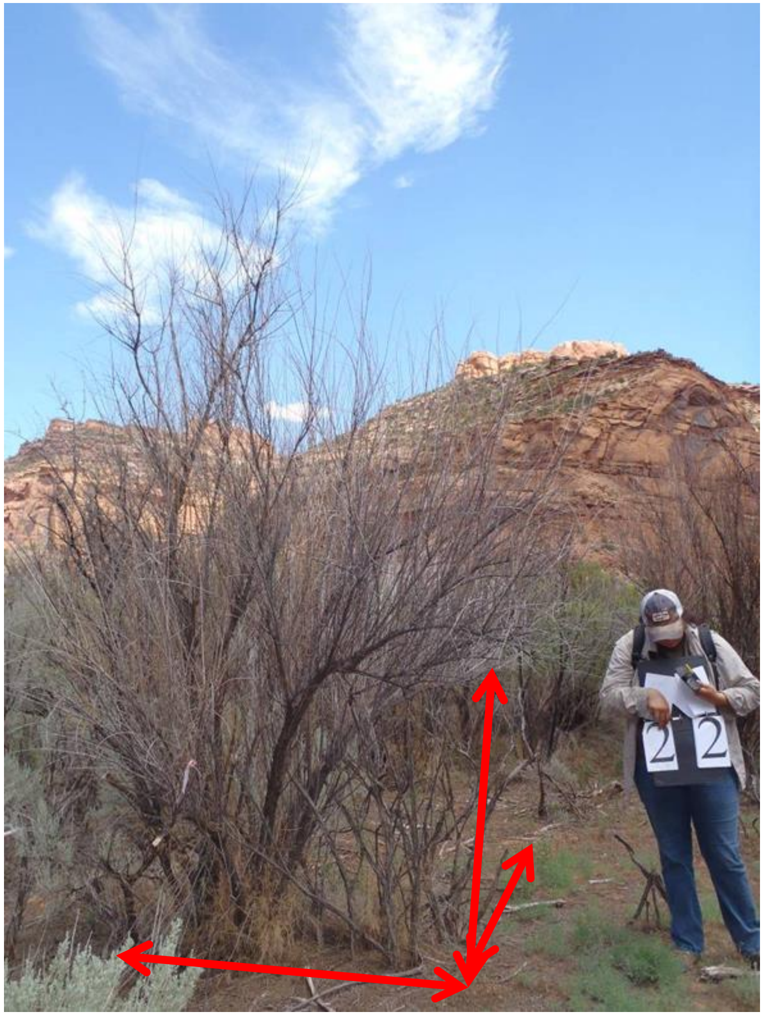
Stan Young ranch along East Salt Creek in Mesa County before and after beetles released.



Lovelock, NV monitoring site, from Tom Dudley

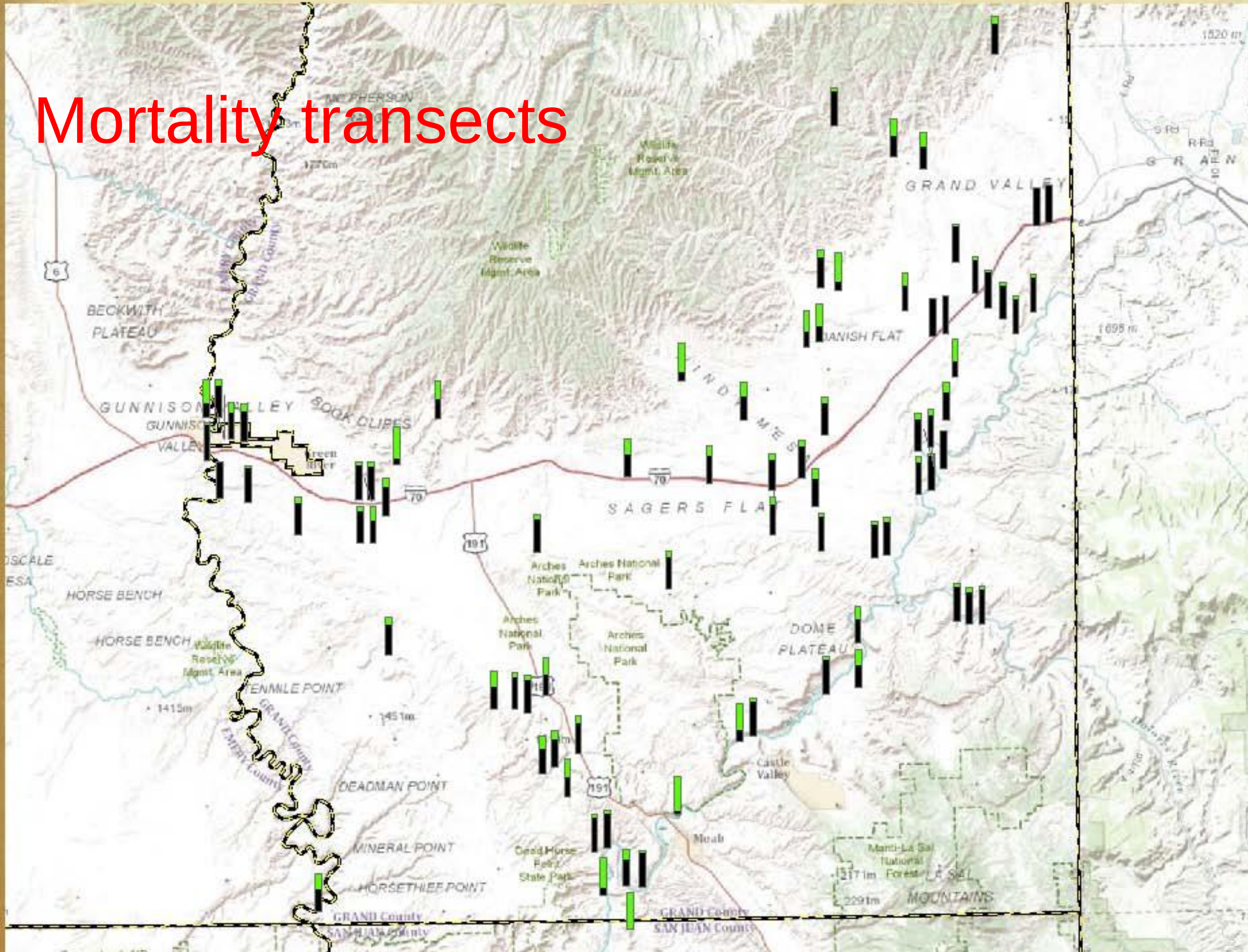


Bedrock 2007
(prior to beetles)



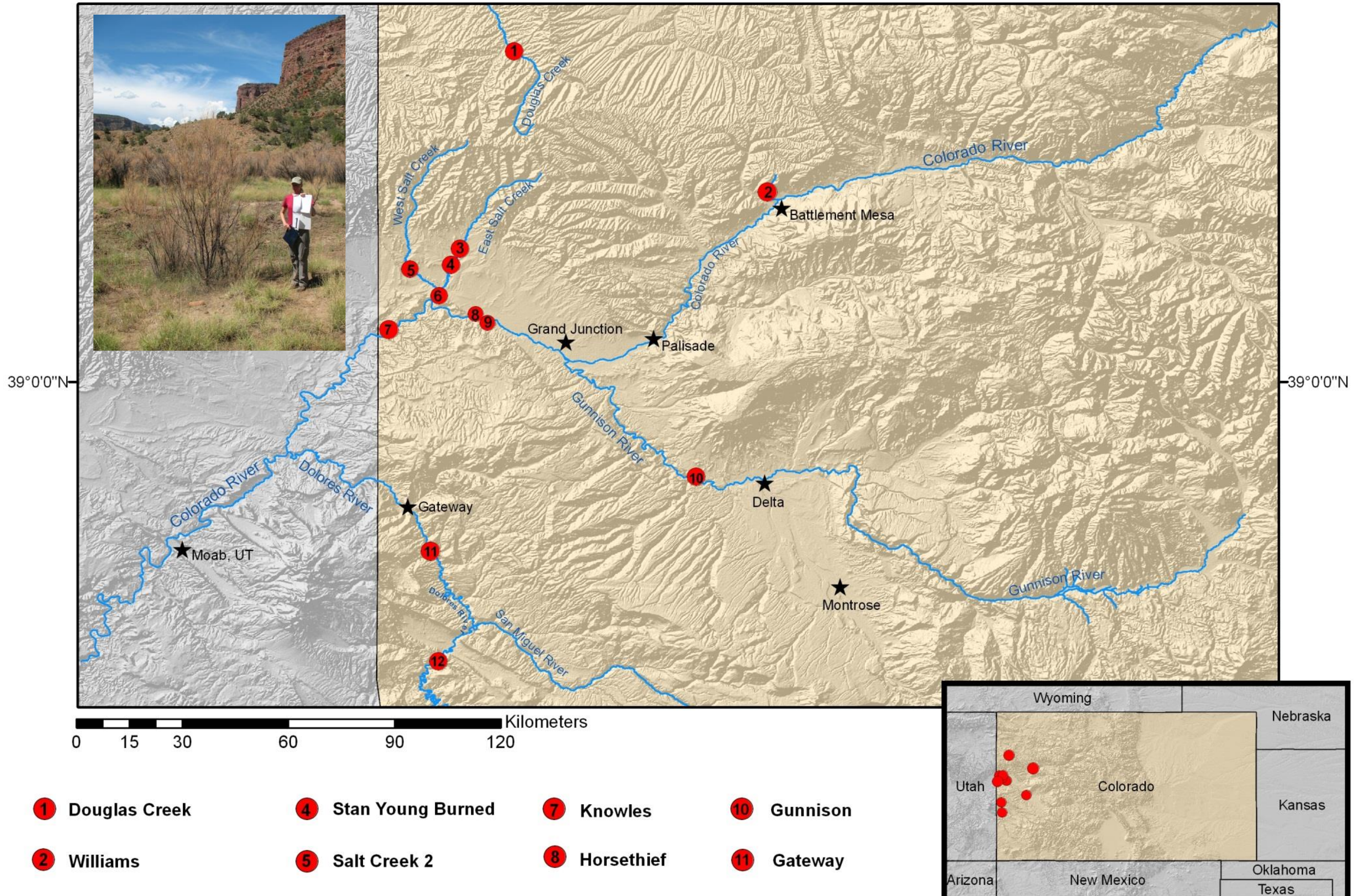
Bedrock 2010

Mortality transects



Adam Thomas, 2013

Tamarisk Monitoring Sites in Western Colorado



1 **Douglas Creek**

2 **Williams**

3 **Stan Young Unburned**

4 **Stan Young Burned**

5 **Salt Creek 2**

6 **Salt Creek 1**

7 **Knowles**

8 **Horsethief**

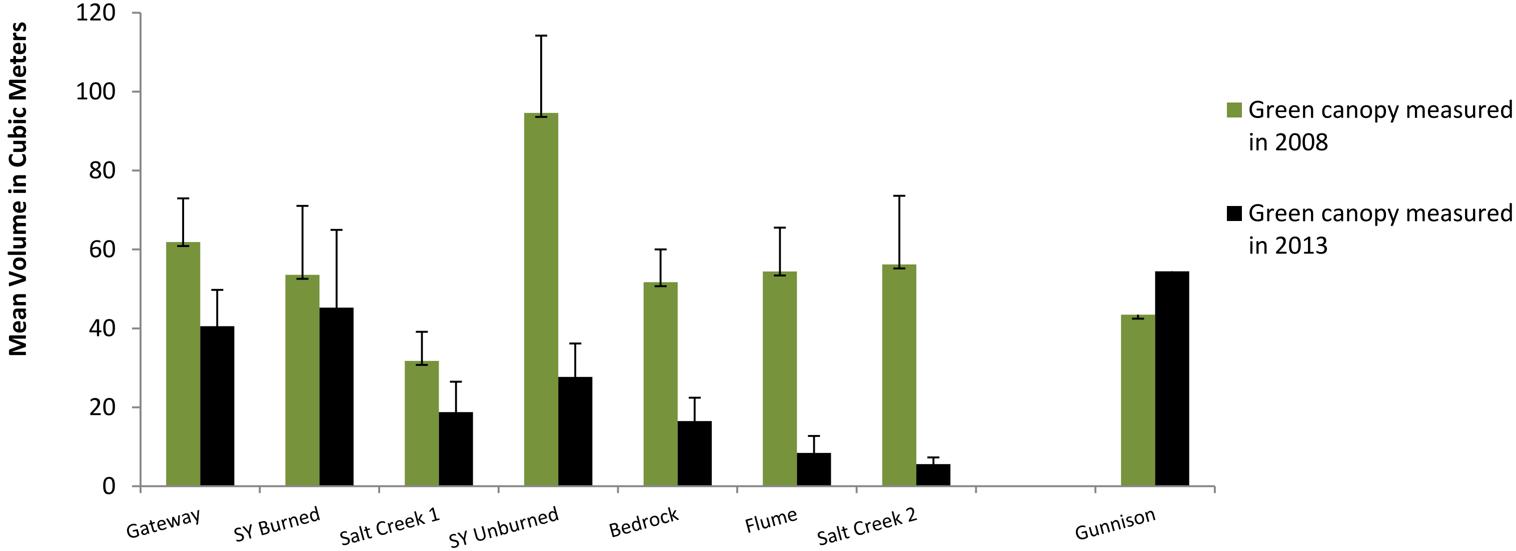
9 **Flume**

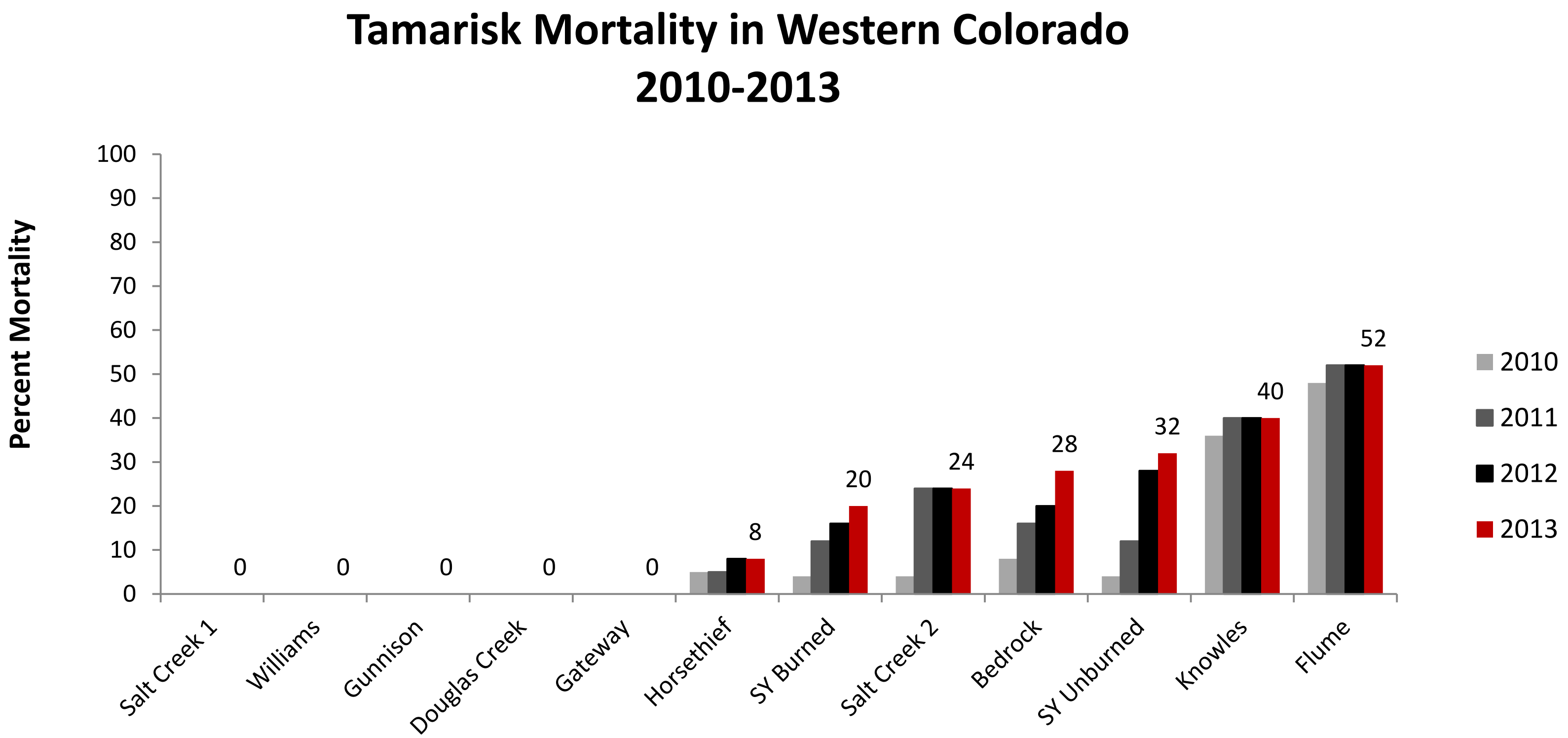
10 **Gunnison**

11 **Gateway**

12 **Bedrock**

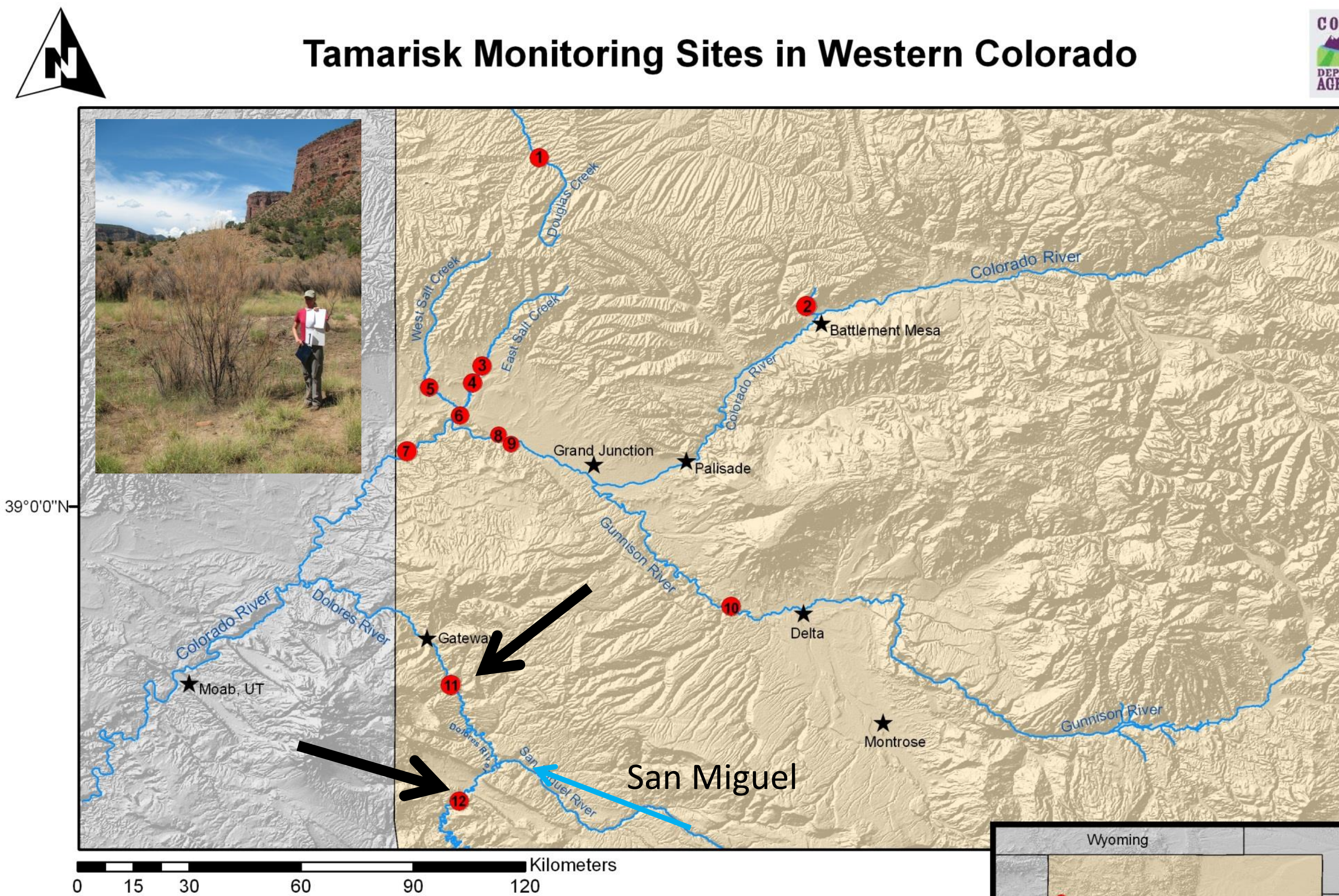
Change in Green Tamarisk Volume at Monitored Sites in Western Colorado, 2008 and 2013





Tamarisk Mortality in Western Colorado
2010-2013
Percent Mortality
100
90
80
70
60
50
40
30
20
10
0
0
0
0
0
0
8
20
24
28
32
40
52
Salt Creek 1
Williams
Gunnison
Douglas Creek
Gateway
Horsethief
SY Burned
Salt Creek 2
Bedrock
SY Unburned
Knowles
Flume
2010
2011
2012
2013

Tamarisk Monitoring Sites in Western Colorado



1 **Douglas Creek**
2 **Williams**
3 **Stan Young Unburned**
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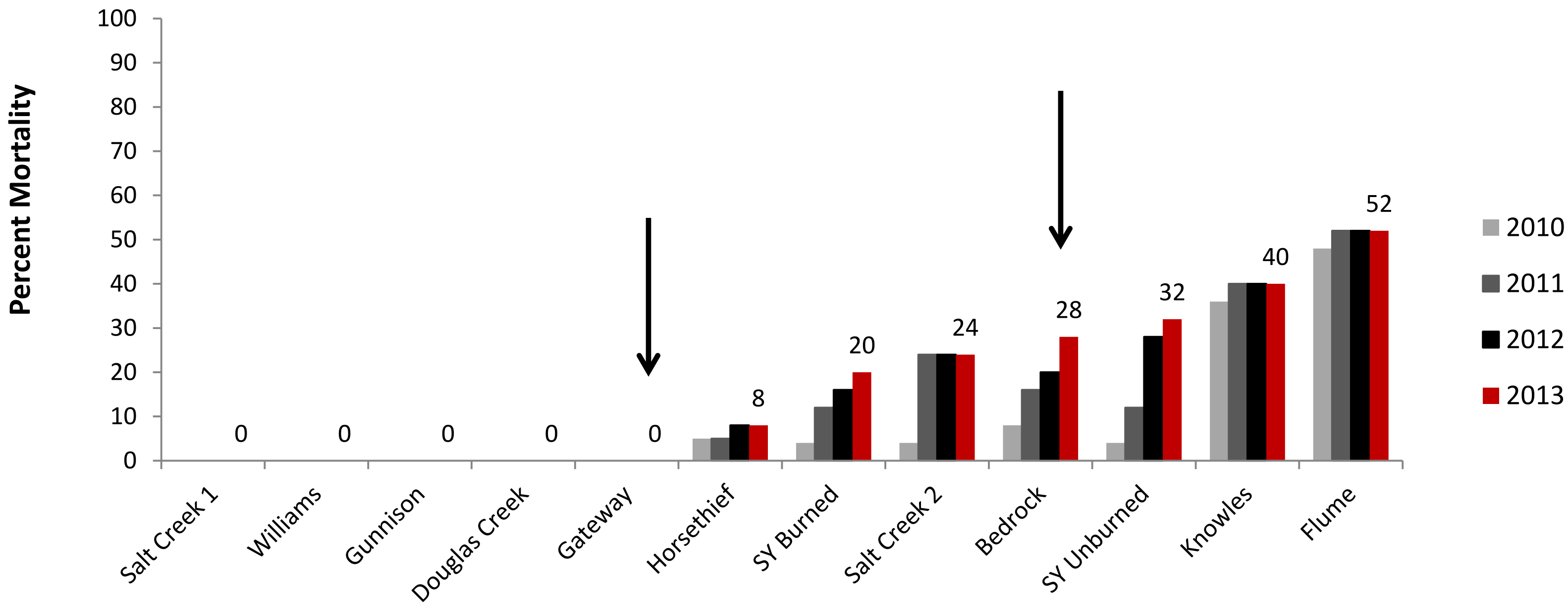
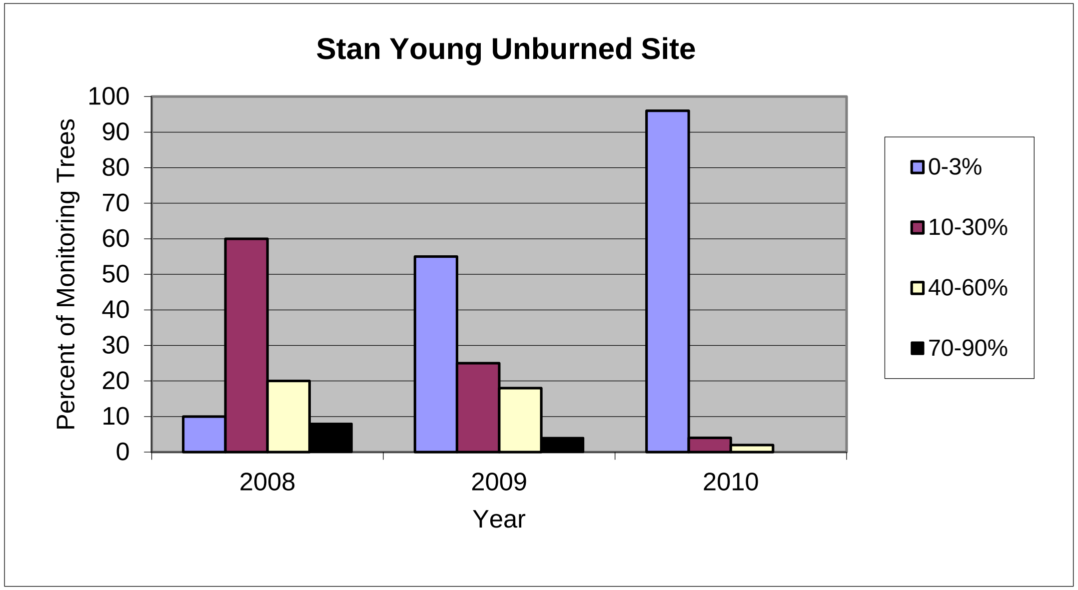
12 **Bedrock**

Tamarisk Mortality in Western Colorado 2010-2013



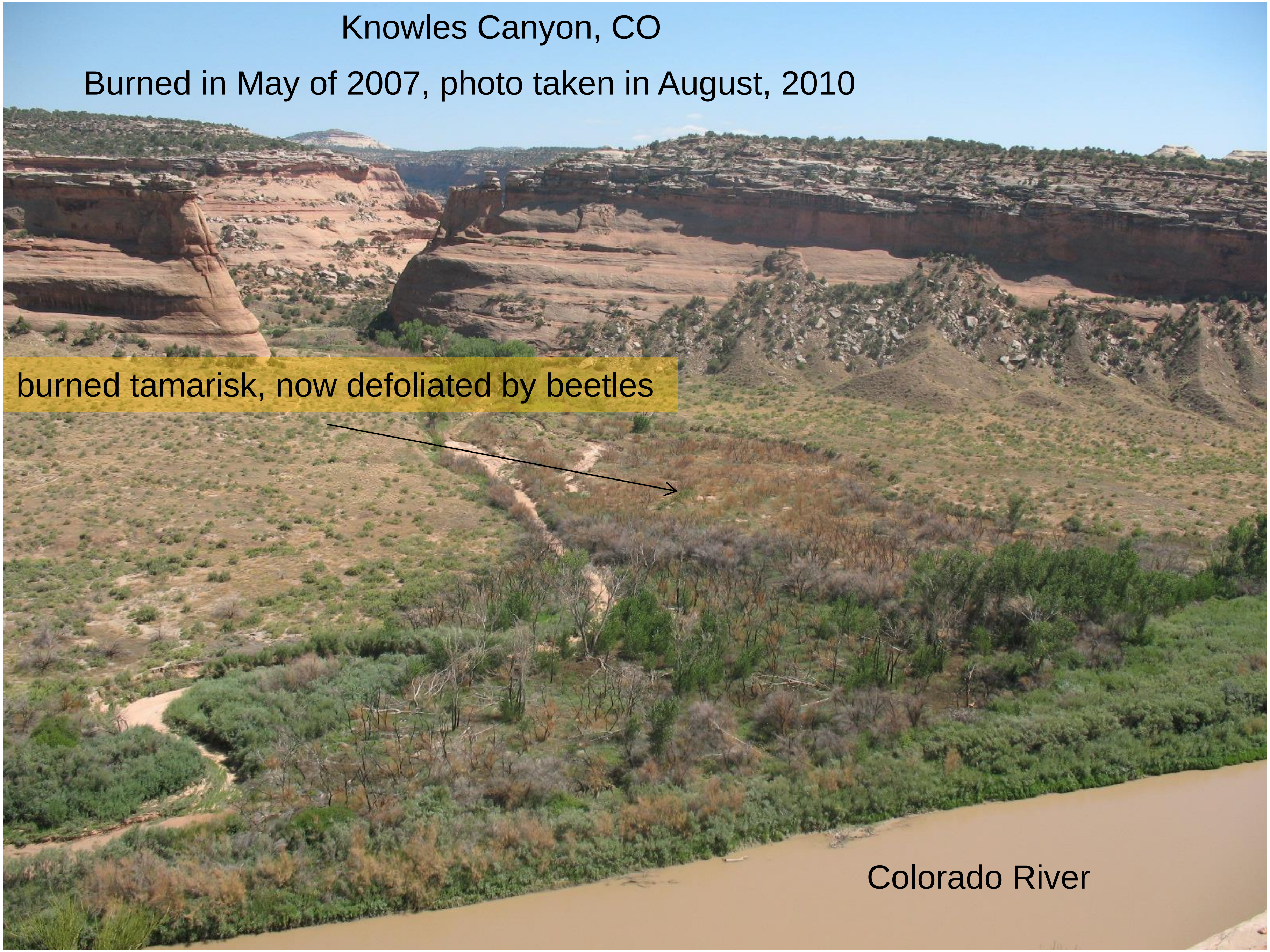
Decline in flowering/seed production



A marked tree representing the 40-60% flowering class

Inability to recover well from fire

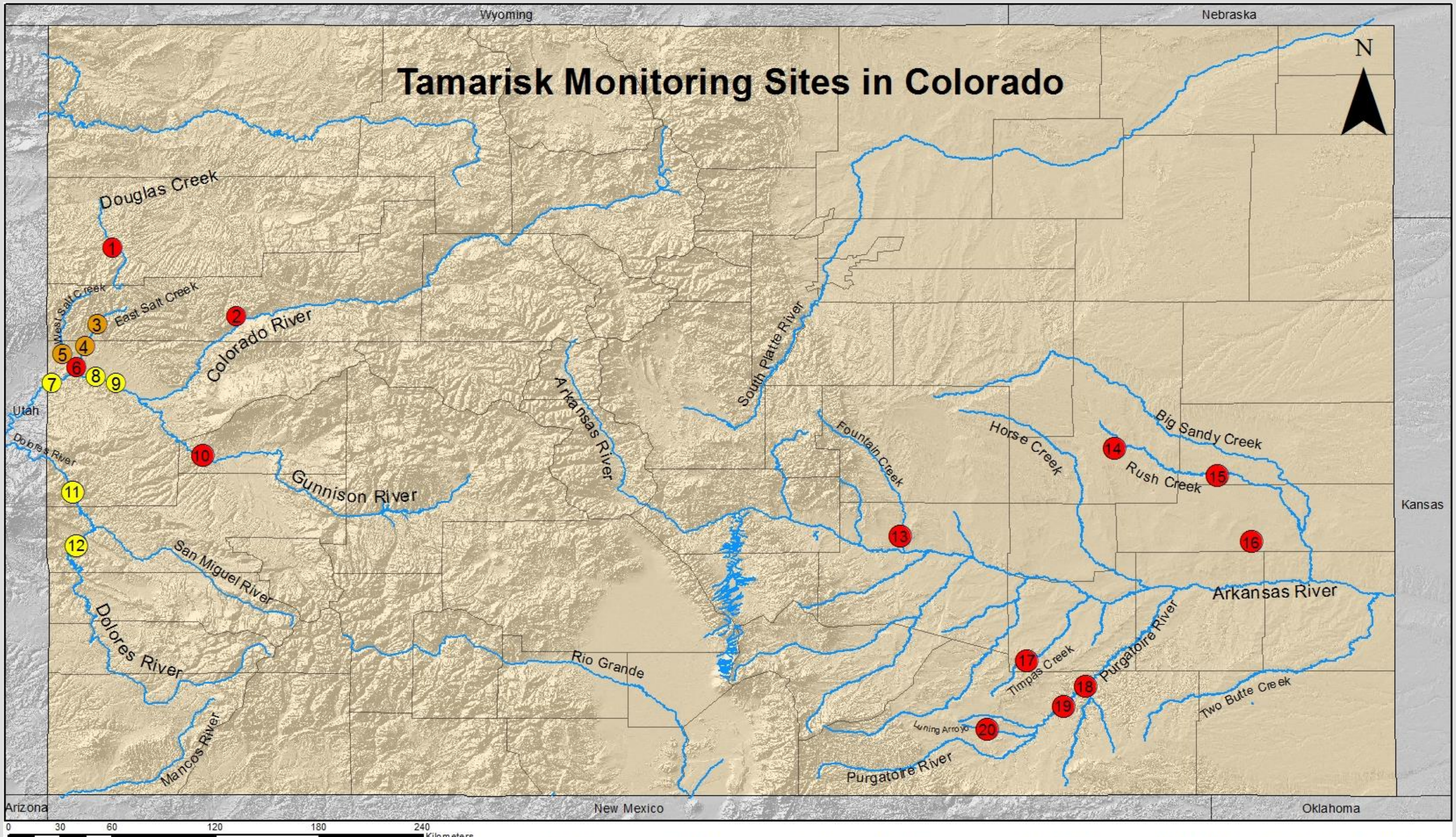
Burned tamarisk attempting to resprout in the presence of beetles (Knowles Creek monitoring site on the Colorado River)


Knowles Canyon, CO
Burned in May of 2007, photo taken in August, 2010
burned tamarisk, now defoliated by beetles
Colorado River

Dewey Bridge, UT 10-5-09

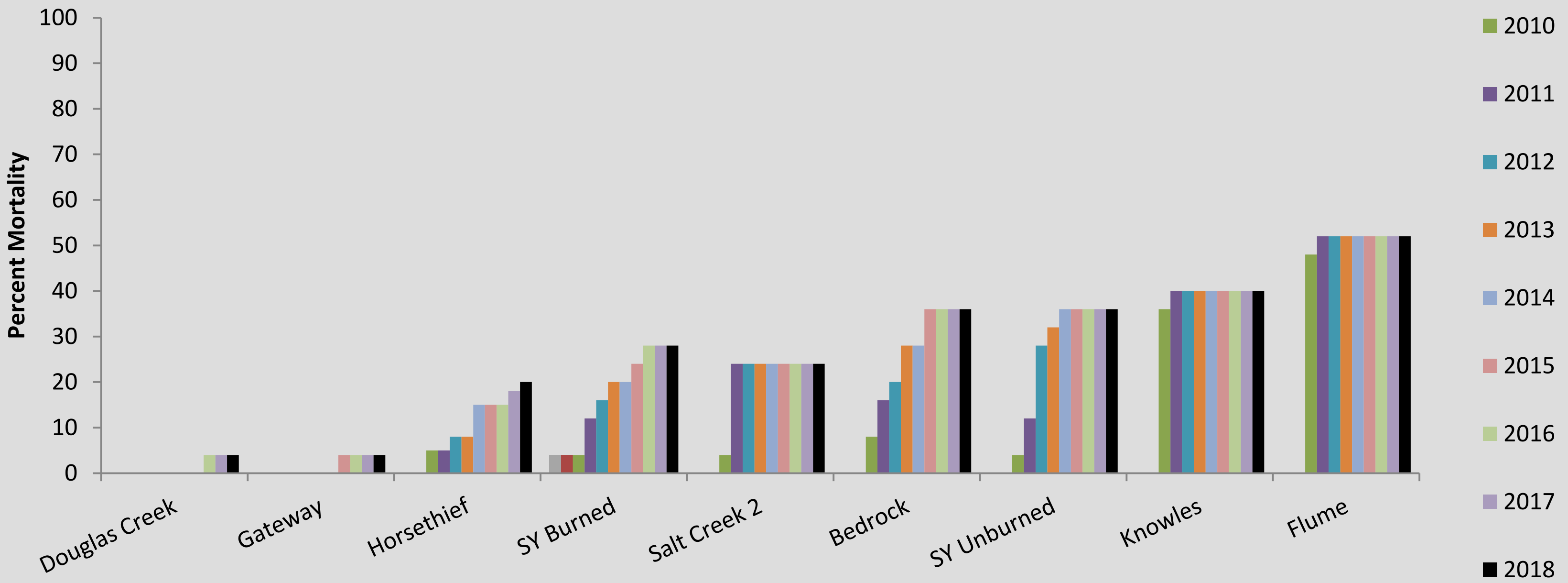
Dewey Bridge UT 8-31-10

Twenty Monitored Sites Across Colorado

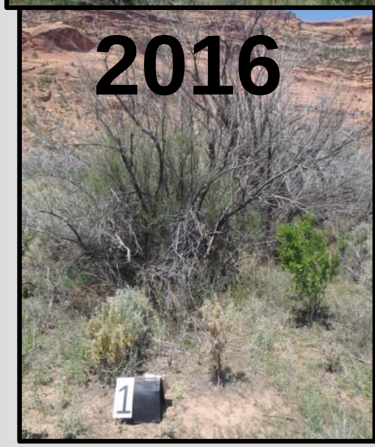


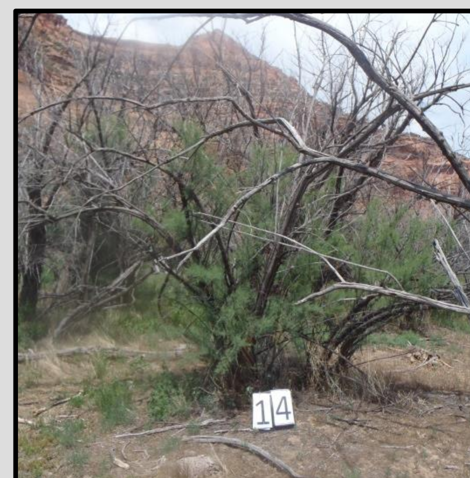
Site Name	2016 Mortality	First Year of Defoliation
1 Douglas Creek	8 %	2011
2 Williams	0 %	2012
3 SY Unburned	36 %	2009
4 SY Burned	28 %	2009
5 Salt Creek 2	24 %	2009
6 Salt Creek 1	0 %	2012
7 Knowles	40 %	2008
8 Horsethief	24 %	2008
9 Flume	52 %	2008
10 Gunnison	0 %	None
11 Gateway	4 %	2008
12 Bedrock	36 %	2008
13 Fountain Creek	40 %	2011
14 Keith James	0 %	None
15 Rush Creek	0 %	None
16 Sweetwater	0 %	2014
17 Bloom	4 %	2013
18 Picketwire	4 %	2013
19 JE Canyon Ranch	0 %	None
20 Wilkinson	0 %	2012

Tamarisk Mortality in Western Colorado 2008-2018

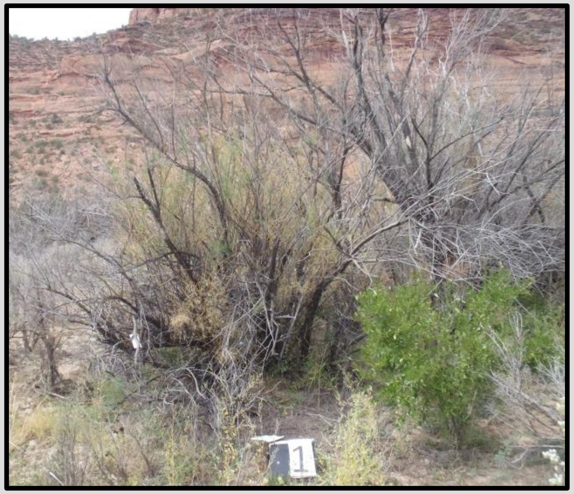


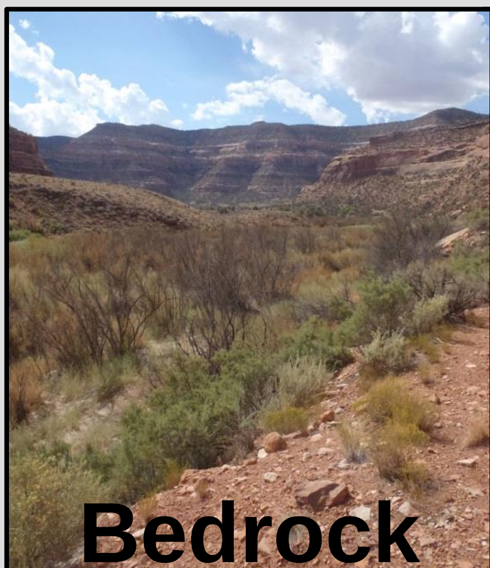
Bedrock 2014-2016 = Low beetles



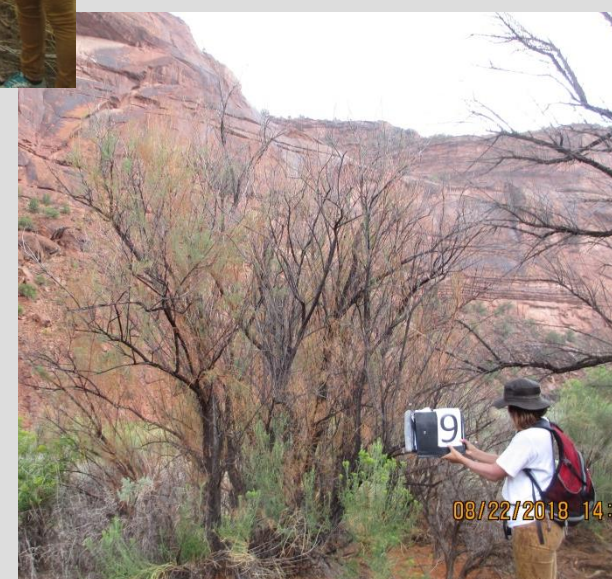


Widespread Defoliation by Aug. 2017

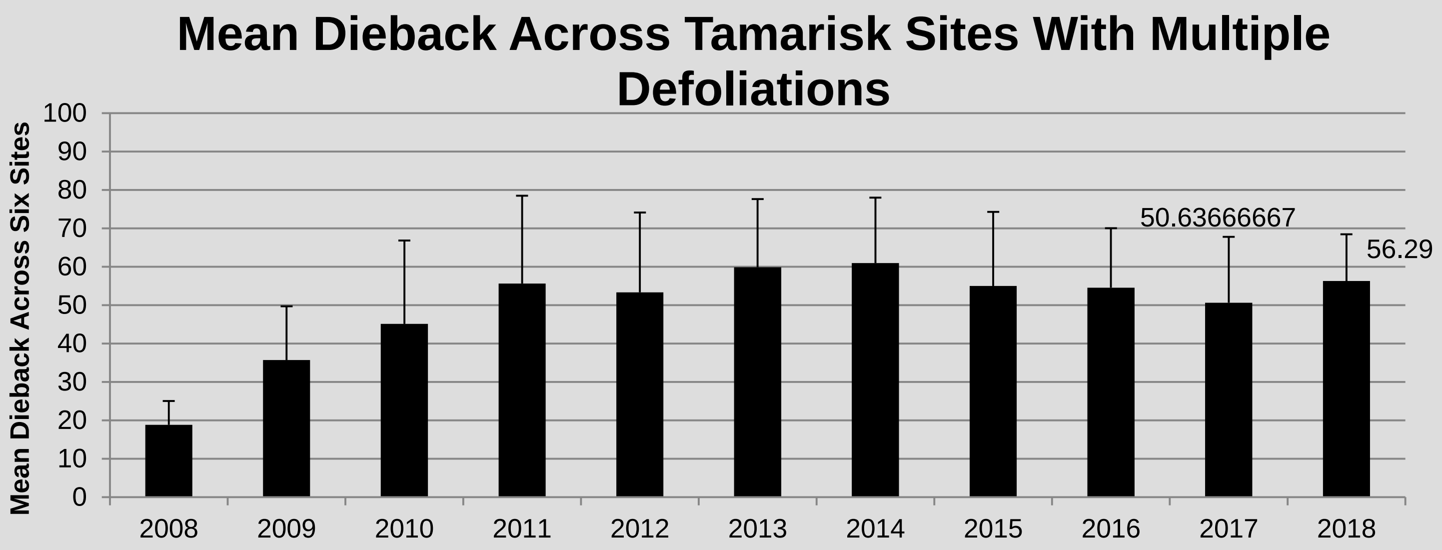




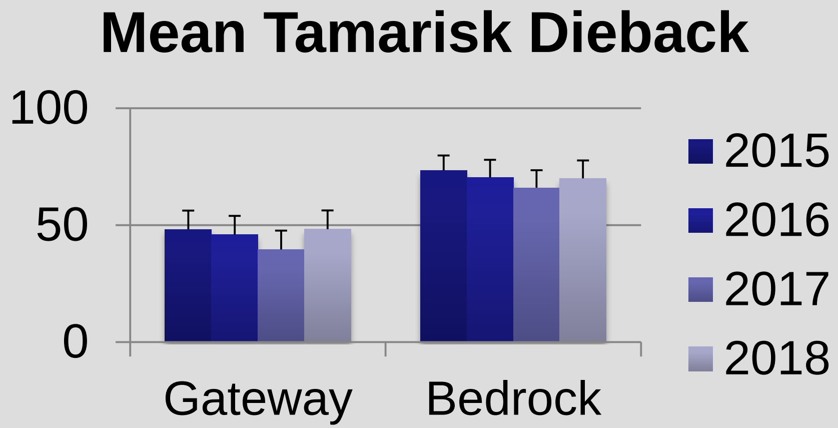
More Damage in 2018



Tamarisk Dieback Across Sites 2008- 2018

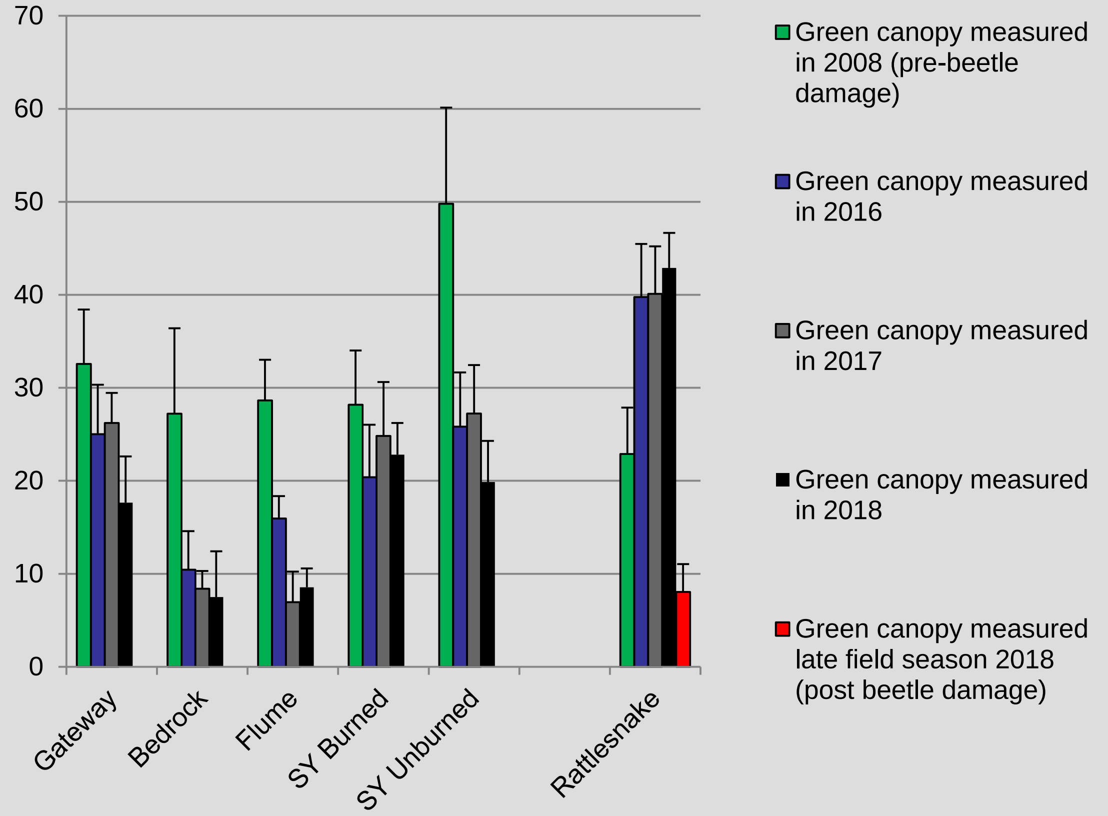


Monitoring Results Gateway and Bedrock

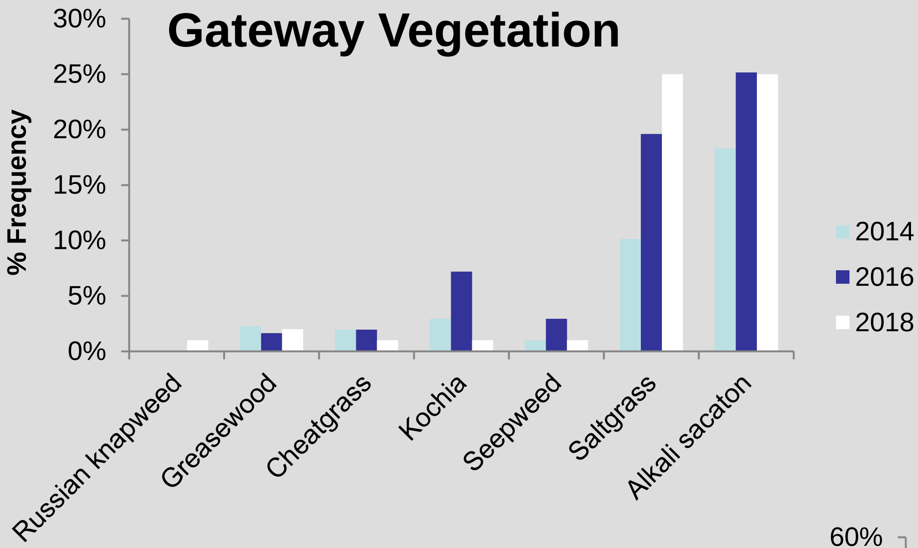


Canopy Volume 2008 vs.2016-2018

- **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.**

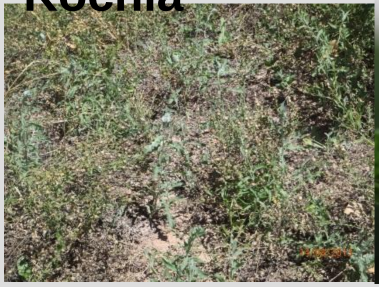


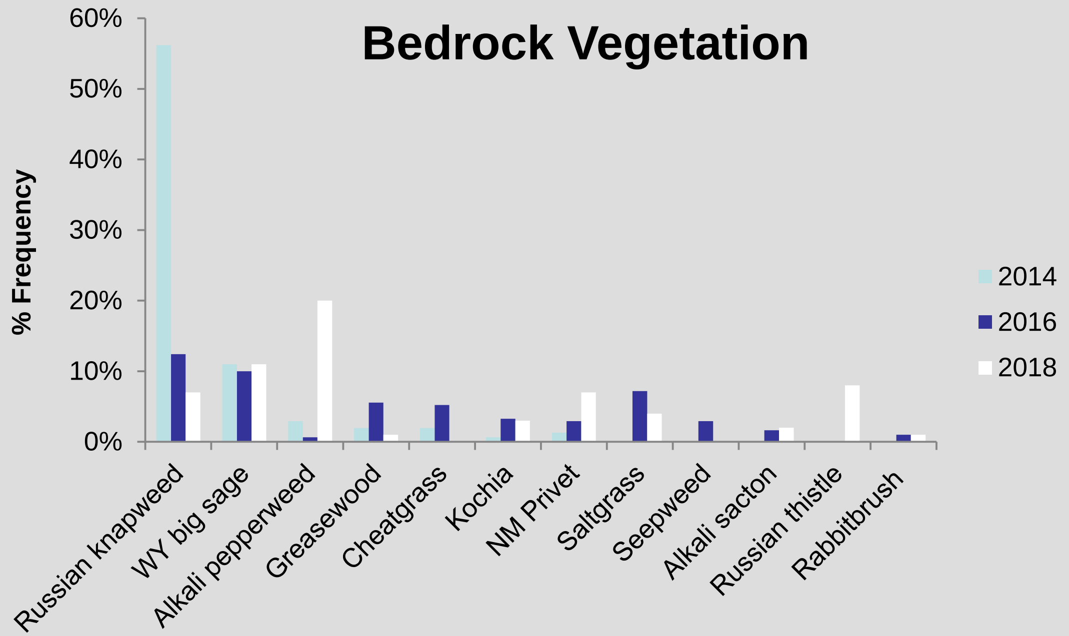
Site Level Vegetation Composition



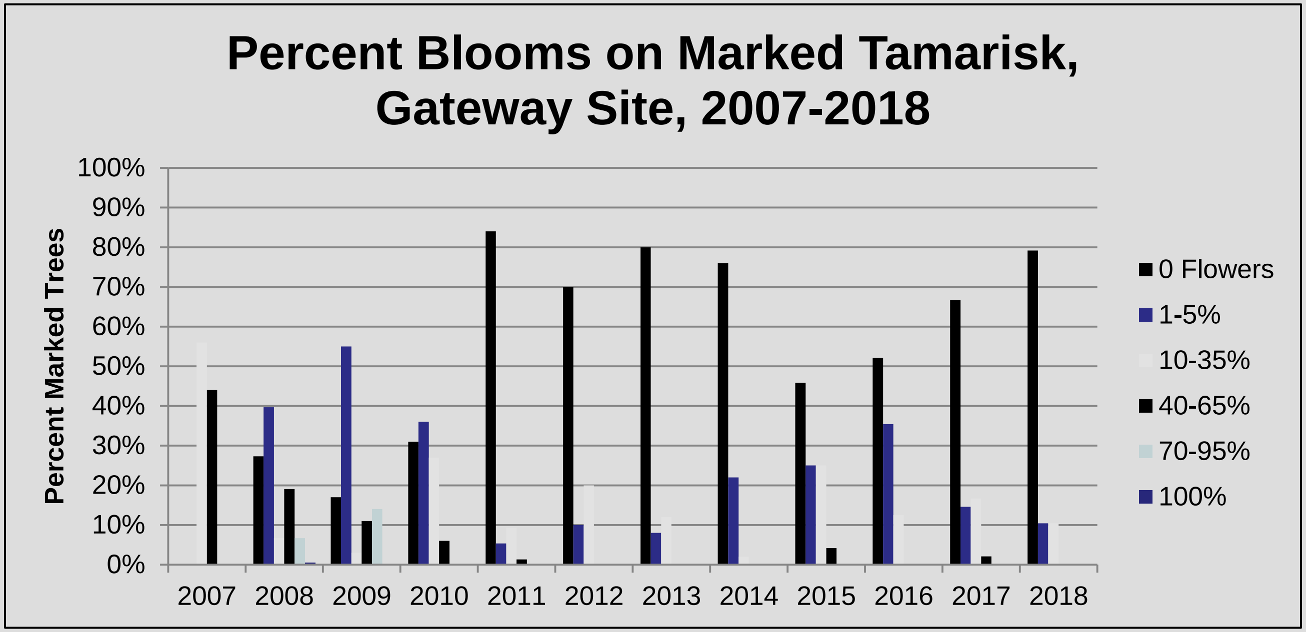
Invaders to keep an eye on:

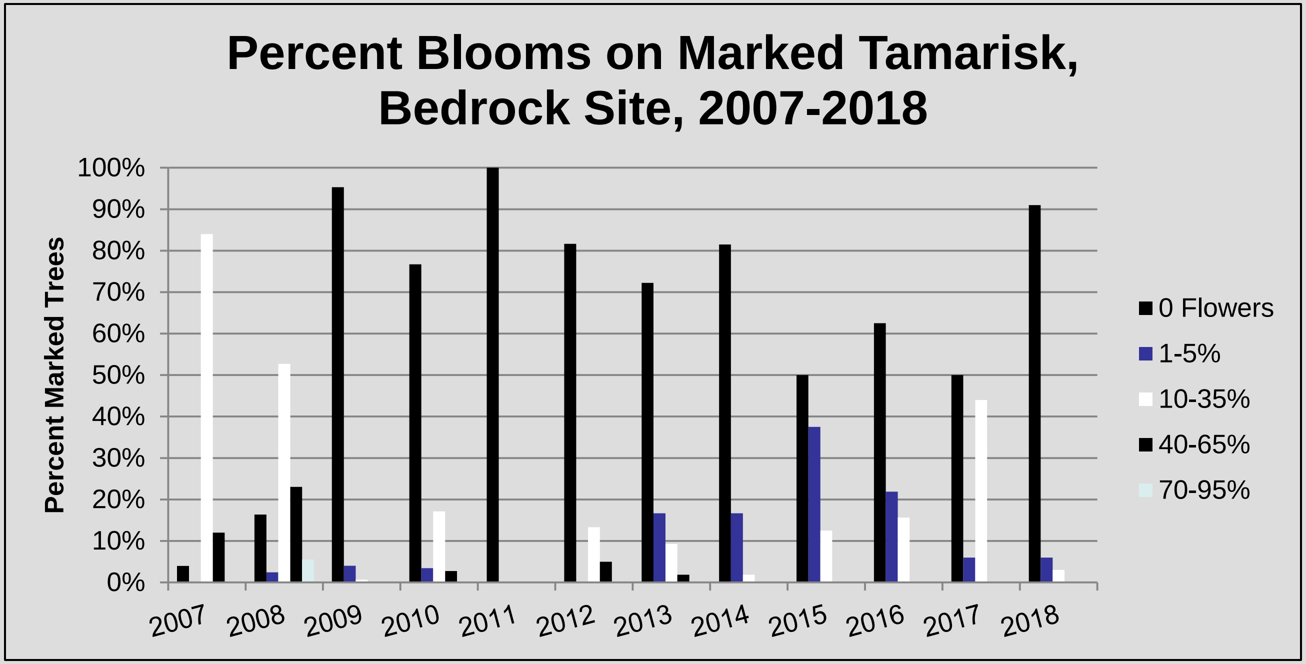
Russian knapweed
Russian thistle
Cheatgrass
Kochia



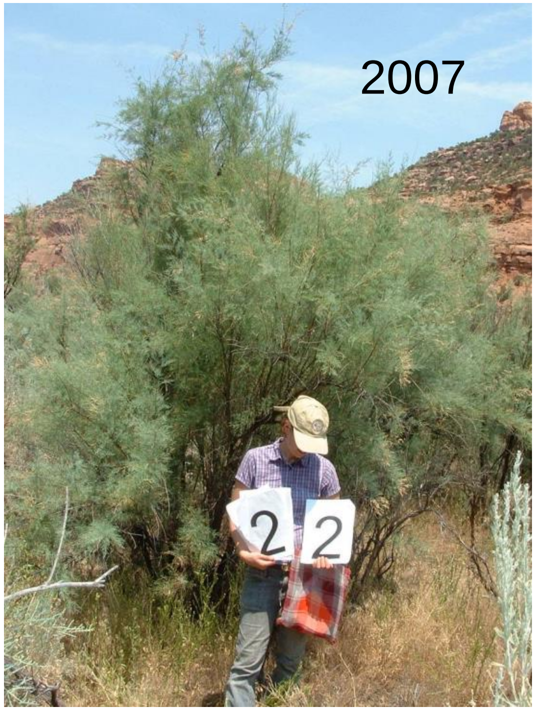


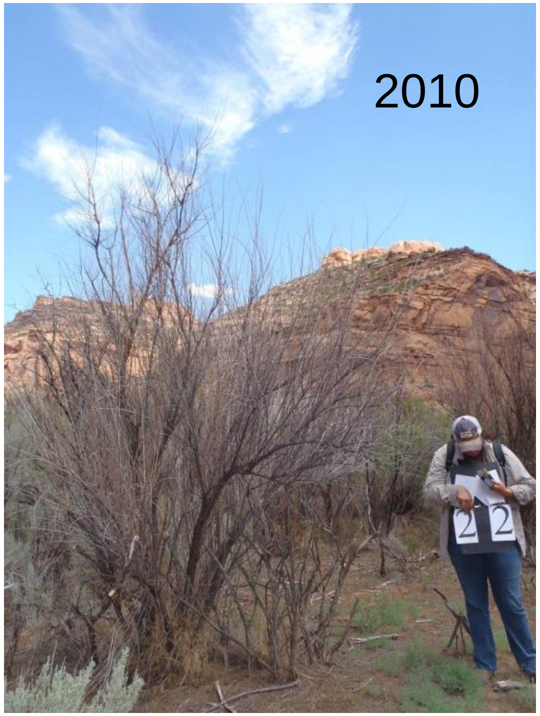
Flower Decline





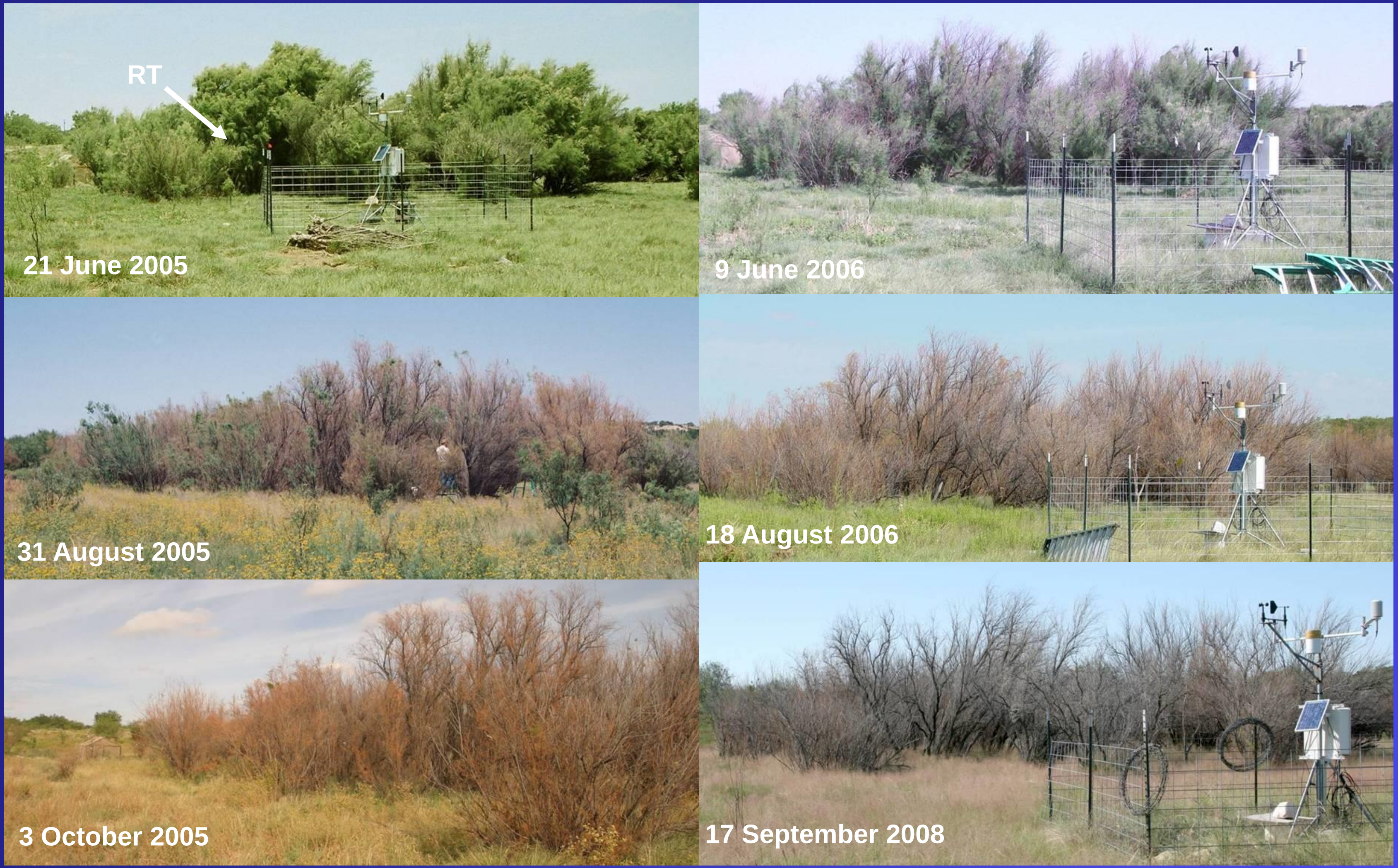
- Cycles of defoliation / refoliation
- Decline in green biomass and vigor
- Decline in flowering/seed production
- Mortality variable
- Inability to recover well from fire





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