

Riparian vegetation response to control of invasive plant species: restoration or retrogression

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Tens of thousands of acres of *Tamarix* have been cleared from public and private lands throughout the western United States in recent decades. The objectives of these projects often include: controlling invasive species, salvaging water, reducing fuel loading and fire damage to native riparian forests, and restoring degraded riparian ecosystems. Many of these efforts could be improved through the incorporation of a strong conceptual framework based on a clearly stated restoration objective that includes: a consideration of site context; a solid monitoring framework aimed at quantifying recovery of important ecosystem attributes, investment in follow-up treatment, solid quantification of yield-on-investment (as opposed to acres of *Tamarix* cleared), with attention to long-term post-removal response of physical and biological systems. We monitored post-*Tamarix* removal response along flow-regulated rivers in two valley settings: one along an alluvial reach of the Middle Rio Grande, NM and the other in a confined, bedrock canyon reach of the Upper Green River, UT. Collectively over 120 hectares of *Tamarix* was removed along 320 km of river as a part of these efforts. Channel response, herpetile, bird, mammal and bat community composition were measured by collaborators in these replicated, block experimental designs. Our focus was on the response of plant communities to *Tamarix* removal. We quantified recovery through measuring plant species composition, riparian forest canopy structure, the effects of fuel reduction efforts on survival of native forests following wildfire, and the role of flooding and flow-related process in long-term recovery of plant communities.

Mechanical removal was highly effective in reducing *Tamarix* cover at treatment sites, however a prevalence of re-sprouting and recruitment from seed along treated reaches indicates that follow-up treatment is necessary to prevent re-establishment of *Tamarix*. Historical reconstruction of channel narrowing and establishment indicate that long-term removal of *Tamarix* is likely to be more successful on abandoned fluvial surfaces, as recruitment continues along fluvially active channel margins. We found that the frequency of exotic herbaceous species was higher in areas disturbed during *Tamarix* removal, resulting in higher proportion of exotic herbaceous species in treated sites compared to controls. The risk of invasion by other exotic species following *Tamarix* removal can be minimized by evaluating site conditions that might facilitate post-removal invasion (e.g., presence of local seed sources, vegetative propagule sources, vectors, the creation of 'open sites'). Vertical forest structure was reduced in treated areas along both rivers, but recovery of such habitat structure has been expedited along the Rio Grande through active transplanting of native shrubs. Patterns of herbaceous vegetation recovery

were strongly related to site-specific factors (light, litter depth, and available moisture); all factors that are influenced by *Tamarix* removal and can be manipulated by managers.

Large magnitude, long-duration floods would be expected to result in changes in channel geometry, mobilization of bars and channel margin deposits, removal of herbaceous and woody vegetation, and establishment of more natural physical, biological, and plant successional processes. The relatively small magnitude, short-duration floods that occurred during this study did not result in restoration of relevant channel processes, nor were woody species differentially advantaged or disadvantaged by small, short duration floods. Whereas floods of larger magnitude may be impossible due to societal constraints along the Rio Grande, large floods are a possibility along the study reaches of the Green River. Such flooding could provide an efficient means of 'passively' restoring key ecological processes and riparian vegetation along a significant portion of the Upper Green River following removal of *Tamarix*, whereas more 'active' restoration will continue to be necessary along the heavily populated Middle Rio Grande. Such differences in physical setting, geomorphic and hydrologic context, and socio-economic constraints highlight the fact that understanding existing conditions, site history, site potential, and possible successional trajectories ('situational awareness' in military lexicon) are all necessary components of strategic riparian restoration. *Tamarix* removal is only one element toward restoration of native riparian vegetation; in certain settings even its removal may have negative ecological effects.