

Riparian Management Effects on Flow Along the Canadian River

Jasper Brusuelas, New Mexico State University, master's degree student

Jasper Brusuelas is a graduate student at New Mexico State University. She is currently pursuing a master's degree in range science and a minor degree in geographic information systems and technology. She is from Las Cruces, NM and has a two-year-old son, Oliver. She is currently living in High Rolls, NM after accepting a pathways position as a natural resource specialist for the US Forest Service in the Lincoln National Forest. She hopes to further her career in range science or botany as she has developed a passion for researching and measuring plants from her attendance at NMSU.

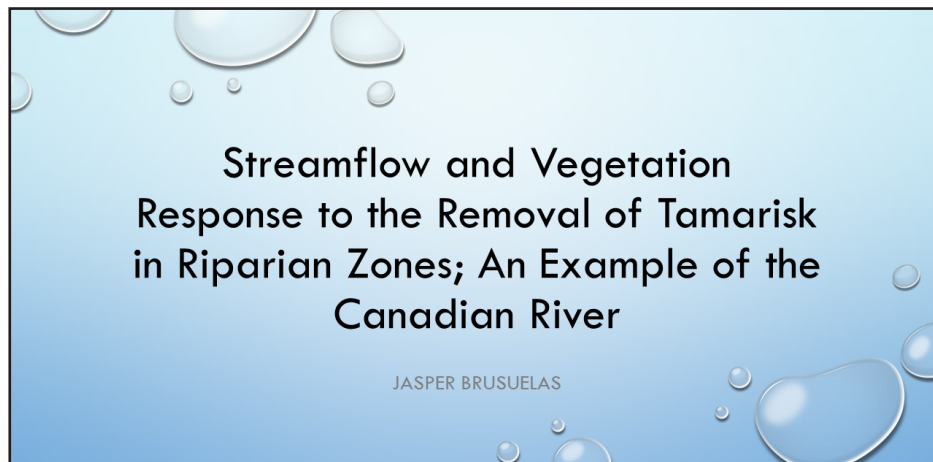
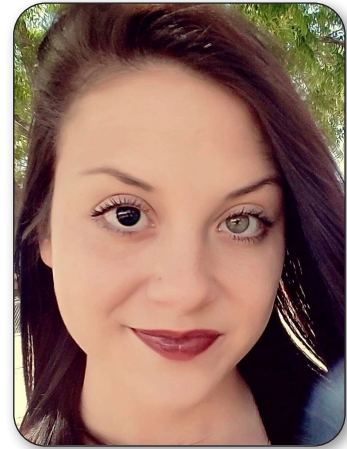


Figure 1. Introduction.

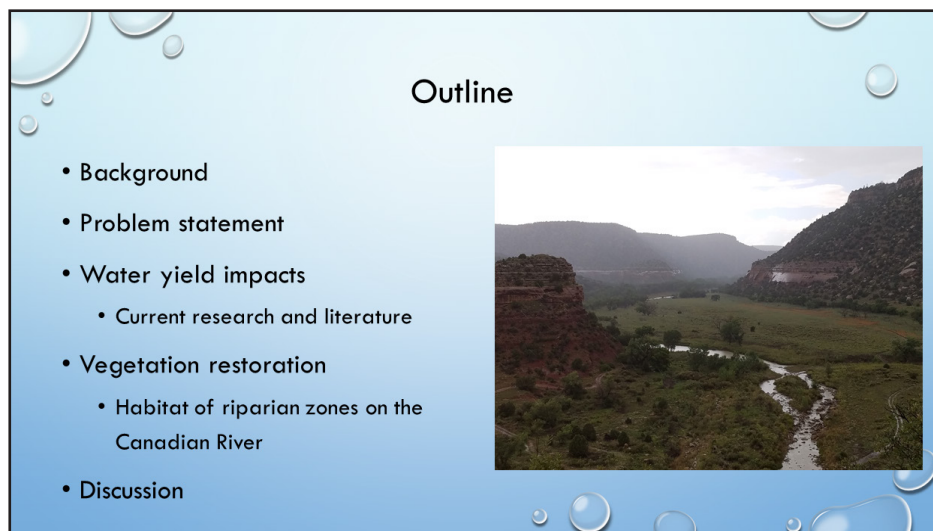


Figure 2. Outline.

The Importance of a Riparian Habitat

- Transition zone between terrestrial and aquatic ecosystems
- Exchange of surface water and groundwater
- Provide critical habitat for wildlife and vegetation





Figure 3. The importance of a riparian habitat.

Tamarix spp.

- Family: Tamaricaceae
- ~55 Species
 - 8 Species in USA
- Shrubs or Trees
- Phreatophyte



<http://www.terrain.org/articles/27/lamberton.htm>

Figure 4. *Tamarix* spp.



Figure 5. *Tamarix* spp. introduced in the 1800s.

Reasons for Introduction



- Ornamental
- Shade
- Wind Breaks
- Stabilize Stream Banks
 - Buffer Strips
 - Erosion
 - Flooding

<http://www.malag.aes.oregonstate.edu/wildflowers/images.php/id-2965/fullsize-1>

Figure 6. Tamarix spp. reasons for introduction.

Dominates Space

Monotypic Stands






Figure 7. Tamarix spp. dominates space.

Dominates Resources

- Facultative Phreatophyte
 - Higher combined K_{rh} , k_l , K_a in unsaturated soils
- Resources
 - Light
 - Water
 - Lowers Water Table
 - Increase ET Levels
 - Soil
 - Releases Salts >> Increases Salinity

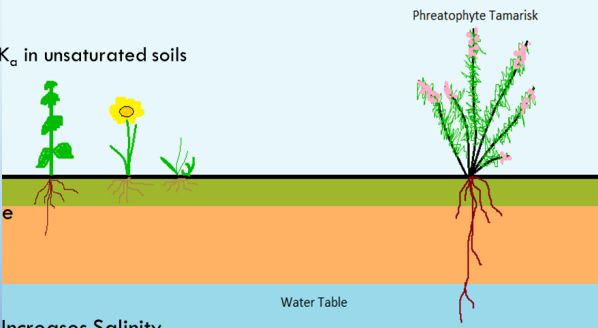


Figure 8. Tamarix spp. dominates resources.

CHALLENGES TO RESTORATION



- Erosion
- Sedimentation
 - Turbidity
 - Water quality and wildlife
- Invasive species

Hydrologically Sensitive Area-
woody plants access water at depths out of reach of non-woody plants (Wilcox et al., 2006).

Figure 9. Challenges to restoration.

Big questions.

Does the presence of tamarisk decrease streamflow?
How much water can be salvaged after removing tamarisk?
Should tamarisk be removed from riparian habitats?

It depends...

Figure 10. Big questions.

- Fire
- Flood
- Extreme Temperatures
- Drought
- Efforts to Destroy



http://sabkha.blogspot.com/2011_03_01_archive.html



<https://www.fws.gov/southwest/refuges/newmex/sanandres/Prescburns.html>

Figure 11. Tamarix spp. is highly resilient.

Xylem Cavitation Resistance- Thriving in an Arid Environment

Maintain **higher rates of transpiration, nutrient uptake, and favorable carbon balance**

across a broad spectrum of environmental gradients (Hultine et al., 2011)

- Resistant to drought
 - Xylem cavitation documented to occur in **cottonwood and willow at -2 mega pascals**
 - **Tamarisk** can retain water potential conductivity at up to **-6 mega pascals** (Pockman and Sperry, 2000)
- **Mean specific conductivity 23 and 46% higher than Fremont cottonwood and Gooding's willow** (Pockman and sperry, 2000)

Figure 12. Xylem cavitation resistance - Thriving in an arid environment.

TAMARISK INDIVIDUALS

- Tamarisk **water use** per unit ground area and the **rate of transpiration** does not exceed that of native woody vegetation (Nagler et al., 2005, Owens and Moore 2007; Shafroth et al., 2010; Hultine and Bush 2011; Sala et al., 1996)
- Tamarisk, cottonwood, and willow **trees of similar size use similar amounts of water per day** (50 l day^{-1}) (Wilcox et al., 2006; Busch and Smith, 1995)

However...

Tamarisk stands **occupy much larger areas of flood plains** than the majority of native species (Hultine and Bush 2011)

Figure 13. Tamarisk water use and rate of transpiration do not exceed that of native woody vegetation, but tamarisk stands occupy much larger areas of flood plains.

Reproductively Successful

- Produce Several Hundred Thousand Seeds Annually
- High Germination Rates
 - Up to 100% Success
- Apical Pappus
 - Wind and Water Dispersal

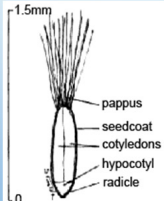




Figure 14. Tamarisk reproductively successful.

- Increase in ET_g
 - Decrease groundwater table (Wang et al., 2014; Tomaso, 1998)
- Increase hydraulic roughness
- Trap and stabilize sediment and debris (Graf, 1982)
 - Increase aggradation
 - Narrowing of stream channels, reduction of channel widths
 - Increase flooding
- Increase in evapotranspiration
 - Increase in salinity (Shafroth et al., 1995)
 - Release salts (Tomaso, 1998)




Figure 15. Tamarisk stands.

- Gatewood et al. (1950), 3760-ha consumed $\sim 920 \text{ mm year}^{-1}$
- Culler et al. (1982), consumed $\sim 1090 \text{ mm year}^{-1}$ water savings of 480 mm year^{-1}
 - **Water savings will only be maintained if incoming vegetation is kept at forbs and grasses**
- 8700 ha tamarisk was cleared, **no change in streamflow** was observed (Weeks et al., 1987)
 - Water use by tamarisk at stand scale was **300 mm year^{-1} greater than the replacement vegetation**
 - Increases in base flow may have been masked from shallow aquifer, increased pumping, rapid tamarix recruitment and tamarix buffer adjacent to the river
- Replacement of tamarix by other woody vegetation will likely show no immediate effect in water savings, **Replacement of tamarix with herbaceous plants may result in water savings of $\sim 500 \text{ mm year}^{-1}$** (Glenn and Nagler, 2005; Wilcox et al., 2006)

Figure 16. Water salvage studies.

- Defoliation during two growing seasons resulted in a **15% decrease in mean annual water use by tamarisk** (Hultine et al., 2010b)
- Defoliation in 2011 and 2012 **decreased ET levels by 18% and 35% since pre-defoliation**
 - Magnitude was dependent on the growth stage of the tamarisk
 - ET recovery was parallel with the establishment of new leaves
- Long term changes in ET are dependent on reoccurring defoliation events over several years (Sachiko et al., 2015)

Figure 17. Control of tamarisk by diorhabda carinulata (species of leaf beetle) and effects on ET.

- **Stands on floodplains had higher evapotranspiration rates** ($\sim 1000 \text{ mm year}^{-1}$) than stands in non-flooding areas (750 mm year^{-1})
- **Evapotranspiration was similar with cottonwoods in non-flooding areas** (Dahm et al., 2002)
 - Similarly water use (750 mm year^{-1}) during dry year and ($\sim 1500 \text{ mm year}^{-1}$) during wet year (Devitt et al., 1998)
- **Tamarisk consumes a greater proportion of water from shallow unsaturated soils than cottonwood and willow** (Busch et al., 1992; Smith et al., 1998)
- **Conflicting results of water use** equivalent to native woody plants (Glenn and Nagler, 2005)
- **Tamarisk have greater water use when stand densities (leaf area index) are higher**
 - Typical of a dominant riparian zone

Figure 18. Results will vary at different scales: tree, stand, and landscape.

- Difficult to measure due to inputs and outputs
- Water use increases as water availability increases (Wilcox et. Al.,)
 - Amount of water used and the variability of use increases in wet seasons as the water table increases
 - Easier to measure differences in water yield
- No changes may be detected if:
 - Tamarix is recruited
 - Abundance of other woody vegetation present
 - Other outputs are present (aquifers, pumps, wells etc.)

Figure 19. Tamarisk landscape.

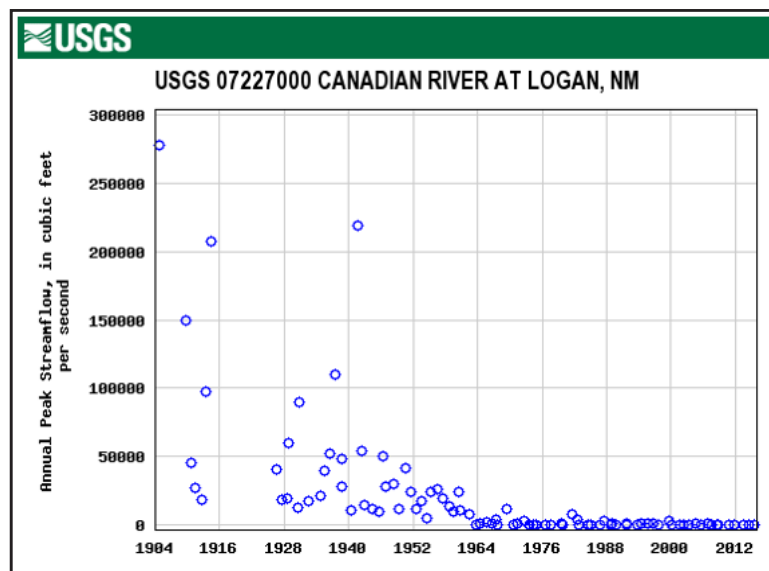


Figure 20. Canadian River streamflow reduction since early 1900s.

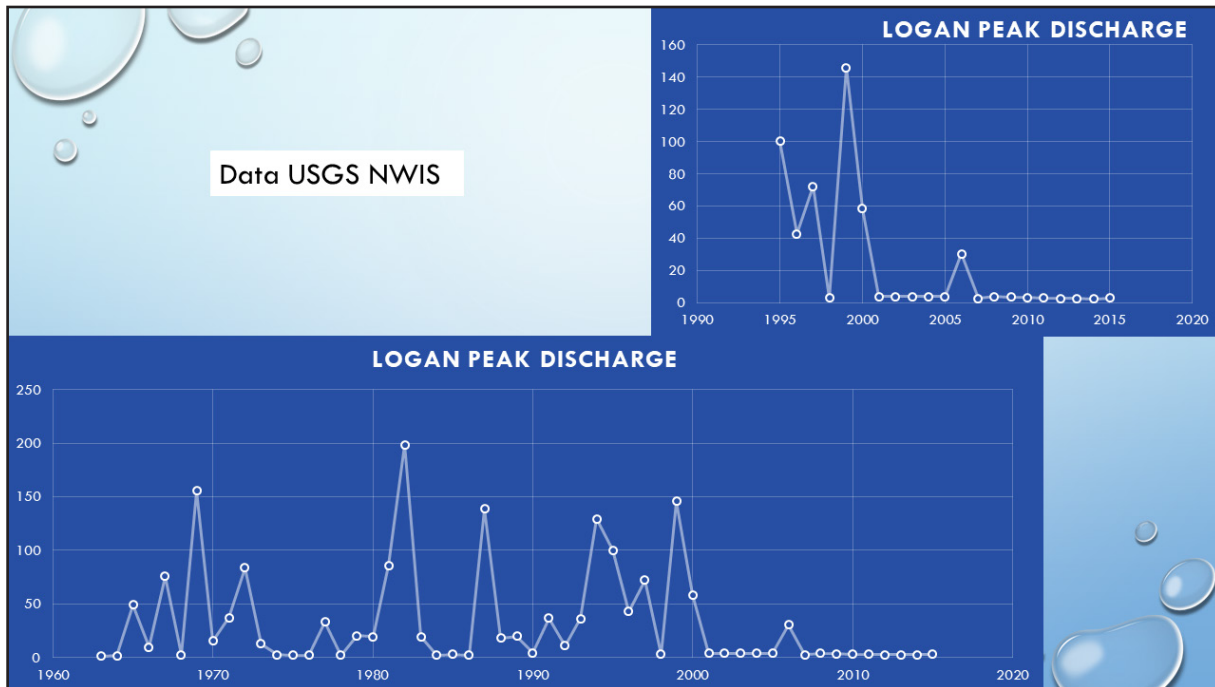


Figure 21. USGS data for Logan Peak discharge.

- What effect does tamarisk removal have on the riparian habitat (remaining vegetation, water yield)?
- What vegetation is going to grow in place of the tamarisk?
- What steps need to be taken for riparian habitat restoration in regards to vegetation and invasive species control?

Figure 22. Vegetation response and restoration in riparian habitats on the Canadian River.

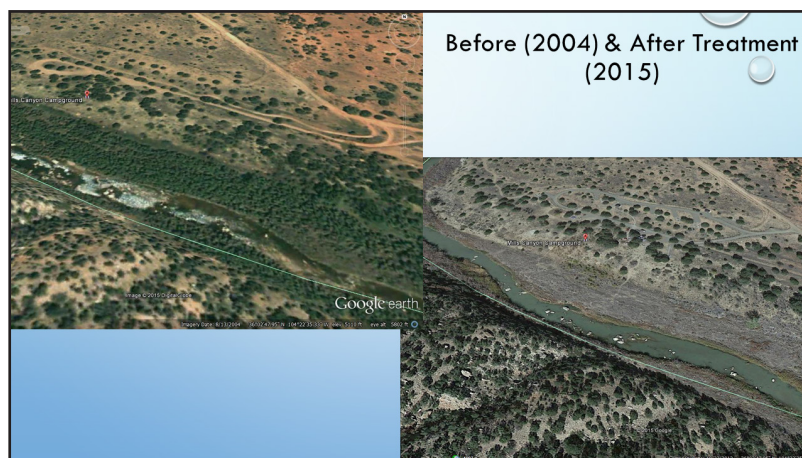


Figure 23. Before (2004) and after treatment (2015).

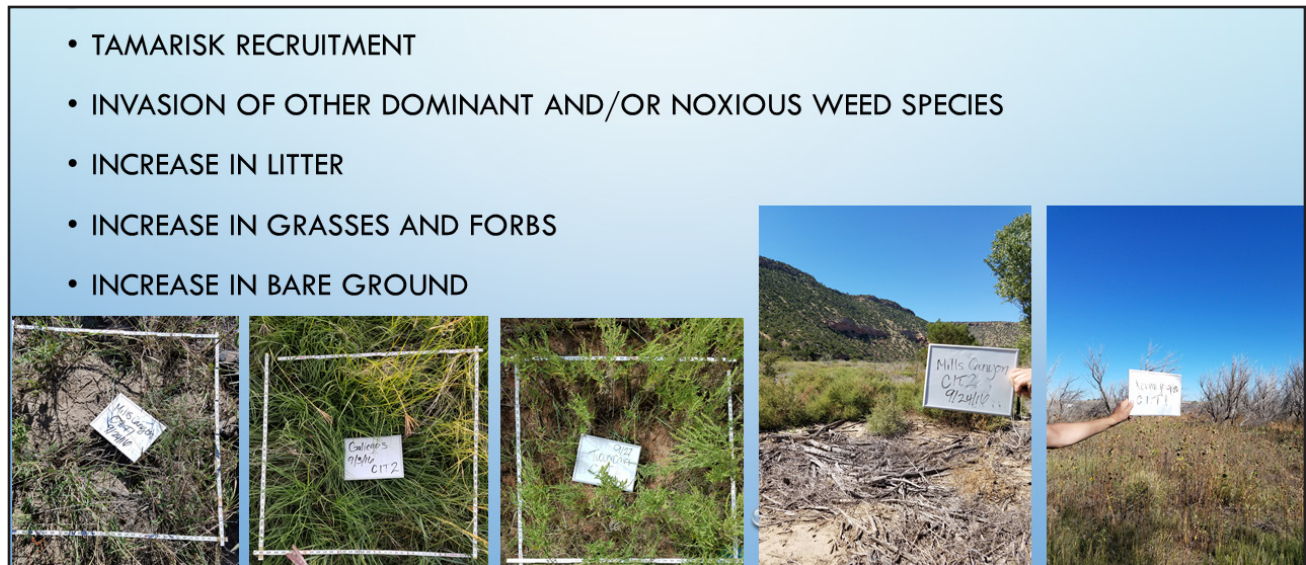


Figure 24. Response of vegetation to the treatment and removal of tamarisk in arid riparian zones; a case study of potential forage availability for mule deer along the Canadian River.

DISCUSSION

- ET and water use of individual plants is equivalent to other individual native woody plants
- Increase in tamarisk stands
 - Increase in ET
 - Decrease in water yield
- Replacement of tamarix with herbaceous plants along with continued tamarix treatments and monitoring may increase water yield and habitat suitability
- Water salvage from tamarix removal is best measured during wet seasons/conditions
- Vegetation response is dependent on water yield, tamarix treatment, soil conditions, and the number of tamarix (woody plants) present

Figure 25. Discussion.



Restoration Recommendations/ Future Research

- Treat and remove tamarix stands that are dominating a landscape setting
- Seed treated areas with a mixture of native, herbaceous (primarily) and grass seeds
- Continue to monitor and treat sites for tamarix recruitment

Future Research on the Canadian river:

Measure changes in streamflow before and after tamarix treatment and seed;
Should be done during Monsoon Season, in areas of high recruitment

Figure 26. Restoration recommendations/future research.