Northern Tamarisk Beetle Impact to Tamarisk and Phenology in Western Colorado on a Ten Year Scale

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Study Goals:

Northern tamarisk beetles (*Diorhabda carinulata)* and their impact to tamarisk continue to be monitored at sites throughout Colorado by the CDA, Palisade Insectary, as initiated in 2008. Currently twelve sites are located in western CO and eight sites in eastern CO for a total of 20 monitoring sites. To date all 12 sites in western CO have undergone at least two to eight defoliation events. Despite lower beetle abundances measured across sites in 2011 and 2014 through 2016, beetle numbers have steadily increased across all sites in western CO from 2017 to 2019. Here we examine these increases along with impact to tamarisk over a ten year scale.

Methods:

Seasonal patterns of abundance of *D. carinulata* and their herbivory damage to more than 250 individually marked tamarisk trees are assessed once to twice each season in order to track phenology of the northern tamarisk beetle and their impact on tamarisk (below) beginning in 2008.

Tamarisk defoliation at Salt Creek 2, near Mack CO, 8/16/19.

Changes to Canopy Volume and Percent Flowers

Canopy Volume 2008-2019

Since 2008 canopy volume has decreased significantly across frequently monitored sites which have undergone multiple beetle defoliations as opposed to a site which has not (Rattlesnake Gulch, Fig. 1). Although we began measuring slight increases in canopy volume as beetle defoliation slowed in 2014 through 2016 across sites, decreases in canopy volume were measured again in 2017 through 2019.

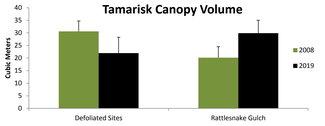


Figure 1. Plot comparing canopy volume at sites prior to frequent beetle defoliations beginning in 2008 and a site first defoliated in 2018 (Rattlesnake Gulch).

Canopy Volume 2018 and 2019

In 2018 and 2019, defoliation was widespread with all sites in western CO undergoing defoliation events. The steady rise of beetle numbers continued from growing populations at West Salt Creek in 2016. For the first time since the onset of the study in 2008, the Rattlesnake Gulch site, underwent complete defoliation of all marked trees as beetles moved up the Gunnison River into Delta County. In 2019 we measured a 27% decrease in canopy volume at this site (Fig. 2).

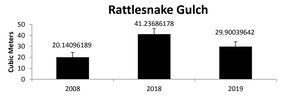


Figure 2. Plot comparing canopy volume measured prior to beetle defoliation and post (2019) at Rattlesnake Gulch.

Tamarisk defoliation at Gateway 2006, 2008, and 2019 (above).

Percent Flowers 2008-2019

At sites where trees have been completely defoliated multiple times we have seen a dramatic decline in trees that fall within high and intermediate density flowering categories such as the Bedrock and Gateway Sites on the Dolores River (Fig 3).

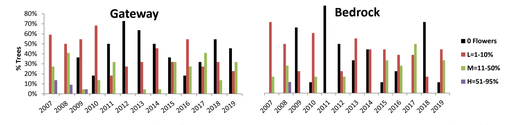


Figure 3. Plots showing percent of trees flowering iO, 1-5%, 11-50%, and 51-95% categories at Gateway (top left) and Bedrock Sites (top right) as compared to Rattlesnake Gulch (bottom left) where defoliation did not occur until 2018 .

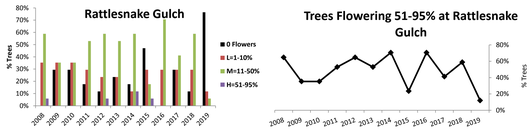


Figure 4. Plots showing percent of trees flowering 0, 1-5%, 11-50%, and 51-95% categories at Rattlesnake Gulch prior to beetle defoliation in 2018 and 2019.

At Rattlesnake Gulch flowering has been variable over the years but generally the dominant category is intermediate (11-50%). The potential for seed production is much greater at a site with low beetle impact (Rattlesnake Gulch on the Gunnison) than sites with high beetle impacts (Gateway and Bedrock on the Dolores) as the above plots demonstrate (Fig. 4).

Tamarisk Dieback and Mortality

Tamarisk Dieback 2008-2019

Mean tamarisk dieback has increased substantially across sites with consecutive beetle defoliations since the onset of this study. From 2008 to 2009 mean dieback has increased by 89%. In 2010 and 2011 mean dieback increased by 26% and 23% respectively. From 2011 forward tamarisk dieback has stabilized at 56%, with fluctuations from 1-12% either decreasing or increasing (Fig 5).

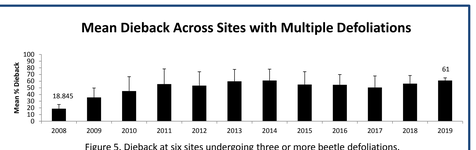
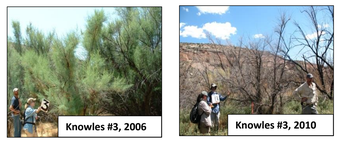


Figure 5. Dieback at six sites undergoing three or more beetle defoliations.



Tree Mortality 2008-2019

Since the onset of this study tree mortality has increased significantly across sites with two or more defoliations including Gateway, Horsethief, SY Burned, SY Un-burned, Salt Creek 2, Bedrock, Knowles, and Flume (Fig. 6). By 2010, six of seven sites which were defoliated over consecutive years (2008 and 2009) exhibited tree mortality ranging from 4% to 48%. By 2011, mean tree mortality increased by 7% among these sites and 4% in 2012. From 2013 through 2018 mean tree mortality increases among these sites only ranged from 1% to 2%. Initial spikes in mortality have since slowed and never reached 60% or greater across monitoring sites.

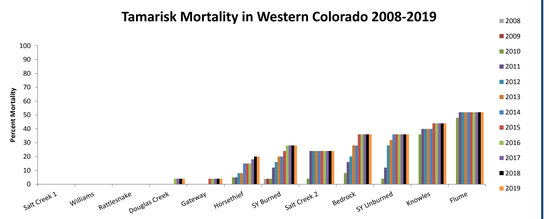


Figure 6. Mean tree mortality at sites in western CO, 2008-2019.

Beetle Phenology

Timing of Overwintering Adult Emergence 2011-2019

Beginning in 2011, *D. carinulata* have been surveyed for emergence from winter diapause . Initially sticky traps were used along with sweep samples. Today sweep sampling is preferred and specific locations near Grand Junction are repeatedly sampled (Fig .7). Adult emergence has fluctuated through time and ranged as late May 8th and as early as April 6th (Fig. 8).

Population Size Through Time 2008-2019

In 2008, *D. carinulata* collections were initiated in effort to move growing populations in western CO for establishment in eastern CO. Since this time over ~4 million beetles have been moved to the Arkansas River Basin. Despite movement of such large numbers successful establishment has dwindled likely due to a variety of factors including predation by ants. In contrast western CO populations have continued to thrive despite years with low beetle activity demonstrated in fig. 9. We continue to measure two generations per season following emergence of overwintering adults in spring in western CO (fig. 10).

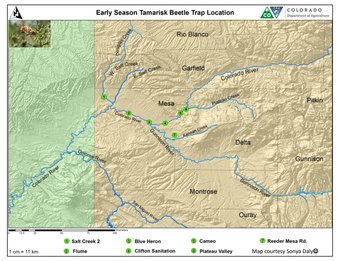


Figure 7. Map of phenology sampling points in western CO.

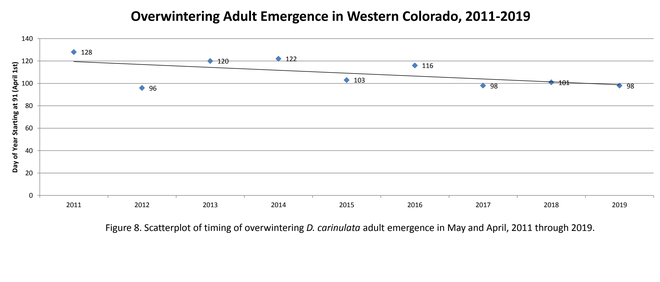


Figure 8. Scatterplot of timing of overwintering *D. carinulata* adult emergence in May and April, 2011 through 2019.

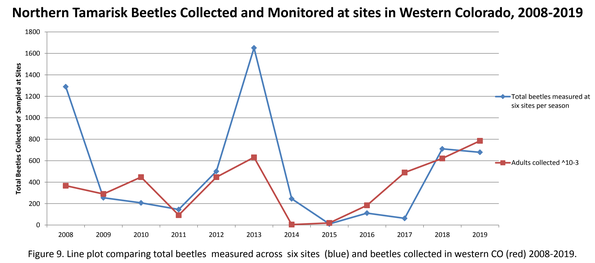


Figure 9. Line plot comparing total beetles measured across six sites (blue) and beetles collected in western CO (red) 2008-2019.

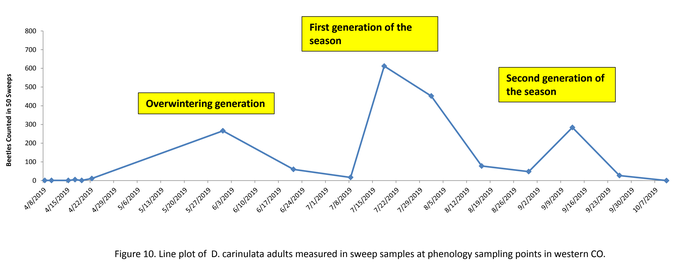


Figure 10. Line plot of D. carinulata adults measured in sweep samples at phenology sampling points in western CO.

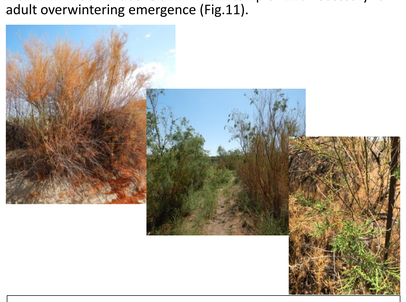
Tamarisk Phenology

Measurements of bud break, senescence, and defoliation events were recorded using phenocams and photo surveys in 2018 and 2019. Bud break and senescence were recorded to occur slightly earlier in 2019 vs. 2018 at measured sites. A higher elevation site (~5900 Ft.) near Rangely CO, Douglas Creek or DC, was shown to have earlier bud break and senescence by ~15 days vs. sites near Grand Junction. Tamarisk near Palisade CO, budded ~7 days earlier than tamarisk on Horsethief Bench (~4500 Ft.) near Fruita CO (Fig. 11).

Preliminary results using Dr. Len Coop's Degree Day Model indicates growing degree days for tamarisk appear to fall around ~200 DD using a minimum threshold of 5C. Degree days for *D. carinulata* development have been determined by this model as well with ~230 DD above a minimum temp of 11C necessary for adult overwintering emergence (Fig.11).

Bud break and tamarisk growth in spring 2018.

Bud break and tamarisk growth in spring 2019.



Photos showing beetle defoliation and re-growth in 2019.

Bud break at Horsethief ~4/8/19

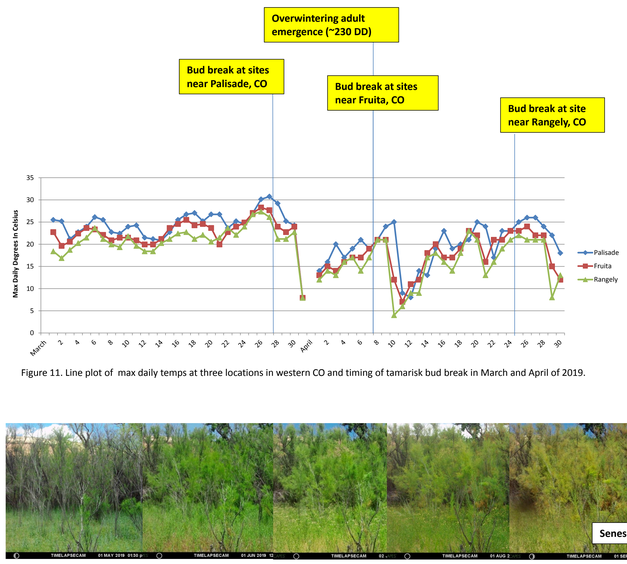
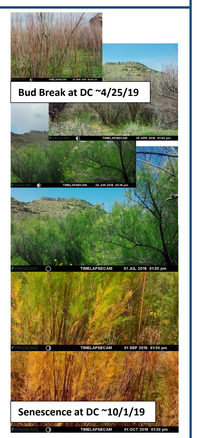


Figure 11. Line plot of max daily temps at three locations in western CO and timing of tamarisk bud break in March and April of 2019.



In Summary:

Beetles can diminish the ability of tamarisk to spread by seed through reducing flowering ability. We should see an overall long term decline in tamarisk statewide as flowering is suppressed by biocontrol.

We see dramatic increases in tamarisk dieback across beetle defoliated sites over time (19% in 2008 and 61% 2019).

In 2013 and 2019 we measured and collected the most *D. carinulata* in western CO since initial population spikes in 2008; indicating the cyclic nature of established beetle populations.

Overwintering adults typically emerge by mid to late April or ~230 DD from January 1st. Peak abundances occur by early June, mid July and September with two generations in CO.

Depending on site elevation and temperature tamarisk bud break occurs in late March to early April with senescence by mid October to early November in western CO.