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Saltcedar (*Tamarix* spp.) and Russian Olive (*Elaeagnus angustifolia*) in the Western United States—A Report on the State of the Science

Dense, saltcedar-dominated riparian vegetation along the lower Colorado River, California and Arizona. Photo: Patrick B. Shafroth.

The Salt Cedar and Russian Olive Control Demonstration Act of 2006 (Public Law 109–320) directs the Department of the Interior to submit a report to Congress that includes an assessment of several issues surrounding these two nonnative trees, now dominant components of the vegetation along many rivers in the Western United States. This report was published in 2010 as a U.S. Geological Survey Scientific Investigations Report (available online at http://pubs.usgs.gov/sir/2009/5247). The report was produced through a collaborative effort led by the Bureau of Reclamation and U.S. Geological Survey, with critical contributions from the U.S. Department of Agriculture and from university researchers.

The document synthesizes the state of the science and key research needs on the following topics related to management of saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) in the Western United States: their distribution and abundance (extent); the potential for water savings associated with controlling these species; considerations related to wildlife use of saltcedar and Russian olive habitat and restored habitats; methods of control and removal; possible utilization of dead biomass following control and removal; and approaches and challenges associated with site revegetation or restoration. A concluding chapter discusses possible long-term management strategies, potentially useful field-demonstration projects, and a planning process for on-the-ground projects involving removal of saltcedar and Russian olive.

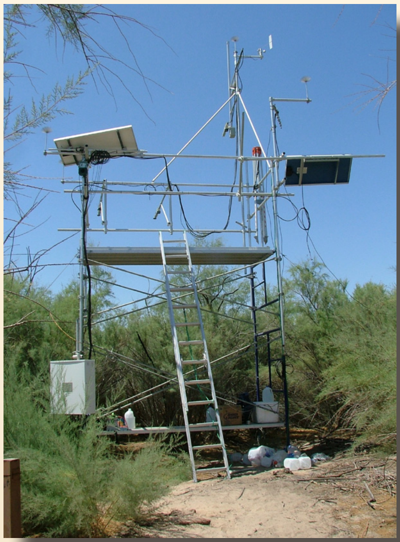
Distribution and Abundance of Saltcedar and Russian Olive in the Western United States

Saltcedar and Russian olive are both broadly distributed throughout the Western United States. An extensive study of native and nonnative riparian plants in riparian areas in the 17 states west of the 100th meridian indicated that saltcedar and Russian olive were the third and fourth most frequently occurring woody riparian plants and the second and fifth most abundant (out of 42 native and nonnative species). The abundance of saltcedar and Russian olive varies across the Western United States; these species can be dominant, codominant, or subdominant relative to native species. Abundance is often determined by environmental factors such as climate, water availability, soil salinity, degree of streamflow regulation, and fire frequency. Habitat suitability maps generated by the National Institute of Invasive Species Science indicate that neither species is currently fully occupying its potential range, suggesting that further spread under current conditions is likely. However, there are

Photograph of mixed riparian vegetation Chinle Wash, Arizona, including native Fremont cottonwood, and nonnative Russian-olive and saltcedar. Photo: Lindsay V. Reynolds.

discrepancies between empirical and modeled distributions of saltcedar because modeled distributions based on habitat characteristics depict potentially suitable habitat for a given species and not its actual distribution. Actual distributions of species are limited by various factors, such as competition with other species, disease, and herbivory, reducing the area that a species actually occupies. Better maps of current distribution and rigorous monitoring of distributional changes through time are needed to resolve differences in predictions of potential future spread.

The Potential for Water Savings Through the Control of Saltcedar and Russian Olive

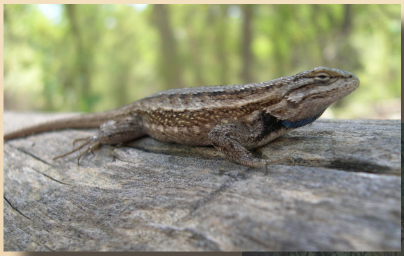


Tower with micrometeorological and eddy covariance sensors for measuring evaportranspiration of riparian vegetation along the lower Colorado River, California. Photo: Pamela L. Nagler.

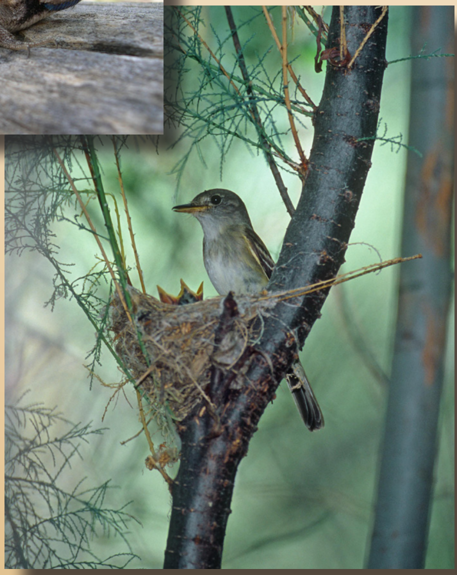
There has been concern for decades that the expansion of nonnative plants such as saltcedar and Russian olive on floodplains has increased water loss by transpiration and thus has reduced river flows and groundwater supplies available for human uses. Contemporary studies of evapotranspiration that use state-of-the-art measurement techniques suggest that mesic native species (for example, cottonwood or willow) transpire about the same or more water than nonnative species. However, because saltcedar may be able to persist on sites that are higher above the water table and too dry for most mesic native species, saltcedar may increase the areal extent of transpiring vegetation at a site and total transpiration-related water losses. Projects that remove saltcedar and Russian olive with the intention of making more water available for beneficial use by reducing evapotranspiration and increasing flow in streams have produced mixed results. Generating water savings through vegetation removal requires long-term replacement of saltcedar and Russian olive with plant communities that transpire less water than saltcedar or Russian olive (xeric species). This is challenging for many reasons. To date, research and demonstration projects have not shown that it is feasible to save significant amounts of water for consumptive use by controlling saltcedar or Russian olive. Future studies of water savings should be designed at a scale large enough to detect changes to the water budget; they should employ measurement methods of sufficient resolution to detect expected changes; and they should cover all significant variables in and natural variation associated with the local water budget. Further, the variable nature of climate in the Western United States requires that the outcomes of removing invasive plants and installing replacement ground cover be examined over a period of many years to fully understand whether water savings are realized.

Saltcedar and Russian Olive Interactions with Wildlife

Although it has long been assumed that saltcedar and Russian olive negatively affect riparian habitat and wildlife, field studies on arthropods, birds, amphibians, reptiles, and mammals indicate that this is not uniformly the case. Some wildlife species utilize habitat dominated by saltcedar or Russian olive, whereas others depend more on native vegetation. Arthropod diversity is typically higher overall in native compared to nonnative vegetation, and arthropod productivity is similar in stands dominated by either native or nonnative species. Saltcedar and Russian olive can have substantial habitat value for a diverse group of birds, particularly generalists. Saltcedar does not provide good habitat for some groups of birds, though, such as timber drillers and cavity nesters. Dense, monospecific stands of saltcedar typically provide much lower quality bird habitat than mixed stands of native vegetation and saltcedar. The Federally listed Southwestern Willow Flycatcher (*Empidonax traillii extimus*) breeds in riparian patches dominated by native trees such as willow (*Salix* spp.), but over half the known breeding sites occur in stands that include saltcedar. Yellow-billed Cuckoos (*Coccyzus americanus*), the western subspecies of which is a candidate for listing under the Federal Endangered Species Act, typically prefer cottonwood-dominated riparian areas for breeding, yet they have been found to breed extensively in the dense saltcedar stands along reaches of the Pecos River in New Mexico (although this population is not considered part of the western subspecies). Many mammals (mainly rodents) utilize saltcedar, Russian olive, and native vegetation, though mammal populations also are influenced by proximity to adjacent, upland habitats. Snakes, lizards, and amphibians utilize mixed stands of cottonwood, saltcedar, and Russian olive, and lizards are not negatively affected by (and may benefit from) the changes in habitat resulting from clearing of nonnative species. Saltcedar and Russian olive control may affect aquatic invertebrate communities by altering the quality and timing of leaf or woody plant material inputs to stream channels. Future research



Prairie lizard (*Sceloporus consobrinus*) in the riparian forest of the middle Rio Grande. Photo: Heather L. Bateman.



Nest and chicks of the Federally endangered Southwestern Willow Flycatcher (*Empidonax trailii extimus*) in a saltcedar shrub on the Salt River, Arizona. Photo: M. Zimmerman.

needs related to the effects of nonnative vegetation control and removal on wildlife include the need for more experimental studies that compare the responses of multiple wildlife taxa in (1) saltcedar and Russian olive-invaded habitats compared with native habitats and (2) saltcedar and Russian-olive removal sites compared with both native and nonremoval sites. There is also a need to determine the effects of nonnative species control on thermal regime and structure of habitats. Research on wildlife responses to saltcedar biological control warrants particular attention.

Methods to Control Saltcedar and Russian Olive

Saltcedar and Russian olive may be controlled using biological, mechanical, chemical, and integrated (multiple) approaches. Each approach has associated advantages, disadvantages, risks, methodologies, and costs. Best management approaches (such as integrated pest management) address whole systems and integrate realistic goals and comprehensive strategies for suppression, prevention, revegetation, maintenance, and monitoring of sites following control. Long-term monitoring and follow-up treatment is necessary, as saltcedar and Russian olive may resprout or reinvade sites, or sites may be colonized by other nonnative species following control measures. Stand and site characteristics (for example, plant density, ground and canopy cover, canopy volume and height, crown diameter, stem count and stem diameter, site access) influence how saltcedar responds to control measures and play a major role in determining the most effective treatment (including the equipment specifications and labor needed, the type of inventorying and monitoring that should be performed, and the range and rate of treatment). Costs depend on local circumstances and treatment method. Saltcedar leaf beetles (*Diorhabda elongata* and other related taxa) are proving to be effective biological control agents for saltcedar and have successfully defoliated saltcedar at release sites in Nevada, Utah, Colorado, and Wyoming over the past several years. However, there are concerns with saltcedar biological control, particularly regarding possible effects on wildlife habitat, but also including biomass disposal (as the beetles leave dead woody vegetation in place), possible herbivory of nonhost plants, and possible increased sediment erosion. Understanding the effects of saltcedar biological control on riparian ecosystems (including the potential for water savings and wildlife population responses) is arguably the most pressing need for research and monitoring.

Extraction and Utilization of Saltcedar and Russian Olive Biomass Following Removal

The biomass (wood) removed following control of saltcedar or Russian olive is a resource that may have a variety of uses. Saltcedar wood has promise as a constituent in particleboard and filler in wood-plastic composites used outside for such things as decking, railings, fencing materials, and sign boards. Neither saltcedar nor Russian olive has been used in making wood pellets for heating; however, saltcedar wood can be made into a marketable charcoal that burns at a temperature comparable to mesquite. Saltcedar and Russian olive biomass might be used to produce "bio oil" used in boilers, turbines, and diesel generators to produce heat and power. The wood of saltcedar is similar in density to maple and oak, is rather inelastic relative to hardwood species, but has strength properties typical of hardwood, making it potentially useful for commercial products. The economic feasibility of using saltcedar or other invasive species commercially depends on a variety of factors, including the costs of harvesting and transporting the material, processing (for example, manufacturing wood flour, chips, or pellets), local pricing of plastics and additives, and the availability of manufacturing facilities. Future work on using dead biomass following control of saltcedar or Russian olive could focus on identifying the harvesting, processing, and utilization challenges that might be unique to each species and addressing problems that may arise when both species are present in a given location. More potentially marketable products may be identified by testing the wood properties of saltcedar and Russian olive, and further testing of some products, such as composites, fuel pellets, and bio oil generated from both species is needed.

Biological control by leaf-eating beetles has resulted in seasonal defoliation of saltcedar in many areas throughout the West, including this stretch of the Colorado River near Moab, UT. Defoliated saltcedar are the rust-colored plants in the midground. Photo: Patrick B. Shafroth.

Restoration and Revegetation Associated with Control of Saltcedar and Russian Olive

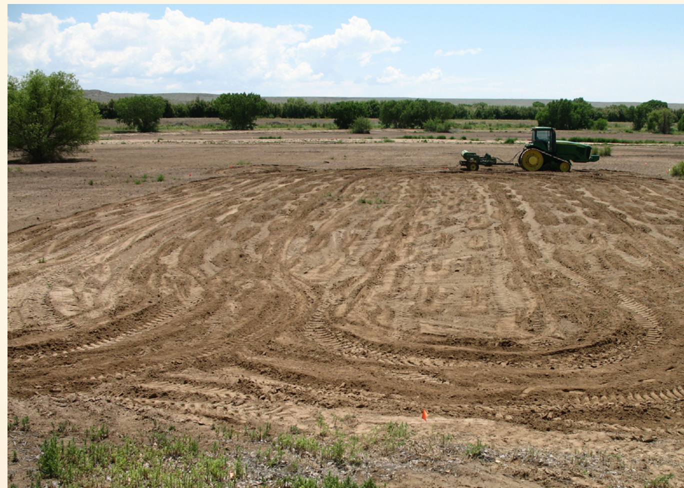
Rationales for controlling or eliminating saltcedar and Russian olive are usually based on assumptions that natural recovery or restoration of native plant communities will follow exotic plant removal. However, control and removal of nonnative species alone does not generally constitute restoration, which in this context may be defined as the conversion of

Natural weathering test rack with extruded composite boards manufactured from saltcedar-, juniper-, and pine-wood flours. Saltcedar boards are those with the darkest coloring. Photo: U.S. Forest Service.

saltcedar- and Russian olive-dominated sites to a replacement vegetation type that achieves specific management goals and helps return parts of the system to a desired state. The historic, current, and future hydrologic and geomorphic characteristics of the site, flood-plain soil characteristics, and other physical and ecological factors influence the potential for replacement vegetation to colonize and become established, and they must be considered to develop clear and realistic goals and objectives, help to prioritize sites for restoration, and guide restoration approaches. Often, management actions are necessary to effect this sort of vegetation change. Two general approaches to restoration are "passive" and "active." Passive approaches (which do not involve active revegetation) include initial invasive species removal, removing or mitigating structures that control channels or flood plains, restoring natural processes such as flooding and associated fluvial processes, or removing stressors that might inhibit native species from becoming established, such as herbivores. Active restoration approaches include site grading, amending the soil, and planting seeds or containerized plants of the desired vegetation. Assessing the outcomes of restoration efforts is crucial and can be accomplished by incorporating experimental components within restoration projects. A commitment to rigorous monitoring over appropriate space and time scales is also necessary. By following the principles of adaptive management, results of such efforts can be used to adjust restoration techniques at a given site and guide efforts at other sites. Future research needs include studies aimed at improving our understanding of which site processes and conditions point to the need for passive versus active restoration approaches. Resource managers need this sort of information to prioritize their restoration activities and make efficient use of limited resources. This may be particularly important in the context of biological control of saltcedar, where the vast areas potentially affected will preclude the widespread application of relatively expensive, active measures.

Demonstration Projects and Long-Term Considerations Associated with Saltcedar and Russian Olive Control and Riparian Restoration

The second phase of *The Salt Cedar and Russian Olive Control Demonstration Act of 2006*, if funded, would allocate funds to demonstration projects that could advance our current understanding of the topics discussed in the other chapters of this report. Many of the information gaps and research needs highlighted in the report could be addressed effectively within the context of carefully designed demonstration projects. However, researchers must recognize the complexity of flood-plain environments across the Western United States and the serious challenge of addressing the many variables that control existing nonnative communities. Well-designed demonstration projects that maximize interdisciplinary connections have great potential to expand our knowledge base, facilitate collaboration, and capitalize on the investment.



Active restoration following nonnative species removal commonly involves site manipulation, which can include grading the soil, seeding, or amending the soil, all of which were done on this site along the Rio Grande in Bosque del Apache National Wildlife Refuge, New Mexico. Photo: by Vanessa B. Beauchamp.

Conducting demonstration projects within an experimental framework enables successes and failures to inform future control and restoration efforts. The potential for transferable knowledge would be increased by using a study framework that could be applied consistently at multiple sites so that results of different demonstration projects could be compared. Studies in a range of climates, valley types, and geomorphic and hydrologic settings, would produce a better understanding of the benefits of restoration efforts across a range of conditions. Accurate assessments of control and restoration outcomes typically take several years to decades to complete as there can be differences in short- and long-term biological and physical responses. Sustaining long-term control and restoration efforts requires long-term funding commensurate with the monitoring goals and likely time scale of system response. Changes in climate and water management also likely will influence the long-term responses of saltcedar and Russian olive to control and restoration activities.

Although there is considerable information available on the biology, distribution, and ecological effects of saltcedar and Russian olive, not all of the system dynamics are well documented and conflicting viewpoints remain. Information generated from carefully designed and implemented demonstration projects can help fill knowledge gaps and improve management of these critical, freshwater-dependent ecosystems in the Western United States.

Contact Information:

Patrick Shafroth
U.S. Geological Survey
Fort Collins Science Center
shafrothp@usgs.gov