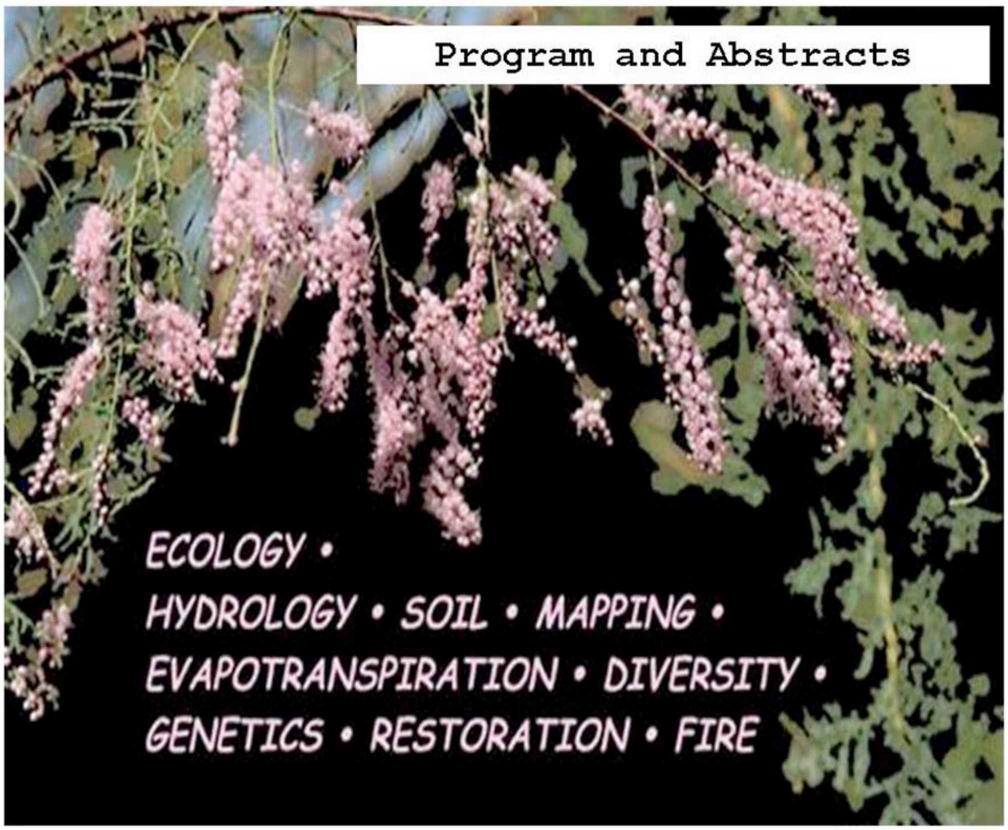
The 2006 Tamarisk Research Conference: Current Status and Future Directions



October 3 & 4, 2006

Fort Collins, Colorado

SPONSORED BY:

- *Colorado State University Agricultural Experiment Station*
- *Tamarisk Coalition*
- *Center for Invasive Plant Management*

and

- *Western Integrated Pest Management Center*
- *USDA Agricultural Research Service*
- *USDA Forest Service, Rocky Mountain Research Station, Stream Systems Technology Center*
- *National Invasive Species Council*
- *World Wildlife Fund*
- *USDA Cooperative State Research, Education and Extension Service*
- *Sandia National Laboratories*
- *US Army Corp of Engineers*
- *US Fish and Wildlife Service*
- *National Park Service*
- *New Mexico Department of Agriculture*
- *BASF Professional Vegetation Management*
- *USGS Western Region*

Tuesday Morning, October 3rd

7:30 - 8:30 Registration

Session 1: Restoration and revegetation

8:30 Bay, Robin F. and Anna A. Sher. Success of active re-vegetation after *Tamarix* spp. removal in Southwestern riparian ecosystems: A quantitative assessment of past restoration projects.

8:50 Beauchamp, Vanessa B. and Patrick B. Shafroth Salinity tolerance and mycorrhizal responsiveness of candidate species for use in restoration of *Tamarix*-dominated xeric riparian areas.

9:10 DeWine, John M. and David J. Cooper. Competition and succession in tamarisk stands: towards biological control using native plants.

9:30 Gieck, Stephanie, A.A. Sher*, S. Nissen, E. Lane, C. Brown, and A. Norton. Re-vegetation obstacles following tamarisk control: cheatgrass invasion and herbicide residues.

9:50 Break

10:10 Shafroth, Patrick B., Vanessa B. Beauchamp, Mark K. Briggs, Kenneth D. Lair, David M. Merritt, Michael L. Scott, and Anna A. Sher. Restoration planning in the context of tamarisk control in the western US.

10:30 Lair, Kenneth D. Key factors and constraints in restoration of native plant communities in arid, monotypic infestations of saltcedar (*Tamarix* spp.) - strategies and techniques.

10:50 Merritt, David M., Mike L. Scott, Bradley J. Johnson. Riparian vegetation response to control of invasive plant species: restoration or retrogression.

11:10 Ogg, Alex G., Steve Christy, and Mike Wille. Response of saltcedar and native grasses to five years of mowing or herbicide applications.

11:30 Tidwell, Vincent C., Jesse D. Roberts, David P. Groeneveld. Systems approach for riparian management.

Session 2: Sedimentation and geomorphic processes

8:30 Mortenson, Susan G., Peter J. Weisberg, and Lawrence E. Stevens. *Tamarix* establishment in Grand Canyon National Park: linking historical aerial photography with flow stage reconstructions.

8:50 Roberts, Jesse D., Scott C. James1, Craig A. Jones, and David Groeneveld. Importance of understanding sedimentation for tamarisk control efforts.

9:10 Alexander, Jason S., Dr. Jack Schmidt, and Dr. Michael Scott. Climate, tamarisk, and river regulation on the Upper Green River of Dinosaur National Monument: hydrologic scenarios for floodplain sedimentation.

9:30 Wilcox, Andrew C., Shafroth, Patrick B. Hydrogeomorphic effects on tamarisk, Bill Williams River, AZ.

9:50 Break

Session 3: Biological control

10:10 Kazmer, David J., C.J. DeLoach, D. Bean, R.I. Carruthers, T.L Dudley, D. Eberts, A.E. Knutson, D.C. Thompson. Biological control of tamarisk: Establishment, population increase, and impacts of *Diorhabda* spp. at experimental release sites in the western US.

10:30 Bean, Dan, Nina Louden, Allard A. Cossé, Robert J. Bartelt, Jerry Shue and Brian Swedhin. Diapause induction limits dispersal of *Diorhabda elongata*.

10:50 Cossé, Allard A., Robert J. Bartelt, Bruce W. Zilkowski, Nina Louden, Daniel W. Bean, Earl R. Andress. Pheromone and host odor attractants for managing *Diorhabda* spp.: biological control agents of saltcedar.

11:10 Dudley, Tom L., Peter Dalin, Robert Pattison, Dan W. Bean, Andrea Caires. Effects of host genotype and condition on performance of *Diorhabda elongata* (Chrysomelidae).

11:30 Dalin, P., T. Dudley, D.C. Thompson, D.W. Bean, D. Eberts, D. Kazmer, J. Michels, P. Moran, J. Milan, C.J. DeLoach. Regional testing of *Diorhabda 'elongata'* ecotypes.

12:00 - 1:30 Lunch (provided)

Anna A. Sher. *Tamarix* as symptom versus driver of ecosystem change: a review of the 2006 Ecological Society of America special session.

Tuesday afternoon

Session 3: Biological control (continued)

1:30 Thomas, Hillary Q. Open field host choice test of *Diorhabda elongata* (Coleoptera: Chrysomelidae) in Northern California.

1:50 Swedhin, Brian, Levi Jamison, Tom L. Dudley, and Daniel W. Bean. Mapping tamarisk biocontrol monitoring sites and the expansion of *D. elongata* populations.

2:10 DeLoach, C.J., A.E. Knutson, P.J. Moran, D. Eberts, G.J. Michels, M. Muegge, D.C. Thompson, D. Richman, J. Sanabria, J.H. Everitt, V. Carney, K. Gardner, J.L. Tracy, T.O. Robbins, J. Hudgeons and R.I. Carruthers. Preliminary success in biological control of saltcedar - Texas/New Mexico.

2:30 Bateman, Heather, Alice Chung-MacCoubrey, Deborah M. Finch, David Hawksworth. Effects of exotic plant removal and fuels reduction on vertebrates along the Middle Rio Grande, New Mexico.

2:50 Break

Session 4: *Tamarix* distribution and ecology

1:30 Follstad Shah, Jennifer J. and Cliff N. Dahm. Soil nitrogen dynamics in stands of *Populus deltoides* ssp. *wislizenii* and *Tamarix chinensis* with differing flood regimes.

1:50 Friedman, Jonathan M., James M. Roelle, Julie Roth, and John F. Gaskin. Evolution of cold hardiness in North American *Tamarix ramosissima*.

2:10 Davern, Tracy. Modeling invasive species using remote sensing: an example using *Tamarix*.

2:30 Siemion, Gibney M. and Lawrence E. Stevens. Tamarisk flowering and seed release phenology in relation to climate and Colorado River hydrography.

2:50 Break

3:10 Reynolds, Lindsay V. Invasion process of tamarisk and Russian olive into Canyon de Chelly National Monument.

3:30 Shafroth, Patrick B. Environmental flows for riparian restoration and *Tamarix* management.

3:50 - 5:00 Breakout Sessions for Sessions 1, 2, 3, & 4.

5:00 - 6:30 Poster Session. Appetizers & Cash Bar.

Wednesday Morning, October 4th

Session 5: *Tamarix* water use

8:00 Cleverly, James R., Michael Slusher, James R. Thibault, Jennifer Schuetz, and Clifford N. Dahm. Drought, restoration, and evapotranspiration in the Middle Rio Grande riparian corridor, New Mexico.

8:20 Groeneveld, David P., Dave Barz, Jesse D. Roberts. ET Estimation by remote sensing and GIS approaches for management.

8:40 Hart, Charles R., M. Keith Owens, and Georgianne W. Moore. Saltcedar management on the Pecos River in Texas: 1999-2005.

9:00 Kluitenberg, Gerard J., James J Butler, Donald O Whittemore, Dave Arnold. Quantifying ground-water savings achieved by tamarisk control: A demonstration project in the riparian zone of the Cimarron River, Kansas.

9:20 Nagler, Pamela L., Edward Glenn, Kamel Didan, Doyle Watts, John Osterberg, and Jack Cunningham. Evapotranspiration by tamarisk from three 1-km^2 sites at Cibola NWR on the lower Colorado River.

9:40 Break

10:00 Pattison, Robert R., Carla M. D'Antonio, Tom Dudley, Kip Allande. Impacts of the saltcedar leaf beetle on saltcedar (*Tamarix* spp.) water use in central Nevada.

10:20 Stein, Josh S., David P. Groeneveld, Jesse D. Roberts. Groundwater modeling aspects to estimate water salvage.

10:40 Break

Session 6: Chemical control strategies

8:00 Beck, George and James R. Sebastian. Using sulfonylurea herbicides to control tamarisk.

8:40 Christy, Stephen J. Control of individual saltcedar plants with herbicides.

9:00 Franco, Jose G., Kirk McDaniel, Brent Tanzy, and Keith Duncan. Management of saltcedar regrowth with carpet-roller applied herbicide.

9:20 Lee, Barney G. Precision Application of Aerially Applied Herbicide

9:40 McDaniel, Kirk, Charles R. Hart, and Alan McGinty. Saltcedar control with rotary and fixed wing aircraft.

10:00 Nissen ,Scott J., Galen R. Brunk, and Dale L. Shaner. Aerial application methods to reduce imazapyr impacts on riparian restoration.

10:20 Westra, Philip. Novel herbicide combinations for tamarisk control with minimal ecosystem impact.

10:40 Break

11:00 - 12:30 Research needs in tamarisk: Managers' perspectives

11:00 Hanson, Leanne, Patrick B. Shafroth, and Frank D'Erchia. Tamarisk research priorities of land and water managers: results from a USGS partnership meeting.

11:30 Dello Russo, Gina, Bosque del Apache National Wildlife Refuge. Research needs on the middle Rio Grande: Management changes in response to a changing environment.

12:00 Van Landingham, Shelly, Colorado State Forest Service. Research needs in my world (i.e. Southeastern Colorado).

12:30 - 1:30 Lunch (provided)

Lori Williams, Nation Invasive Species Council. National Invasive Species Council: What we are and what we do.

Wednesday Afternoon

Session 7: *Tamarix* impacts on native species

1:30 Paradzick, Charles E. and Julie C. Stromberg. Basin-scale hydrology, vegetation, and patch selection by the southwestern willow flycatcher along the Lower San Pedro and Gila Rivers, Arizona.

1:50 Moline, Angela B. and LeRoy N. Poff. Native and exotic riparian leaf litter as food for aquatic macroinvertebrates: Tamarisk, cottonwood, and Russian olive

2:10 Sogge, Mark K., Eben H. Paxton1, and Susan J. Sferra. The suitability of tamarisk as habitat for riparian breeding birds; data and perspectives from the Southwest.

2:30 Longland, William S., Tom L. Dudley, Derek Hitchcock, Daniel Harmon. Effects of tamarisk invasion and biological control on birds.

Session 8: Modeling and synthetic approaches

1:30 Kumar, Sunil, Paul Evalgelista, Thomas Stohlgren, Alycia Crall, Greg Newman. Modeling aboveground biomass of *Tamarix* (*Tamarix ramosissima)* in the Arkansas river basin in southeastern Colorado, USA.

1:50 Dionigi, Chris P. The National Invasive Species Council: Up-date and *Tamarix* economics-based planning tool development.

2:10 Lair, Kenneth D., Anna A. Sher, Scott O'Meara, and Michelle K. Cederborg. Native species displacement and dominance by saltcedar (*Tamarix* spp.) over time - is it a continuous, linear process? A conceptual framework for assessing ecological restoration potential, strategies and techniques.

2:30 McGinty, Allan, Ben Brooks, Jack DeLoach, Allen Knutson, Mark Muegge and Okla Thornton. Upper Colorado River saltcedar management program.

2:50 - 4:00 Breakout Sessions for Sessions 5, 6, 7 & 8.

Posters

Ament, Nathan, Mac Lewis, Tim Carlson, Paul Evangelista, Tom Stohlgren. Comprehensive inventory and mapping of tamarisk within Colorado's river systems and major tributaries -- protocols, results, lessons learned, costs, and information dissemination.

Bowser, Steven, Al Brower, Dan Cooper, Bill Eichinger, John Prueger, Larry Hipps, and Salim Bawazir. The ET Toolbox: A Practical Application of LIDAR Saltcedar Research

Carrithers, Vanelle F., Mary Halstvedt, Tom Whitson, and Alex Ogg. Control of saltcedar using Triclopyr.

Christy, Steve, Alex Ogg, and Mike Wille. Restoration of Big Horn River floodplain after removal of heavy infestations of saltcedar and Russian olive.

Drus, Gail M., Tom L. Dudley, and Matt L. Brooks. Does herbivory enhance fire induced mortality?

Dunn, James M., Lenae Fonte, and Alyson Graffis. Connecting growth rates of *Tamarix ramosissima* to river discharge in two western Colorado rivers.

Gaskin, John F. and Patrick B. Shafroth. Hybridization of *Tamarix ramosissima* and *T. chinensis* (saltcedars) with *T. aphylla* (Athel) (Family Tamaricaceae) in the southwestern USA determined from DNA sequence data.

Gaskin, John F. and David J. Kazmer. Comparison of ornamental and wild saltcedar *Tamarix* Spp. along eastern Montana riverways using chloropast and nuclear DNA sequence markers.

Hansen, Richard W. and William C. Kauffman. Implementing biological control of saltcedars using *Diorhabda elongata*: the USDA-APHIS-PPQ cooperative release program in the western US.

Hendrick, Kelly D. Mapping *Tamarix* for the Canadian River Riparian Restoration Project.

Hudgeons, Jeremy L., Allen E. Knutson, Kevin M. Heinz, C. Jack DeLoach, and Tom L. Dudley. Effects of herbivory by *Diorhabda* leaf beetles on carbohydrate reserves of tamarisk.

Hummel, Ondrea. Middle Rio Grande Bosque Restoration Projects, U.S. Army Corps of Engineers, Albuquerque District.

Jashenko, R.V., I.D. Mityaev, C.J. DeLoach. New potential agents for tamarisk biocontrol in US.

Kennaway, Lisa. Evaluating remote sensing tools for mapping the distribution of saltcedar (*Tamarix* spp.) in a biocontrol study site.

Kerns, Becky K., Catherine G. Parks, Bridgett J. Naylor, Alan A. Ager, and Jerome S. Beatty. Tamarisk in the Pacific Northwest: Assessing reality and risk.

Knutson, Allen, Mark Muegge, and C. Jack DeLoach. Implementing biological control of *Tamarix* with leaf beetles in West Texas.

Locke, Terri, Nina Louden, Brian Swedhin1, and Richard Hansen. Collection, storage and release of *Diorhabda elongata* for the biocontrol program of tamarisk.

Medina, Alvin L., Tyler D. Johnson, and Jackson M. Leonard. Influence of saltcedar and associated woody vegetation on channel geomorphology of the upper Verde River.

Owens, Keith M. and Georgianne W. Moore. How much water can a tree really use?

Petersen, Beth and David Thompson. Effects of mixing Greek and Chinese saltcedar leaf beetles in large field cages.

Rice, Nicholas A., Shanahan A. Seth, Keiba Crear. *Tamarix* removal for successful native revegetation along the Las Vegas Wash, Clark County, Nevada.

Richards, Ruth and Dr. Ralph E. Whitesides. Saltcedar control by grazing with goats compared to herbicides.

Sanabria, J., C.J. DeLoach, J.L. Tracy, and T.O. Robbins. Modeling of *Diorhabda elongata* dispersal during the initial stages of establishment for the control of *Tamarix* spp.

Sanabria, J., J.L. Tracy, T.O. Robbins, and C.J. DeLoach. Use of morphometrics and multivariate analysis for classification of *Diorhabda* ecotypes from the Old World.

Stromberg, Julie C., Sharon J. Lite, Charles Paradzick, and Patrick B. Shafroth. *Tamarix* Abundance in arid basins of Arizona reflects prevailing hydrology.

Valencia, R.A. and C.E. Paradzick. Southwestern willow flycatcher mitigation land management and Endangered Species Act requirements: implications of salt cedar control.

Wille, Mike, Steve Christy, and Alex Ogg. Control of saltcedar with Pasturegard and other herbicides in north central Wyoming.

Williams III, Livy, Keirith A. Snyder, William S. Longland, Robert R. Blank, James A. Young, and Raymond I. Carruthers. Biologically-based integrated management of saltcedar on western rangeland watersheds.

Climate, tamarisk, and river regulation on the Upper Green River of Dinosaur National Monument: hydrologic scenarios for floodplain sedimentation (Session 2)

Jason Alexander[1], Dr. Jack Schmidt[1], and Dr. Michael Scott[2].
[1]Utah State University. jsalexander@cc.usu.edu. [2]USGS

Comprehensive inventory and mapping of tamarisk within Colorado's river systems and major tributaries -- protocols, results, lessons learned, costs, and information dissemination (Poster)

Nathan Ament[1], Mac Lewis[2], Tim Carlson[3], Paul Evangelista[4], Tom Stohlgren[5]
[1,2,3]Tamarisk Coalition, Grand Junction, CO 81502. nament@tamariskcoalition.org, mlewis@tamariskcoalition.org, tcarlson@tamariskcoalition.org. [4]National Institute of Invasive Species Science, Natural Resource Ecology Lab, Fort Collins, CO 80523. paulevan@nrel.colostate.edu. [5]USGS, National Institute of Invasive Species Science, Fort Collins, CO 80523. toms@nrel.colostate.edu

Abstract:

Quantifying and characterizing the tamarisk infestations on each major river system in Colorado provides useful information that is utilized by many diverse groups. The resulting data produced by this inventory is vital to effective land management, water management, and tamarisk control efforts. In the initial phase of the survey, land managers, county weed managers, private land owners and other knowledgeable experts were consulted in order to collect existing quantity and location data regarding tamarisk in their respective areas. Following this contact survey, the observational component of the study was executed by a two person team coupling field techniques with the utilization of GIS software to produce a detailed comprehension of the tamarisk infestation in Colorado. The areas of focus in this inventory were major river systems in Colorado including: the Colorado, Arkansas, Purgatoire, Uncompahgre, Animas/ La Plata, Dolores, White, South Platte, Republican, Gunnison, Yampa, Rio Grande, and most major tributary creeks. In order to possess representative imagery of these areas in question, high resolution aerial photographs from 2005 were acquired from the USDA National Agriculture Imagery Program. After consultation of local authorities, the two person mapping crew performed on-the-ground verification of the tamarisk infestations visible in the aerial imagery with the goal of 85-90% accuracy. This information was then recorded in digital GIS format. The resulting data set is a collection of photos, quantity / location data, and other useful attributes.

By creating a sufficiently accurate, low-cost inventory tamarisk mapping method in Colorado, this study sets a functional example for future mapping efforts in other states. Additionally, the data set has been used for the following uses: utilization in conjunction with newly developed cost models to provide cost estimates for removal/ revegetation efforts, incorporation with tamarisk water-use models to calculate overall water losses, and integration with above-ground biomass models (NIISS, NREL-CSU) to generate biomass estimates for tamarisk infestations.

Effects of exotic plant removal and fuels reduction on vertebrates along the Middle Rio Grande, New Mexico (Session 3)

Heather L. Bateman[1], Alice Chung-MacCoubrey-, Deborah M. Finch[1], David Hawksworth[1]
[1]Biology Department, University of New Mexico, Albuquerque, NM hbateman@unm.edu, achungmaccoubrey@fs.fed.us, dfinch@fs.fed.us, dhawksworth@fs.fed.us

Abstract:

Riparian cottonwood forests of the Middle Rio Grande have been severely invaded by exotic tree species, which, in combination with large accumulations of woody debris, make these forests prone to catastrophic, stand-reducing fires. Land managers need effective methods that eliminate fuel loads and invasive plants with minimal impacts on native vegetation and wildlife. As a component of a larger study, this project is evaluating the effects of fuels reduction and invasive plant removal on herpetofauna, avifauna, and bat communities. Here we present preliminary analyses of the first 6 years of this study. In 2000, we established 12 study sites and a randomized block design (4 treatments, 3 replicates). Pre-treatment data were collected from 2000-2003, and post-treatment data were collected from 2003-2006. We used pitfall and funnel traps to monitor reptile and amphibian populations, Anabat detection systems to monitor bat activity, and point count stations to estimate abundance and density of birds. The reptile and amphibian community was dominated by upland species rather than riparian obligates, and species composition did not change significantly after treatment. Based on principal components and regression analysis, 5 of 6 lizard species were

less abundant in dense, cluttered, and invaded understories or more abundant in habitats with few exotics. Restoration treatments do not appear to have a negative impact on existing lizard populations. Using minutes of recorded bat activity as an index of relative site use, we determined that treatments increased summer bat activity (more minutes of activity) relative to untreated sites. Birds were placed into four nesting guilds. Overall bird species richness did not change in response to treatment; however there were species-specific responses to treatments. Three mid-story nesting species and one ground-shrub nesting species showed declining abundance from treatments, whereas cavity nesting and canopy nesting species were not affected by treatments.

Success of active revegetation after *Tamarix* spp. removal in Southwestern riparian ecosystems: A quantitative assessment of past restoration projects (Session 1)

Robin F. Bay[1] and Anna A Sher[1,2]

[1]Department of Biological Sciences, University of Denver, Denver, Colorado 80208 USA. [2] Department of Research, Herbaria, and Records, Denver Botanic Gardens, Denver, Colorado 80206

Abstract:

Infestation by the non-native tree *Tamarix* spp. has made habitat restoration projects necessary to maintain the ecological integrity of many riparian communities in the Southwest. These restoration projects may include *Tamarix* removal, manipulation of hydrographs, and active revegetation of native species. There is no single strategy for achieving success in these projects; rather success will vary by site based on specific site characteristics and methods used. Revegetation success, plant species diversity, and vegetative cover were evaluated at 28 sites in New Mexico, Arizona, and Nevada where active revegetation was completed after *Tamarix* removal. These data were incorporated into regression tree models with predictor variables that included number of years since removal (1-18 years) and multiple management, climate, soils, and hydrological variables to determine success of *Tamarix* control, revegetation success, and plant community responses. Our results suggest that there are easily measurable site characteristics that lead to greater native cover and richness, planting success, and *Tamarix* control. Lower soil salinity and pH and coarser soil texture as well as proximity to permanent water, sufficient precipitation, and good drainage all favored native species. Additionally, success increased with time since *Tamarix* removal, both increasing native cover and richness and decreasing *Tamarix* cover. Overall, those site characteristics that promoted native species success were the same as those that contributed to a lower cover of *Tamarix*. These quantitative models are intended to assist researchers and land mangers to design more effective riparian restoration efforts in this critical arid lands ecosystem.

Diapause induction limits dispersal of *Diorhabda elongate* (Session 3)

Daniel W. Bean[1], Nina Louden[1], Allard A. Cossé[2], Robert J. Bartelt[2], Jerry Shue[1] and Brian Swedhin[1]

[1]Colorado Department of Agriculture, Biological Pest Control, Palisade Insectary, 750 37.8 Road, Palisade, Colorado 81526. dan.bean@ag.state.co.us, ninalouden@hotmail.com, shue.jerry@gmail.com, bswedhin@hotmail.com. [2]USDA Agricultural Research Service National Center for Agricultural Utilization Research Crop Bioprotection Research Unit 1815 N. University Street Peoria, Illinois 61604. bartelrj@ncaur.usda.gov, cosseaa@ncaur.usda.gov

Abstract:

In this study we investigated the role of the developmental state of adult *Diorhabda elongata* (diapause or reproductive) in determining dispersal behaviors as well as dispersal-associated behaviors such as release of aggregation pheromones under laboratory conditions and response to pheromones and plant volatiles in the field.

The induction of reproductive diapause in *D. elongata* occurs under daylengths less than about 14 hr 40 min while most of the population will be reproductive at longer daylengths. This occurs in laboratory reared insects as well as in field populations. The developmental path of laboratory reared insects can be controlled by simple manipulation of photoperiod and in the field the decrease of daylength in the summer induces hibernal diapause.

On live plants, under controlled temperature and photoperiod, adult beetles showed a significantly higher percentage of dispersal behaviors (flight and attempted flight) under long days (16L:8D) than under short days (12L:12D). Under long days the dispersal behaviors were significantly more frequent late in the day than in the morning. In addition the short day treated insects ceased feeding and moved from the plants to the leaf litter beneath the plants after about 15 days. Males emitted the aggregation pheromone blendb at a rate approximately 100 times greater under long days than under short days. These laboratory based results suggested that dispersal,

aggregation and mating would be dependent on long day photoperiods and thus developmental state in the field.

Dispersal and developmental state of *D. elongata* populations were monitored during two different years at two different field sites. First, at the Lovelock, NV release site beetles were monitored during the summer of 2003. Diapause was induced in early August and the expansion of the population slowed and ceased by August 25. At two field sites on the Colorado River the rate of tamarisk defoliation and the movement of beetles were greatest in July and early August of 2006. By mid August the beetles had reached the full extent of their summer dispersal, defoliation slowed, and most of the population entered diapause.

Diapause-destined beetles still flew from defoliated areas to nearby areas that had green foliage. Using traps baited with green leaf volatilesc or with pheromone we found that the ecological context of diapause destined beetles dictated dramatically different responses to attractants. Adult beetles moving through defoliated areas were strongly attracted to plant volatiles and weakly attracted to the pheromone mixture. In areas adjacent to defoliated trees, where beetles were extremely abundant on green foliage, there was no attraction to either pheromones or green leaf volatiles.

From these results we conclude that reproductive adults are the main dispersal agents in this species. They show dispersal behavior even in the presence of green foliage and our observations indicate that they have at least two different dispersal modes; short distance reproductive swarming and long distance flights. These may be related to population density or resource availability; this is an area for further investigation. As adults enter diapause dispersal is limited to the search for green foliage. Hungry adults are attracted to green leaf volatiles and when they find suitable foliage they remain there, feed and eventually drop to the leaf litter for overwintering.

These results add to an understanding of dispersal in *D. elongata*. The shift in behavior that comes with diapause can be incorporated into predictive dispersal models. Collection of large numbers of insects for biocontrol implementation will be aided by a better understanding of when and where aggregations may be found.

[a]Bean et al. 2006. Environ. Entomol. in press; [b]Cossé et al. 2005. J. Chem. Ecol. 26:1735-1748; [c]Cossé et al. 2006. J. Chem. Ecol. in press.

Salinity tolerance and mycorrhizal responsiveness of candidate species for use in restoration of *Tamarix* -dominated xeric riparian areas (Session 1)

Vanessa B. Beauchamp[1], Patrick B. Shafroth1
[1]US Geological Survey, Fort Collins, CO, 80526. vanessa_beauchamp@yuma.acns.ColoState.EDU, pat_shafroth@usgs.gov

Abstract:

Thousands of hectares of riparian vegetation dominated by *Tamarix* have been controlled in the southwestern United States, using a combination of strategies including herbicide application, burning and mechanical removal. There is substantial scientific knowledge and numerous case studies that can inform revegetation of relatively mesic riparian sites with native cottonwood and willow. However, revegetation of upper floodplain or “xeric riparian” areas, where over bank flooding is impossible, soil salinity is high, groundwater is deep and mycorrhizal fungal symbionts are potentially absent, still presents a significant challenge to riparian land managers along the Rio Grande and other southwestern rivers. Our research aims to address this knowledge gap by identifying suitable native plant species and revegetation techniques for these xeric riparian sites. Components of this study include: 1) identification of candidate native plant species and communities via characterization of reference sites, review of historical botanical accounts of the Rio Grande valley, and communication with restoration practitioners; 2) germination trials where seeds of candidate native species are germinated in solutions of differing salinity levels; 3) greenhouse trials to examine the effect of salinity and mycorrhizal fungi on seedling survival and growth; and 4) field experiments testing the efficacy of various revegetation methods in soils of varying texture and salinity. Results from these experiments will be used to develop cost-effective protocols aimed at restoring xeric riparian shrubland and grassland communities.

Tamarisk control with sulfonylurea herbicide tank mixes (Session 6)

George Beck[1] and James R. Sebastian[1]
[1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523. George.Beck@colostate.edu, jseb@lamar.colostate.edu

Abstract:

A great deal of research has been conducted to evaluate herbicides to control tamarisk before revegetation efforts. The most efficacious treatment to date is imazapyr (Habitat) plus glyphosate (Rodeo) at 0.5 lb ai + 0.5 lb ai/A (Habitat plus Rodeo at 1 qt + 12 fl oz/A). The cost of this treatment is about $72/A. Sulfonylurea herbicides have the same mechanism of action as imazapyr and might provide equivalent control and typically cost less than imazapyr. Sulfonylurea herbicides at this time could only be applied to areas not immediately adjacent to water. An experiment was established to evaluate sulfonylurea herbicide tanks mixes to control tamarisk. The location was near Berthoud, Colorado where tamarisk surrounds a small lake about 50 acres in size. Herbicides were applied on September 16, 2005 through a CO_2 pressurized backpack sprayer at 30 gallons per acre. Tamarisk was about 4 ft tall and 100% green at application, a result of mowing 12 months earlier. Herbicides evaluated included metsulfuron plus dicamba plus 2,4-D at 1.0 oz ai + 0.87 lb ai + 2.4 lb ai (Escort plus Rangestar at 1.67 oz product plus 6.7 pt/A); metsulfuron plus triclopyr at 1.0 oz ai + 2.0 lb ai/A (Escort plus Remedy at 1 oz product plus 2 qt/A); chlorsulfuron plus triclopyr at 1.0 oz ai + 2.0 lb ai/A (Telar plus Remedy at 1.33 oz product plus 2 qt/A); imazapyr plus triclopyr at 0.5 lb ai + 2.0 lb ai/A (Habitat plus Remedy at 1 qt + 2 qt/A); and imazapyr plus glyphosate at 0.5 lb ai + 4 lb ai/A (Habitat plus Roundup at 1 qt + 4 qt/A). A crop oil concentrate was added to all treatments at 1% v/v (equivalent to 1 gallon per 100 gallons of spray solution). Herbicide treatments in this experiment cannot be used in water. At 8 months after treatments (MAT) were applied, all herbicide combinations controlled 87 to 100% of tamarisk and caused 10 to 90% injury to sedges. Treatments began to break at 11 MAT. Metsulfuron plus dicamba plus 2,4-D, metsulfuron plus triclopyr, and chlorsulfuron plus triclopyr controlled 55 to 68% of tamarisk 11 MAT and caused 20 to 40% sedge injury. Imazapyr plus triclopyr controlled 91% of tamarisk and caused 100% injury to sedges 11 MAT while imazapyr plus glyphosate controlled to 93% of tamarisk and caused 90% sedge injury at the same time frame. The sulfonylurea herbicide tank mix treatments clearly would have to be re-applied at 12 MAT thus, adding to the expense of management. However, sedge injury from the sulfonylurea herbicide tank mixes was much less than the imazapyr tank mixes and could save money on seed mixes for revegetation. Use of sulfonylurea herbicides and their tank mixes need more evaluation before recommending them to control tamarisk.

The ET Toolbox: A practical application of LIDAR saltcedar research (Poster)

Steven Bowser[1], Al Brower[2], Dan Cooper[3], Bill Eichinger[4], John Prueger[5], Larry Hipps[6], and Salim Bawazir[7]

[1]Bureau of Reclamation, Albuquerque Area Office, Albuquerque, NM 87102. sbowser@uc.usbr.gov. [2]Bureau of Reclamation (retired), Technical Service Center, Denver, CO, 80225. abrower@do.usbr.gov. [3]Las Alamos National Laboratory, Las Alamos, NM, 87545. dcooper@lanl.gov. [4]University of Iowa, Iowa City, IA, 52242. william-eichinger@uiowa.edu. [5]U.S. Department of Agricuture - Agricultural Research Service, National Soil Tilth Laboratory, Ames, IA, 50011. Prueger, John, prueger@nstl.gov. [6]University of Utah, Logan, UT, 84322-4820. biomet@cc.usu.edu. [7]New Mexico State University, Las Cruces, NM, 88003. abawazir@nmsu.edu

Abstract:

In order to properly manage water resources in the western U.S. we need to quantify saltcedar water use. Reliable quantitative information about the ET of tamarisk has been lacking. Our goal is to quantify ET rate estimates, and use the information to improve the ET Toolbox. The common question posed is how much water does saltcedar use. Unfortunately, the question is typically never sufficiently qualified to allow for a meaningful response. We have and can answer this question – on a site specific and real-time basis.

The method utilized to answer this and related ET questions, is the use of the only scanning Raman light distance and ranging (LIDAR) system in existence. The industrial laser, scanning mirror, receiving telescope and control system were constructed by Las Alamos National Laboratory. The field portable system is currently operated by the University of Iowa. The system essentially captures and images the real-time 3-dimensional moisture field above the canopy, and back-calculates the ET rate necessary to produce the atmospheric moisture conditions captured in the scan images.

A slightly more in-depth discussion of the method begins with the production of the laser, which is eye-safe when it leaves the scanning mirror, from high voltage electrical excitation of several rare gases. Laser pulses are emitted at the rate of 150 per second as the system scans vertically and horizontally above the area of interest, collecting approximately one-gigabyte of return data per day of operation. Return data for nitrogen and water collected by telescopes allow calculation of the

Raman shift, and known mixing ratios allow for the creation of three-dimensional time dependent moisture fields over a region of several hundreds of meters.

The system allows the user to create and display the time-dependent atmospheric moisture conditions, allowing visualization and correlation with generally available weather and water availability parameters.

The LIDAR was deployed over cottonwood and saltcedar at the Bosque del Apache Wildlife Refuge, NM, in two campaigns, each lasting several weeks, and has also been deployed over Elephant Butte reservoir near Truth or Consequences, NM, and along the Rio Grande in Albuquerque, NM. The LIDAR system has also been deployed at other national and international sites.

The calculated ET values in the Bosque del Apache indicated that the dense saltcedar uses more water than the plantation cottonwood at the site. On a same day basis, the *Tamarix* ET was two to four times that of the cottonwood. The rates of ET calculated by the LIDAR were compared to eddy covariance measurements made at two locations in the Tamarisk stand. There was reasonable agreement between the two approaches, suggesting that the LIDAR estimates were reliable.

However, there is no single "rate" and there is no meaningful "average" that describes saltcedar ET as a generalization. Only site and time-specific qualified data are useful in describing these parameters. Monotypic saltcedar which is homogeneous to the eye and an infrared camera has many simultaneous, geographically distinct and variable ET flux rates within a stand. Point source measurements can not capture the geographic and temporal variability clearly distinguishable in LIDAR scans.

The LIDAR research presented here has supported numerous improvements to the accuracy of ET Toolbox (http://www.usbr.gov/pmts/rivers/awards/), a water management decision support tool and direct data feed for the Upper Rio Grande Water Operations Model (URGWOM). Both the ET Toolbox and the URGWOM are necessary for water management decisions in a basin where ~67% of the surface water depletions are temporally variable and ET related.

The research tool described here allows the researcher to directly 'see' and measure ET from a target site/population. In specific locations under specific conditions, two or more target populations can be directly compared to answer the questions regarding comparative rates, or the effects of management can be directly measured over time.

Control of saltcedar using triclopyr (Poster)

Vanelle F. Carrithers[1], Mary Halstvedt[1], Tom Whitson[2] and Alex Ogg[3]
[1]Dow AGroSciences, LLC, Mulino, OR 97042 and Billings, MT 59106. vfcarrithers@dow.com, mbhalstvedt@dow.com.
[2]University of Wyoming (retired), Powell, WY 82435. dwhitson@vcn.com. [3]USDA-ARS (retired), Ten Sleep, WY 82442. ogga@tctwest.net

Abstract:

Saltcedar is a rapid growing non-native deciduous tree reaching a height of 20 feet at maturity. It is one of the most invasive, hard-to-control woody plants in the world, is the fourth most important species listed on the Federal Noxious Weed List, and has been recorded in 15 western states. Introduced from Eurasia into the western United States in the early 1800's, this plant rapidly spreads along rivers, lakes and streams and quickly out-competes desirable vegetation capturing valuable and limited site resources. Most importantly, saltcedar can utilize the water resource, up to 200 gallons per plant per day.

Systemic herbicides are one of the most effective methods to control infestations. The optimum herbicide is one that will control saltcedar and not harm desirable grasses and other vegetation. Once saltcedar is controlled, the site should be monitored for resprouting or new seedlings and site restoration can begin. Triclopyr, a selective broadleaf herbicide, is the active ingredient in Garlon™ 3A, Garlon 4 and Remedy™ herbicides. Triclopyr amine is also registered as an aquatic use herbicide (currently sold as Renovate™, some aquatic uses on the Garlon 3A label). Triclopyr has several characteristics that make it a unique fit for control of saltcedar: (1) it does not control monocot species (grasses) so these desirable plants are left to grow, reproduce, and become competitors with saltcedar resprouts and seedlings; (2) Garlon 3A has riparian uses on the label allowing for use around water; (3) it can be used in various application techniques allowing for use almost anytime year round; and (4) it has minimal soil residual so restoration can begin soon after application. Triclopyr is also sold in a combination product, Pasturegard™, with fluroxypyr, another selective herbicide active ingredient.

The information presented here is based on field experience since the mid-1980's along with some new data. Test results found that the most consistent results were with applications applied to individual saltcedar plants by cut stump, basal bark or high volume foliar applications. Basal bark and cut stump applications can be made at any time during the year as long as the stems are not under water or snow, as long as the herbicide does not freeze when applied, and the tree is not frozen. The standard recommendations are: (1) cut stump (treated within 1 hour after cutting) of mixture of 50% herbicide (Garlon 3A, Garlon 4) and 50% water or a mixture of 25-33% of Garlon 4 or Remedy in an oil carrier; or (2) basal bark applications of Garlon 4 or Remedy at 25-33% in an oil carrier applied to the lower 15-18 inches of stem applied any time of the year, except when the bark is wet, frozen, or frost is present on stems.

Research in Wyoming has shown promise with applications of Remedy on resprouting saltcedar after cutting. Treatments were applied in August 30, 2002 using a backpack sprayer at 25 psi on resprouts 6 to 12 inches tall. The trial site had been mowed with tractor-mounted Brush Hog on July 23, 2002. There was a moderately dense stand of alkali sacaton in the plot area. Plots were 12 feet wide by 60 feet long with 3 replications of (1) Remedy: 1 qt + 3 qts basal oil; (2) Vista™ (fluroxypyr alone): 1 qt + 3 qts basal oil; or (3) Stalker† (imazapyr): 12 oz + 3.63 qts of basal oil and were compared with untreated plots. At 11 months and 2 years after treatment, respectively, results showed control at 99/97% for Remedy, 100/100% for Vista and 98/98% for Arsenal† (Habitat† - both imazapyr). It was of great interest that the alkali sacaton was least effected by the Vista (86% cover after 2 years) and Remedy (76% cover), versus the Arsenal (44% cover).

Other current research in Wyoming has shown that basal bark applications of Remedy at 25% or Pasturegard at 25% in a basal oil carrier have excellent control at 2 years after treatment. Applications were made on November 4, 2002 with a backpack sprayer and single nozzle at 25 psi. Plants were mostly 6 to 8 feet tall, mature and had numerous dormant shoots. Results at 2 years after treatment showed 100% control of treated plants for Remedy and Pasturegard compared with 67-83% for Stalker at application rates of 7.8 or 15.6%.

†Trademark of BASF Corporation

Control of individual saltcedar plants with herbicides (Session 6)

Steve Christy[1], Alex Ogg[2] and Mike Wille[3]

[1]Big Horn Basin Exotic Plant Steering Committee, Worland, WY, 82401. schristy@yahoo.com. [2]Big Horn Basin Exotic Plant Steering Committee, Ten Sleep, WY, 82442. ogga@tctwest.net. [3]Fremont County Weed and Pest District, Riverton, WY, 82501. mwille@wyoming.com

Abstract:

Field experiments were conducted in northern Wyoming in 2002 through 2004 to determine the best herbicide treatments for killing individual plants of saltcedar (Tamarisk). Herbicides were applied as foliar summer sprays or as dormant-season, basal-bark treatments to individual plants of saltcedar. Nontreated controls were included in all experiments and all treatments were replicated on six plants. Foliar sprays were applied to small saltcedar plants (3 to 4 feet tall with 3 to 6 stems) on July 29, 2002 using a hand-held, backpack sprayer equipped with a single cone-jet nozzle and operated at 25 psi. Sprays were applied to wet plants thoroughly. A power sprayer equipped with a handgun nozzle and operated at 50 psi was used to apply herbicides to individual, large saltcedar plants (6 to 8 feet tall with 10 to 20 stems) on August 15, 2002. Sprays were applied to wet plants thoroughly. A handheld, backpack sprayer equipped with a single cone-jet nozzle adjusted to apply a thin stream of liquid and operated at 25 psi was used to apply dormant-season, basal-bark treatments on either November 4, 2002 or on April 8, 2003. Bark oil was used as a carrier solution for all basal-bark treatments. Saltcedar plants were 6 to 8 feet tall and had 10 to 20 stems. Sprays were applied to wet the lower 1-foot of the plant and the entire circumference of all stems. One year after application, Vista™ (fluroxypyr) applied at 2% v/v with ½% methylated seed oil (MSO), Pasturegard™ (triclopyr + fluroxypyr) at 5% v/v with ½% MSO and Arsenal™ (imazapyr) at 1.5% v/v plus 1% MSO had killed 100% of the small saltcedar plants. Pasturegard at 2% v/v + ½% MSO had killed 60% of the small plants. Only Arsenal at 1.5% v/v with 1% MSO had killed all of the large saltcedar plants one year after application. Percent kill one year after application of Rodeo™ (glyphosate) at 2% v/v with ½% nonionic surfactant, Krenite™ (fosamine) at 3% v/v with ½% MSO, and Pasturegard at 2%v/v with ½% MSO varied from 17 to 40%. Percent kill of large plants with these latter mentioned herbicides improved significantly after 2 years and varied from 60 to 83%. Pathfinder II™ (triclopyr formulated in oil) at 100%v/v, Remedy™ (triclopyr) at 25% v/v, and

Pasturegard at 25% v/v applied as basal-bark treatments in November 2002 killed 100% of the saltcedar plants. Stalker™ (oil soluble formulation of imazapyr) at 7.8% v/v killed 67% to 83% of the plants after 2 years. Plants surviving the Stalker treatment were injured severely. Except for Pathfinder II, which killed all plants, and Stalker, which killed similar number of plants, all of the other herbicides applied as basal-bark treatments in April were less effective than the fall treatments.

Restoration of Big Horn River floodplain after removal of heavy infestations of saltcedar and Russian olive (Poster)

Steve Christy[1], Alex Ogg[2] and Mike Wille[3]
[1]Big Horn Basin Exotic Plant Steering Committee, Worland, WY, 82401. schristy@yahoo.com. [2]Big Horn Basin Exotic Plant Steering Committee, Ten Sleep, WY, 82442. ogga@tctwest.net. [3]Fremont County Weed and Pest District, Riverton, WY, 82501. mwille@wyoming.com

Abstract:

Restoration of native plant communities on the Bighorn River in northern Wyoming is becoming increasingly important due to the establishment of a variety of invasive and noxious weed species. A demonstration project for riparian restoration has been established on approximately 300 acres at the Goose Island site just south of Manderson, WY, along the Big Horn River. This study is aimed at protecting existing stands of cottonwood trees, and restoring the site to native woodlands. Treatments were designed to reduce the density of exotic plant species, primarily Russian olive and Tamarisk. Other invasive species on the site are Russian knapweed, perennial pepperweed, leafy spurge, Canada thistle and whitetop (hoary cress). Primary objectives of the treatments were to 1) protect existing stands of cottonwood from wildfire hazards by reducing fuel loads; 2) reduce the density and frequency of exotic weed invasions; 3) increase recruitment of native vegetation on the site; 4) provide a demonstration and interpretive site for future restoration projects. Combinations of mechanical and chemical treatments were initiated in the spring of 2000 to achieve these goals. Revegetation treatments include the planting of grasses to establish competition with the noxious weeds. The species planted include Bozoisky wildrye, Trailhead basin wildrye, Critana thickspike wheatgrass, Sodar streambank wheatgrass, Luna pubescent wheatgrass, Lodorm green needlegrass, Pryor slender wheatgrass, Rosana western wheatgrass, alkali sacaton, Jose tall wheatgrass, and Shoshone beardless wildrye. Several forbs were also in the mix. Results to date have documented the difficulty in controlling Tamarisk and Russian olive infestations. Conventional techniques of reseeding and planting with rooted seedlings of desirable trees and shrubs have been unsuccessful because of extremely dry conditions. Establishment of cottonwoods by planting 2-m poles 1-m deep has been hampered by changing ground water levels, high soil salt concentrations and low precipitation. Imazapyr and triclopyr show some promise of being able to control if not eliminate saltcedar and Russian olive from the sites. While removal of some invasive non-native species has been successful at the Goose Island Restoration project, restoration of desirable species has not. It remains important to establish competitive grass communities to dissuade against future weed invasions. Vigorous plant competition is the best long-term strategy for noxious weed control in these riparian sites.

Drought, restoration, and evapotranspiration in the Middle Rio Grande riparian corridor, New Mexico (Session 5)

James R. Cleverly[1], Michael Slusher[1], James R. Thibault[1], Jennifer Schuetz[1], and Clifford N. Dahm[1]
[1]Department of Biology, University of New Mexico, Albuquerque, New Mexico, 87131. cleverly@sevilleta.unm.edu, cheepnis@cheepnis.com, jrtebo@sevilleta.unm.edu, jschuetz@sevilleta.unm.edu

Abstract:

The purpose of this research is to investigate ecosystem water budgets and tamarisk invasion in the Middle Rio Grande corridor of New Mexico. Specifically, this study compares water use patterns across a multi-year severe drought in native (cottonwood), non-native (tamarisk and Russian olive), and restored forests. To measure water use by each of these forests, three-dimensional eddy covariance (3SEC) systems were mounted upon towers above the canopy. This is the only method available for directly measuring fluxes of water, energy, and carbon dioxide between terrestrial ecosystems and the atmosphere. Four towers were erected in 1999, located at Bosque del Apache National Wildlife Refuge (NWR) (monospecific tamarisk), Sevilleta NWR (tamarisk-saltgrass mosaic), near the towns of Belen and Rio Communities (native cottonwood forest), and in

Albuquerque's south valley (cottonwood forest with tamarisk and Russian olive understory). The non-native understory in Albuquerque's south valley was removed during the winter of 2003-2004. A fifth tower was installed in 2003 over a Russian olive and coyote willow stand at the La Joya State Game Refuge. Drought struck this region in September 2001 and persisted into the winter of 2005, when record snowfall generated three months of spring and summer flooding. Vapor pressure deficit, or the leaf-to-air moisture gradient, increased with drought from 2.35 to 2.55 kPa over the tamarisk stands and from 1.95 to 2.25 kPa over the cottonwood forests. Ecosystem water use was highest in the invaded cottonwood forest (128 +/- 2 cm/yr), intermediate at the monospecific tamarisk, native cottonwood, and Russian olive sites (110 +/- 6), and lowest at the site dominated by tamarisk and saltgrass (79 +/- 4 cm). Crown dieback in cottonwood was observed at a location where the water table was deeper than 3-m, while tamarisk and Russian olive showed no chlorosis. At the site where the non-native understory was removed, a first-year 26% reduction in ET during the following year was measured, but water salvage relative to the un-restored sites was negligible during the second year. Regrowth of cut tamarisk stumps accounted for the transience in ET reduction, implying that efficacy of removal is a crucial factor in applying restoration of tamarisk forests. Attention to post-removal control is especially important during drought, when native species are more vulnerable to deepening groundwater than tamarisk and Russian olive.

Pheromone and host odor attractants for managing *Diorhabda* spp.: Biological control agents of saltcedar (Session 3)

Allard A. Cossé[1], Robert J. Bartelt[1], Bruce W. Zilkowski[1], Nina Louden[2], Daniel W. Bean[2], Earl R. Andress[3]

[1]USDA Agricultural Research Service National Center for Agricultural Utilization Research Crop Bioprotection Research Unit 1815 N. University Street Peoria, Illinois 61604. cosseaa@ncaur.usda.gov, bartelrj@ncaur.usda.gov, zilkowbw@ncaur.usda.gov. [2]Colorado Department of Agriculture, Biological Pest Control, Palisade Insectary, 750 37.8 Road, Palisade, Colorado 81526. Dan.Bean@AG.STATE.CO.US, ninalouden@hotmail.com. [3]USDA APHIS 4151 Hwy 86 Bldg 10 Brawley CA 92227. Earl.R.Andress@aphis.usda.gov

Abstract:

The recent identification of the aggregation pheromone[a] and host odor attractant[b] for the leaf beetle *Diorhabda elongata*, a biological control agent of saltcedar, allowed for a more detailed study of the chemical ecology of this beetle. Field results have shown that male and female *D. elongata* are clearly attracted to the two component pheromone. Additional lab studies have shown that the different *Diorhabda* strains, adapted for release at variable US latitudes, have identical pheromone compositions, but differ in component ratios.

The host odor attractant mimics the release of some antennally active green leaf volatiles that are emitted by saltcedar while being fed upon by adults and larvae. The green leaf compounds currently used in the host odor baits are present in emissions from all *Tamarix* species that are targeted for biological control and these baits are highly attractive to the beetles throughout the season. Furthermore, trapping data showed that combining the pheromone and host odor baits attracted even higher numbers of beetles and this combination showed a strong synergistic effect.

The attractants can be useful tools in the overall biological control program of saltcedar. The attractive baits have been successfully used in monitoring the presence of newly released beetles, in areas such as Lovelock, NV, and Moab, UT. Beetles dispersal from well established populations can be easily followed by baited traps, even in areas with no visual proof of any beetle presence. Also, retaining newly released beetles at the sites of release with the use of both pheromone and host odor has shown promising results, and this technique might be helpful in increasing the success rates of population establishment.

Lab and field work has demonstrated differences in biological activity of the single constituents that make up a behaviorally attractive blend, and these results are aiding our aspirations in trying to understanding the complex chemical beetle-plant interactions and mechanisms of beetle colonization of uninfested saltcedar.

[a]Cossé et al. 2005. J. Chem. Ecol. 26:1735-1748; [b]Cossé et al. 2006. J. Chem. Ecol. in press.

Regional testing of *Diorhabda 'elongata'* ecotypes (Session 3)

P. Dalin[1], T. Dudley[1], D.C. Thompson[2], D.W. Bean[3], D. Eberts[4], D. Kazmer[5], J. Michels[6], P. Moran[7], J. Milan[8], C.J. DeLoach[9]

[1]Marine Science Institute, University of California, Santa Barbara. dalin@msi.ucsb.edu, tdudley@msi.ucsb.edu. [2]New Mexico State University, Las Cruces. dathompson@nmsu.edu. [3]Colorado Department of Agriculture, Palisade Insectary & University of California, Davis. dan.bean@ag.state.co.us. [4]US Bureau of Reclamation, Denver. deberts@do.usbr.gov. [5]Agriculture Research Service, US Department of Agriculture, Sydney. dkazmer@sidney.ars.usda.gov. [6]Texas Agricultural Experiment Station, Bushland. asychis@aol.com. [7]Agriculture Research Service, US Department of Agriculture, Weslaco. pmoran@weslaco.ars.usda.gov. [8]Bureau of Land Management, US Department of the Interior, Boise. Joseph_Milan@blm.gov. [9]Agriculture Research Service, US Department of Agriculture, Temple. jdeloach@spa.ars.usda.gov

Abstract:

The Eurasian saltcedar leaf beetle *Diorhabda elongata* has been introduced into several western states for the biocontrol of tamarisk. Establishment was successful at some sites, with heavy defoliation and subsequent mortality of plants observed at sites in northern Nevada. However, at sites south of 37-38° N, the original form of *D. elongata* (collected in Fukang, China 44.1° N) failed to establish. Incubator studies indicated that failure was because this ecotype responds to declining daylength by entering reproductive diapause too early in the season to successfully overwinter.

The purpose of the present study is to test different ecotypes of *D. elongata*, currently held under quarantine in the US (China I 44.1° N, China II 43.5°, Uzbekistan 38.1°, Greece 35.1° and Tunisia 34.4°), inside double secure cages in the field at sites ranging from 33-48° N in latitude. Our predictions are: 1.) Beetles will be reproductively active for the longest time period at those latitudes that match their latitudes of origin, and, 2.) Beetles will have the highest over-wintering survival at matching latitudes. Regulatory concerns that *D. elongata* ecotypes pose risks to the native salt-marsh plant Frankenia salina have delayed this research, but we were able to initiate the study in August of this year. Observations do, however, suggest that taking advantage of the full range of beetles might lead to increased success of the biocontrol program. At one southern site in Texas (31.5° N), the Crete ecotype has established with substantial population growth in 2006. The current experiment will provide crucial knowledge about how to promote biocontrol of tamarisk over the widespread range of infestations in western United States.

Modeling invasive species using remote sensing: an example using *Tamarix* (Session 4)

Tracy Davern[1,2], Tom Stohlgren[1], Robin Reich[2]

[1]US Geological Survey, Fort Collins, CO. tracy.davern@Colostate.edu, tom_stohlgren@usgs.gov. [2]Colorado State University, Fort Collins, CO. robin.reich@colostate.edu.

Abstract:

Determining the species-environment relationship is an important question in ecology, especially in invasion ecology. Determining which factors in the environment affect the distribution and abundance of an invasive species is important for early detection and rapid response. The main objective of this study was to develop a methodology that can be used to find the potential habitat and percent cover of *Tamarix* sp., an invasive riparian tree, using a combination of remote sensing, field data, and predictive modeling. We examined two different geographic locales that *Tamarix* sp. inhabits to evaluate the consistency of predictor variables over a larger geographic region. We used regression techniques that model spatial relationships between field data, environmental variables and Landsat TM images. Our overall accuracy in predicting the presence or absence of *Tamarix* sp. was as high as 97%. Likewise, up to 89% of the variation in the foliar cover of *Tamarix* sp. could be explained by predictor variables. Variables selected in the models were not the same for the two geographic regions suggesting that locally derived models may improve regional assessments of plant invasions.

Preliminary success in biological control of saltcedar - Texas/New Mexico (Session 3)

C.J. DeLoach[1], A.E. Knutson[2], P.J. Moran[3], D. Eberts[4], G.J. Michels[5], M. Muegge[6], D.C. Thompson[7], D. Richman[7], J. Sanabria[8], J.H. Everitt[9], V. Carney[5], K. Gardner[7], J.L. Tracy[1], T.O. Robbins[1], J. Hudgeons[2] and R.I. Carruthers[10]

[1]USDA-ARS, Grassland, Soil and Water Research Laboratory, Temple, TX. jdeloach@spa.ars.usda.gov. [2]Texas A&M University Research & Extension Center, Dallas, TX. a-knutson@tamu.edu. [3]USDA-ARS, Kika de la Garza Subtropical Agricultural Research Center, Beneficial Insects Research Unit, Weslaco, TX. pmoran@weslaco.ars.usda.gov. [4]USDI-Bureau of Reclamation, Denver, CO. deberts@do.usbr.gov. [5]Texas A&M Experiment Station, Bushland, TX. asychis@aol.com. [6]Texas A&M University, Texas Agricultural Extension Service, Ft. Stockton, TX. ma-muegge@tamu.edu. [7]New Mexico State University, Department of Entomology, Plant Pathology and Weed Sciences, Las Cruces, NM. dathomps@nmsu.edu; nmbugman@taipan.nmsu.edu. [8]Texas Agricultural Experiment Station, Temple, TX. sanabria@brc.tamus.edu. [9]USDA-ARS, Kika de la Garza Subtropical Agricultural Research Center, Integrated Farming & Natural Resources Research Unit, Weslaco, TX. jeveritt@weslaco.ars.usda.gov. [10]USDA-ARS, Exotic and Invasive Weeds Research Unit, Albany, CA. ric@pw.usda.gov

Abstract:

Biological control has successfully controlled 13 exotic, invasive weeds of rangelands and natural ecosystems in the United States since 1945, control of others is in progress, and many more have been controlled worldwide. We initiated biological control of saltcedars (*Tamarix* spp.) at Temple, TX in 1986, using host-specific insect herbivores that regulate saltcedar populations in the Old World. Our cooperators in France, Israel, Kazakhstan, China and Turkmenistan tested 20 candidate control insects. Then, after quarantine testing at Temple, and being joined by the new ARS-EIWR Unit at Albany, CA (led by Carruthers) we released the leaf beetle, *Diorhabda* sp. (Coleoptera: Chrysomelidae) from Fukang, China and Chilik, Kazakhstan, into the open environment at 10 sites in May 2001. They established at 5 of the 6 northern sites and by August 2006 had defoliated approximately 85,000 acres at Lovelock, NV, 30,000A at Schurz, NV and Delta, UT, 8,000A at Lovell, WY and 300A at Pueblo, CO (discussed by others at this symposium).

These northern beetles failed to overwinter or to establish in Texas and southern California because the short summer daylengths cause premature overwintering diapause. In 2002, our overseas cooperators sent *Diorhabda* ecotypes from 4 more southern latitudes. In tests at Temple and Albany, these beetles severely attacked the most widespread and damaging saltcedars, attacked other *Tamarix* spp. less, and were safe for all other 60 plant species tested. We released the Crete/Posidi, Greece ecotype into field cages and then into the open environment at 9 sites in Texas, 3 in New Mexico, and 2 in California from 2003 to 2005. We now have overwintering, establishment and rapid increase at Big Spring, and Lake Merideth, TX and probably also near Artesia, NM. At Big Spring, we released 38 adult Crete beetles in late April 2004 which defoliated 2 small trees by July; we added another 500 beetles in July which together with those defoliated another large tree by late September. In 2005, these increased rapidly and defoliated an area of 1.6A (210 large and medium-sized trees) by mid September. By late August 2006, they had defoliated an area of 10A. We have redistributed these beetles to several sites in the Big Spring/Sweetwater area and at Ft. Stockton, TX during 2005-6 and studied best methods for release. In uncaged, open field tests in southern Texas near Kingsville and Encino, and at Big Spring and Ft. Stockton, we are comparing the effects of the Crete and Tunisia beetles on saltcedar vs. the exotic athel (*Tamarix* aphylla) trees in preparation for consultations with Mexico regarding releases along the Rio Grande. Athel has some beneficial values for shade trees and windbreaks in the southern U.S. and northern Mexico. At Lake Merideth, TX we released the Posidi, Greece and Uzbek ecotypes in 2005 which now are established, dispersing and defoliating saltcedar. Near Artesia, NM, we released the Crete ecotype in August 2003 but they failed to establish after initially overwintering and defoliating saltcedar. A release of the Fukang ecotype in field cages near Artesia in May 2005 continued to reproduce into October, overwintered well, and were released into the field in May 2006. These field populations have significantly increased, probably representing an adaptation to more southern areas with shorter daylength. Intensive monitoring is underway. Where established, these beetles are providing self-sustained, permanent, environmentally friendly, and low cost control of saltcedars that is safe to all native plant species. We expect this to allow recovery of native riparian plant communities where water tables and soil salinity are satisfactory, and to improve wildlife and fish habitat, reduce wildfires, increase availability of water, and increase recreational usage of parks and natural areas.

Competition and succession in tamarisk stands: towards biological control using native plants (Session 1)

John M. DeWine[1], David J. Cooper[1]

[1]Graduate Degree Program in Ecology and Forestry Range and Watershed Stewardship. Colorado State University, Fort Collins, CO 80523. jdewine@cnr.colostate.edu, dcooper@rm.incc.net

Abstract:

Tamarisk species (*Tamarix ramosissima* Ledeb., *T. chinensis* Lour., *T. gallica* L. and hybrids), have invaded riparian areas throughout western North America to the detriment of native plants and animals. Tamarisk is a relatively recent addition to North American plant communities, thus competitive and successional processes are still developing. Box elder (*Acer negundo* L. var. *interius* (Britt.) Sarg.) is a potential native competitor found in mid elevation canyons throughout western North America. The following questions were addressed: (1) Does tamarisk facilitate box elder establishment? (2) Is box elder or tamarisk the superior competitor? (3)What are the successional trajectories in mixed box elder and tamarisk stands? (4) Can mature tamarisks be killed by limiting available light (PAR) to levels that commonly occur under box elder canopies? (5) How much shade is needed to diminish the growth of or kill tamarisk? (6) Is there a shade threshold below which box elders, but not tamarisk, can grow?

Facilitation was studied by analyzing the survival of box elder seedlings planted in intact or cleared tamarisk stands. Competition was studied through neighborhood analysis and successional trends were analyzed through dendrochronology in mixed stands. The shade tolerance of mature tamarisks was analyzed by building light exclosures around mature tamarisks. Comparative shade tolerances were analyzed using shade cloth of varying interception levels in a greenhouse experiment in Fort Collins, CO. Field studies and experiments were conducted in canyons of Dinosaur National Monument (DNM), Colorado.

Tamarisk facilitated box elder seedling survival. Box elder was the superior competitor; the presence of canopy box elders within one and two meters was significantly related to tamarisk but not box elder mortality. The presence of canopy tamarisk trees was not related to box elder or tamarisk mortality. Tamarisk establishment predated or was concurrent with box elder establishment on newly formed surfaces. Tamarisk initially dominated the canopy, but box elder eventually overtopped and killed the tamarisk. The shade generated by box elder canopies was capable of killing mature tamarisks in DNM. Box elder had superior shade tolerance to tamarisk, and maintained positive growth and survived under higher shade than tamarisk. The manipulation of competitive and successional processes through the promotion of box elder and other native tree establishment is suggested as a means of bottom up tamarisk control to complement traditional control techniques.

The National Invasive Species Council Up-Date and *Tamarix* Economics-based Planning Tool Development (Session 8)

Chris P. Dionigi[1]

[1]National Invasive Species Council. U.S. Department of the Interior, Office of the Secretary, 1849 C. St. N.W., Washington, DC 20240. Chris_Dionigi@ios.doi.gov

Does Herbivory Enhance Fire Induced Mortality?

Gail M. Drus[1], Tom L. Dudley[2], and Matt L. Brooks[3]
[1]Department of Ecology, Evolution and Marine Biology. University of California, Santa Barbara. USA. 93106. [2]Marine Science Institute. University of California, Santa Barbara. USA. 93106. Dept. of Environmental & Resource Science. University of Nevada, Reno. USA. 89512. [3]US Geological Survey. Western Ecological Research Center. Las Vegas Field Station. Henderson, NV. USA. 89074

Abstract:

The 2001 release of *Diorhabda elongata* (saltcedar leaf beetle) in northern Nevada, USA as a biocontrol agent of tamarisk has created a platform upon which to integrate biological control technologies with prescribed burning. Separately, each control method is of limited effectiveness; tamarisk recovers rapidly following fire, while biocontrol is slow acting and may not cause massive mortality. We hypothesize that the combination of herbivory induced plant stress and fire will result in enhanced mortality. The study site is composed of intermittently grazed land located in the Humboldt river floodplain in Lovelock, NV. Nine half-hectare plots of dense tamarisk have been divided into three experimental treatments: summer burn (Late August), fall burn (Late October) and control. Pre-fire plant community composition was found to consist primarily of *Tamarix ramosisima* and other invasive weeds. Representative trees in each plot have been identified and tagged for extensive monitoring, which includes foliage volume, understory, and survivorship. Physiological stress will be described via nonstructural carbohydrate sampling and tree ring analysis. This study may provide information leading to the development of a tamarisk management program that can be presented to regional land managers, policy makers, landowners and scientists concerned with invasive species control.

Does Herbivory Enhance Fire Induced Mortality? (Poster)

Gail M. Drus[1], Tom L. Dudley[2], and Matt L. Brooks[3]
[1] Department of Ecology, Evolution and Marine Biology. University of California, Santa Barbara. USA. 93106
[2] Marine Science Institute. University of California, Santa Barbara. USA. 93106. Dept. of Environmental & Resource Science. University of Nevada, Reno. USA. 89512
[3] US Geological Survey. Western Ecological Research Center. Las Vegas Field Station. Henderson, NV. USA. 89074

Abstract:

The 2001 release of *Diorhabda elongata* (saltcedar leaf beetle) in northern Nevada, USA as a biocontrol agent of tamarisk has created a platform upon which to integrate biological control technologies with prescribed burning. Separately, each control method is of limited effectiveness; tamarisk recovers rapidly following fire, while biocontrol is slow acting and may not cause massive mortality. We hypothesize that the combination of herbivory induced plant stress and fire will result in enhanced mortality. The study site is composed of intermittently grazed land located in the Humboldt river floodplain in Lovelock, NV. Nine half-hectare plots of dense tamarisk have been divided into three experimental treatments: summer burn (Late August), fall burn (Late October) and control. Pre-fire plant community composition was found to consist primarily of *Tamarix ramossisima* and other invasive weeds. Representative trees in each plot have been identified and tagged for extensive monitoring, which includes foliage volume, understory, and survivorship. Physiological stress will be described via nonstructural carbohydrate sampling and tree ring analysis. This study may provide information leading to the development of a tamarisk management program that can be presented to regional land managers, policy makers, landowners and scientists concerned with invasive species control.

Effects of host condition and genotype on performance of *Diorhabda elongata* (Chrysomelidae) (Session 3)

Tom Dudley[1,2], Peter Dalin[1], Robert Pattison[3], Dan W. Bean[4], Andrea Caires[5]
[1]Univ. of Calif., Santa Barbara. tdudley@msi.ucsb.edu, dalin@msi.ucsb.edu. [2]Univ. of Nevada, Reno.. [3]USDA-ARS, Reno. rpattiso1@hotmail.com. [4]Colorado Dept. of Agriculture, Palisade, CO. dan.bean@ag.state.co.us. [5]Utah St. Univ. threepin10@yahoo.com

Abstract:

Herbivore behavior and performance can be related to host plant qualities that vary with growing conditions, nutrient availability, foliage age or prior experience, or genotype. Such variation across a broad geographic range may account for some of the mixed results seen following the introduction of the saltcedar leaf beetle *Diorhabda elongata* (sensu latu) for biocontrol of *Tamarix* spp. A series of field and greenhouse studies in California and Nevada showed how several factors alter insect

responses, including: 1) nitrogen (NO3) augmentation accelerated larval growth and time to pupation, although pupae were significantly smaller than insects on plants grown in control soil; 2) moderate increase in soil salinity had no significant effect on growth, but high levels (resulting in visible salt exudation) caused foliage to be avoided by larvae and adults; 3) in the field, plants defoliated the previous year were avoided by adult beetles early in the season; 4) prior defoliation reduced larval growth and survival in a field experiment but had no effect when defoliation was simulated with potted plants - tissue age probably caused control (non-defoliated) plants to be a poorer resource; 5) larval growth was slightly better on T. *ramosissima* foliage than on *T. parviflora*, *T. aphylla* or a *T. aphylla* x *ramosissima* hybrid grown in pots; 6) under 'natural' field conditions, *T. parviflora* was avoided by adult insects; 7) oviposition on field transplants of the previous 4 genotypes was high on *T. ramosissima* and the *T. aphylla* x *ramosissima* but very low on *T. aphylla* and *T. parviflora*, while all genotypes close (< 2 m.) to defoliated 'natural' *T. ramosissima* were eaten by dispersing starved larvae but at greater distance oviposition alone led to defoliation of only the 'preferred' genotypes. Host factors, particularly host species, account for target plant avoidance and poor *Diorhabda* establishment at some sites, and may reduce biocontrol agent performance at others, so should be incorporated into introduction plans in order to better predict establishment success across the infested range of tamarisk/saltcedar.

Connecting growth rates of *Tamarix ramosissima* to river discharge in two western Colorado rivers (Poster)

James M. Dunn[1], Lenae Fonte[1], and Alyson Graffis[1]
[1]Geography Program, School of Social Sciences, University of Northern Colorado, Greeley CO 80639. James.Dunn@unco.edu, lenaefonte@gmail.com, alyson@graffis.org

Abstract:

In the spring of 2005, a group of undergraduate students at University of Northern Colorado joined together to ask the question: Is Tamarisk (*Tamararix ramosissima*) vitality a function of streamflow volume on the lower Gunnison River? River discharge is reported daily and averaged for monthly records by the USGS. Tree vitality is indicated by standardized ring width (ring width is used with ring diameter to calculate mass-added for each year). A similar study area was established on the Colorado River, between Grand Junction and Westwater, Utah, but the data from that area are not available at this date.

Random sampling in four elevation zones (average wet shoreline up to 2.5 feet, then every 2.5 feet for remaining zones) resulted in the collection of 48 trees along the Gunnison River, between Escalante Bridge and the hamlet of Whitewater, Colorado. Data were collected in May of 2005. Additional data collected in the summer of 2006 will be added to the analysis in the future. Each tree disk was then transected twice to yield a sample of 96 ring counts. An attempt was made to cut the largest tree in the sample site, and to cut the tree as close as possible to the ground. Samples were then cut smooth, sanded, and prepared for ring counts and measurements. Initially, disks were entered on standard skeleton charts to record ring width impressions. Ring measurements were recorded and analyzed for missing rings and other data-recording errors using Cofecia software.

Tree samples were sufficiently separated by distance to allow us to assume that each sample comes from an individual tree, even though tamarisk are known to have multiple boles. No attempt was made to excavate the entire tree because the study area is located in a protected recreational wilderness that experiences heavy human use. Permission to cut boles was granted the Bureau of Land Management.

Ring widths initially were detrended to correct for tree diameter (this is a mathematical correction to eventually make all rings relatively comparable as a function of mass-added. Corrected ring widths (standardized widths) were compared to monthly stream discharge collected by automated gauging stations operated by the U.S. Geological Survey. Before calculating any statistical connections between ring widths and streamflow, the data were analyzed with Cofecia software that identified data entry flaws or other data recording problems that needed secondary inspection. Ideally, once that process is done, monthly streamflow records could be paired with annual ring width data. In the present study, we present the analysis without a complete repair to the dataset, though that work is expected to be completed later in 2006.

The findings are preliminary. The strongest correlation found (and the only statistically significant month) is a positive value during the month of August. It appears that years with high stream volume in August promote rapid tree growth and years that have low August flows have

diminished growth. No other month showed a significant connection between these two variables. It is suspected that tamarisk trees can withstand hot summers in Western Colorado, but begin to fatigue by the end of July. During Colorado's warmest month of August, low stream flows cause enough stress to limit growth, while adequate water during August permits average and above average growth.

Tree stand age were averaged to see if there is an elevational preference. Trees averaged 20.26 years age in this study with the oldest trees being 7.5-10 feet above wet line (average of 29.5 years) and the youngest trees found between 2.5 and 5 feet (15.67 years).

Later in 2006, we will replicate the study using data from the Colorado River in the same region of western Colorado. If streamflow and tree growth confirm August as a critical month, then there may be good cause to examine the tree's seeding response during poor flow years. In other words, does the Tamarisk produce fewer seeds during years when August flow is low? If the answer to that question is positive, then intentionally reducing streamflow in August may assist in the slowing of the rate of spread of the trees. Refining this further will produce the threshold flow level needed to have the desired impact. Reducing the flow further might be harmful to native tree species.

This study would be aided by similar studies of native trees, particularly cottonwood and box elder. Reducing streamflow in August would only work if it did not inhibit the survival of those native species.

Soil nitrogen dynamics in stands of *Populus deltoides* ssp. *wislizenii* and *Tamarix chinensis* with differing flood regimes (Session 4)

Jennifer J. Follstad Shah[1] and Cliff N. Dahm[1]
[1]Department of Biology, University of New Mexico, Albuquerque,NM,87131. follstad@unm.edu, cdahm@sevilleta.unm.edu.

Abstract:

The biotic structure and function of semi-arid riparian forests around the world are strongly organized by flood pulses. Flow management has reduced the exchange of water, energy, and materials from rivers and floodplains, caused declines in native plant populations, and advanced the spread of non-native plants. Naturalized flow regimes are regarded as a means to restore degraded riparian areas around the world. We examined the effects of flood regime on litter production and soil nitrogen dynamics in riparian forests along the middle Rio Grande of New Mexico dominated by native *Populus deltoides* ssp. wislizenii and non-native *Tamarix chinensis*. Feedbacks between litter production and soil inorganic nitrogen determined the degree of nitrogen accumulation within all riparian study sites. *P. deltoides* and *T. chinensis* flood sites had consistently lower potential net nitrogen mineralization rates than their respective non-flood sites. Flood regime also promoted differences in riparian soil nitrogen concentrations within stands dominated by each species, but flood effects contrasted across species. *P. deltoides* flood sites had low soil nitrogen concentrations, likely due to increased nitrogen uptake by plant and microbial communities, denitrification, and nitrogen export to surface and ground water that are associated with flooding. Litter production was suppressed at *P. deltoides* flood sites relative to *P. deltoides* non-flood sites, although roots from *P. deltoides* flood sites showed a greater capacity to take up inorganic nitrogen. *P. deltoides* non-flood sites had higher soil nitrogen concentrations compared to *P. deltoides* flood sites due to elevated nitrogen inputs associated with increased litterfall and the lack of transport associated with flooding. In contrast, *T. chinensis* flood sites were characterized by greater litter production, nitrogen inputs via litterfall, and concentrations of soil inorganic nitrogen relative to *T. chinensis* non-flood sites. *T. chinensis* has the ability to produce adventitious roots at the elevation of floodwaters, an adaptation that may help to support leaf production during inundation. Litter production at *T. chinensis* non-flood sites was potentially limited by increased competition for nitrogen between plants and microbes, as inferred from soil C:N molar ratios much greater than 25:1. The practice of spring-time naturalized flows within the rivers of semi-arid regions ought to continue when adequate water supplies permit. Flood events associated with these flows promote increased recruitment of native plant seedlings, as well as increased mobilization of nutrients at a time most conducive to plant growth. However, flood inundation may be less important for the preservation of mature forests dominated by *P. deltoides* than the maintenance of shallow groundwater tables that have been shown to support high leaf production. Flood inundation, particularly if long in duration, also promotes increased losses of soil nitrogen and reduces leaf and litter production within stands of *P. deltoides*. Additional research is required to determine the

thresholds at which extended flood duration does more harm than good for the conservation of *P. deltoides* along rivers of the U.S.

Management of saltcedar regrowth with carpet-roller applied herbicide (Session 6)

Jose G. Franco[1], Kirk McDaniel[1], Brent Tanzy[2], and Keith Duncan[3]
[1]Department of Animal and Range Sciences, New Mexico State University, Las Cruces,NM,88003. jgfranco@nmsu.edu, kmcdanie@nmsu.edu. [2]USDI Bureau of Reclamation, Truth or Consequences, NM. 87901. btanzy@uc.usbr.gov. [3]Cooperative Extension Service, Artesia, NM. 88210. erbc@nmsu.edu

Abstract:

A carpet-roller (7 ft. wide and 6 inch diameter) mounted rearwards on a Ford 7610 farm tractor was used to apply imazapyr to the foliage of 3 to 7 ft. tall saltcedar re-growth. This application method is being investigated as a possible alternative to costly mowing while preserving understory vegetation. This study was initiated in 2005 and is located in a 5000 acre area that has been mowed annually for approximately 40 years by the Bureau of Reclamation. The study area was placed on the upper reach of Caballo reservoir which is fed by the Rio Grande in southern New Mexico. Treatments were placed in a randomized split plot design with 3 application dates (mid- June, July and August), 4 herbicide rates, 3 reps and either one or two passes with the carpet-roller over the saltcedar. Our four main effect treatments were a control, a high rate of imazapyr (1.0 lb a.i./ac), a medium rate (0.5 lb a.i./ac), and a low rate (0.25 lb a.i./ac). Pre-treatment data was collected within a week of application and post-treatment data was collected in October 2005 and May 2006 with a final evaluation scheduled in October 2006. Measurements taken relate saltcedar response to the herbicide treatments by various plant size characteristics including height, number of stems per plant, plant volume, density, and canopy cover. Initial estimates suggest that the high and medium rates were effective in defoliating saltcedar whereas the low rate provided less than 50% defoliation. Larger and more robust plants experienced higher defoliation than lower growing plants for the June treatment date. Further evaluations one and two years post treatment are needed to determine conclusive herbicide efficacy results.

Evolution of cold hardiness in North American *Tamarix ramosissima* (Session 4)

Jonathan M. Friedman[1], James M. Roelle[1], Julie Roth[2], and John F. Gaskin[3]
[1]US Geological Survey, 2150 Centre Avenue, Building C, Fort Collins, CO 80526. jonathan_friedman@usgs.gov, butch_roelle@usgs.gov. [2]IAP World Services, 2150 Centre Avenue, Building C, Fort Collins, CO 80526. julie_roth@usgs.gov. [3]US Department of Agriculture, 1500 N. Central Avenue, Sidney, MT 59270. jgaskin@sidney.ars.usda.gov

Abstract:

Native woody plants often demonstrate inherited latitudinal variation in cold hardiness. How long does it take for such variation to evolve in introduced species? We compared cold hardiness in the native *Populus deltoides* subsp. *monilifera* (plains cottonwood) and the introduced *Tamarix ramosissima* (saltcedar). In February and March 2005, we collected cuttings of 25 individuals of each species from 15 sites in the central US ranging in latitude from 29°N to 48°N. Cuttings were rooted in a greenhouse beginning on March 17 and then moved to a shadehouse in Fort Collins, CO, latitude 41°N, on May 31. Sixteen times between September 2005 and June 2006, we exposed stem sections of northern and southern individuals of both species to a range of cold temperatures and determined the killing temperature by measuring freeze-induced electrolyte leakage. Although *Tamarix* was slightly more cold hardy in the early fall and late spring, *Populus* hardened off more rapidly and deeply. In midwinter, *Populus* was unharmed by cooling to -70°C, while *Tamarix* was killed at -30 to -40°C. There is strong inherited latitudinal variation in both the timing and extent of cold hardiness for both species. Northern individuals survive colder temperatures earlier in the season than southern individuals. Analysis of 9 microsatellite DNA loci shows a north-south genetic gradient in *Tamarix* in the central United States; southern *Tamarix* is more closely related to *T. chinensis* and northern *Tamarix* is more closely related to T. *ramosissima*. Hybridization between these two *Tamarix* species has apparently introduced the genetic variability necessary for rapid evolution of the latitudinal gradient in cold hardiness.

Hybridization of *Tamarix ramosissima* and *T. chinensis* (saltcedars) with *T. aphylla* (Athel) (Family Tamaricaceae) in the southwestern USA determined from DNA sequence data (Poster)

John F. Gaskin[1] and Patrick B. Shafroth[2]
[1]U.S. Department of Agriculture, Agricultural Research Service, Northern Plains Agricultural Research Lab, P.O. Box 463, Sidney, MT 59270. jgaskin@sidney.ars.usda.gov. [2]U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Fort Collins, CO 80526. pat_shafroth@usgs.gov

Abstract:

Morphological intermediates between *Tamarix ramosissima* or *T. chinensis* (saltcedars) and *T. aphylla* (athel) were found recently in three locations in the southwestern USA, and were assumed to be hybrids or a previously unreported species. We sequenced chloroplast and nuclear DNA from putative parental and hybrid morphotypes and hybrid status of morphological intermediates was supported. Chloroplast data suggest that the seed source for these hybrids is *T. aphylla*. Invasive *T. aphylla* genotypes found in Australia match those found in the USA. Seed was collected from one of the hybrids and a low percentage of it was viable. This hybrid combination has not been previously reported in the USA or the native ranges of the species. Although populations of this novel *Tamarix* hybrid appear to be uncommon at present, both parental species are considered invasive (saltcedars in North America; athel in Australia), and it is possible that more aggressive hybrid genotypes could be produced. Therefore, natural resource managers concerned with the potential spread of non-native species should be aware of the existence of these plants and monitor their future spread.

Comparison of ornamental and wild saltcedar (*Tamarix* spp.) along eastern Montana riverways using chloropast and nuclear DNA sequence markers (Poster)

John F. Gaskin[1] and David J. Kazmer[1]
[1]United States Department of Agriculture, Agricultural Research Service. Northern Plains Agricultural Research Laboratory, Pest Management Research Unit 1500 North Central Avenue. Sidney, Montana, USA 59270. jgaskin@sidney.ars.usda.gov, dkazmer@sidney.ars.usda.gov

Abstract:

Saltcedars (*Tamarix ramosissima*, *T. chinensis*, and their hybrids) have invaded riverways and lakeshores across the western USA and northern Mexico. In Montana, ornamental plantings of saltcedar have been hypothesized, to varying degrees, to be the origin of nearby, wild populations. To examine this hypothesis, we compared chloroplast and nuclear DNA sequences from 36 ornamental and 182 wild saltcedars from Montana, North Dakota, and Wyoming, USA. We found that ornamental and wild population genotype frequencies were highly dissimilar. Also, genotype frequencies of hypothetical propagule populations under scenarios of random mating, self-fertilization, and clonal reproduction in the ornamental population were highly dissimilar to the genotype frequencies of the wild populations. Assignment tests indicated that the majority of wild genotypes originated from other wild plants, not from ornamental plants. However, ornamental plants could not be excluded as contributors to wild populations because all chloroplast and nuclear haplotypes found in the ornamental plants were found at some frequency in the wild. These findings suggest that while ornamental saltcedars are not the sole source of wild saltcedar, they do have potential to contribute genetic material to an invasion or re-establish a population after existing wild saltcedars are removed.

Revegetation obstacles following tamarisk control: Cheatgrass invasion and herbicide residues (Session 1)

Stephanie Gieck[1], A.A. Sher[1], S. Nissen[2], E. Lane[3], C. Brown[2], and A. Norton[2]
[1]Department of Biological Sciences, University of Denver, and Denver Botanic Gardens Research and Conservation Unit. sgieck@du.edu, asher@du.edu. [2]Bioagricultural Sciences and Pest Management, Colorado State University. snissen@lamar.colostate.edu, csbrown@lamar.colostate.edu, apnorton@lamar.colostate.edu. [3]Colorado Department of Agriculture, Division of Plant industry. eric.lane@ag.state.co.us

Abstract:

Although much is known about tamarisk removal, few quantitative studies exist to document challenges to restoration post-control. Each of the most popular control methods, i.e. mechanical removal and herbicide application, is likely to pose unique challenges, particularly for re-vegetation. For example, it is assumed that mechanical removal of tamarisk is likely to lead to further invasion by other weeds, whereas aerial applications of effective pesticides (such as imazapyr) will impede other weeds but are also likely to leave residues that prevent establishment of desirable species. To

address these issues, we have established a restoration study near Florence, CO, where we have applied three different control methods to tamarisk infestations. Treatments included aerial application of imazapyr, mechanical control, mechanical control with spot applications, and reference (untouched) plots. 20m wide plots/strips of each of these were replicated five times in each of three locations along drainages infested by tamarisk. Within the mechanical control plots, we also investigated the effect of preparing the seed bed with tilling. After one growing season, we quantified the levels of re-infestation by *Bromus tectorum*, as a part of a long-term study. Within the chemical control plots, we measured soil residues of imazapyr after spraying and used these levels to develop a greenhouse bioassay to test response of common restoration species at different half-lives. Despite predictions otherwise, we observed the highest levels of *B. tectorum* in undisturbed plots, with mechanical removal of tamarisk and tillage appearing to reduce re-invasion in one of the sites. As expected, soil residues of imazapyr had dramatic effects on all native species tested, suggesting a high sensitivity even for those species that are commonly used after chemical control. These preliminary results may have important implications for management of sites after tamarisk removal, and demonstrate that existing paradigms may not apply to all locations.

ET estimation by remote sensing and GIS approaches for management (Session 5)

David P. Groeneveld[1], Dave Barz[1], Jesse D. Roberts[2]
[1]HydroBio, Santa Fe, NM, 87501. david@hydrobio.org. [2]Soil and Sediment Transport Group, Sandia National Labs, NM, 88220

Abstract:

For effective system-wide management of tamarisk, a crucial and often overlooked first step is to assess the current state of the river, to evaluate processes and treatments already undertaken, and to project potential cost/benefits and risks to the system. The Pecos River in New Mexico has undergone extensive multi-year, helicopter-based herbicide spraying in an attempt to control tamarisk from its banks and along several tributaries. This study was undertaken to provide an estimate of water salvaged by tamarisk control to provide the basis for conducting a cost/benefit analysis. An estimate of salvage was made as the residual between evapotranspiration (ET) estimated for the year prior to commencement of herbicide spraying (summer 2002) and for the year following final treatments (summer 2005). Accurate estimation of ET quantifies the potential salvage through the decrease of ET in the system. Rather than going to tamarisk use, the salvaged water becomes available to provide increased supply for native vegetation, increased soil water storage, and as the agencies that funded, planned and undertook the herbicide spraying hoped, discharge of the salvaged water to the river.

Color aerial photography was used as a visual reference of the phreatophyte vegetation and LANDSAT TM7 satellite imagery were used to assess water use by riparian vegetation. Image processing techniques expanded the accuracy and precision of Normalized Difference Vegetation Index (NDVI) by conversion to NDVI* that controls non-systematic variation in the data. NDVI* was calibrated to annual totals of precipitation and reference ET (ET0) to yield an estimate of annual ET consumption that was applied to the imagery through the entire study reach from Sumner Dam northeast of Fort Sumner to Brantley Dam north of Carlsbad (about 230 km). The calculations of ET before and after herbicide application were made within a GIS using 30-m pixels. The aerial coverage of the analyses was defined by GPS logs taken by helicopter during aerial application on the main stem (areas that were sprayed outside of our study area-- above Sumner Dam, below Brantley Dam and on tributaries were not analyzed).

From the before-after comparison, an estimated savings of 3.1 AF/acre were realized on the approximately 6,000 treated acres (annual salvage of 18,600 AF). Projection of these results to the herbicide treated areas outside our study area increased estimated water salvage by another 16,700 AF/yr. The water in the Pecos system has an actual value between $13 and $30/AF. Thus, were all of the salvaged water realized in river flow (only a portion would be expected) the value of total salvage of 35,300 AF/yr would be between $460,000 and $1,060,000. The amount of salvage is expected to decline each year as regrowth by tamarisk or other species occurs. The value of "realized" salvage and its dollar value on the Pecos River must be balanced against risks for bank erosion and reservoir sedimentation: in combination these may exceed a billion dollars.

Implementing biological control of saltcedars using *Diorhabda elongata*: the USDA-APHIS-PPQ cooperative release program in the western US (Poster)

Richard W. Hansen[1] and William C. Kauffman[1]
[1]USDA-APHIS-PPQ, Fort Collins, CO. richard.w.hansen@aphis.usda.gov, william.c.kauffman@aphis.usda.go

Abstract:
In 2005, USDA-APHIS-PPQ received permission to initiate implementation releases of the saltcedar leaf beetle, *Diorhabda elongata* (Coleoptera: Chrysomelidae), north of 38° latitude in western states. The purpose of this program is to establish field insectaries in the various states that would be used for intrastate distribution of beetles throughout each state, thus allowing widespread incorporation of biological control into saltcedar management strategies. In July 2005 and May 2006, *D. elongata* adults were collected from an established research site in Nevada and provided to PPQ personnel and/or other project cooperators for field release. To date, about 50 release sites have been established in nine states; generally, initial release sizes range from 2000 to 5000 adult beetles. A standardized monitoring program was implemented at each insectary site; this program collects data describing the condition of saltcedar and associated vegetation, and documents the growth and spread of *D. elongata* populations. Though none of these sites has collectable beetle populations so soon after initial release, it appears that most have established *D. elongata* populations.

Tamarisk research priorities of land and water managers: results from a USGS partnership meeting (Manager's Perspectives)

Leanne Hanson[1], Patrick B. Shafroth[1], and Frank D'Erchia[2]
[1]USGS Fort Collins Science Center, Fort Collins, CO, 80526. pat_shafroth@usgs.gov. [2]USGS Central Region.

Abstract:
In an effort to identify science and information needs of land and water managers related to the control and management of tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*), the US Geological Survey (USGS) Central Region hosted a partnership meeting in August 2003 in Albuquerque, New Mexico. The meeting provided a forum for stakeholders and partner agencies to discuss what types of research would benefit them the most, to present the capabilities of USGS, and to flesh out potential areas of collaboration. Representatives from three Pueblos, the State of New Mexico, multiple New Mexico Soil and Water Conservation Districts, the City of Albuquerque, the Southwest Strategy, the Army Corps of Engineers, the Bureau of Indian Affairs, the Bureau of Land Management, the Bureau of Reclamation, the Natural Resources Conservation Service, the National Park Service, the US Fish and Wildlife Service and the USGS participated in the meeting. Stakeholders and water resource managers presented current activities and identified research that could enhance their efforts. Agency representatives shared information about specific goals and mandates from their organizations, current management techniques and practices, and current and future needs for controlling tamarisk and Russian-olive and restoring native habitats. USGS scientists presented current research and multidisciplinary capabilities that could be applied to address stakeholder and manager needs. Break-out group discussions focused on five topics: control, distribution mapping, restoration/ revegetation, water salvage, and wildlife. Some of the identified research needs include: improving our understanding of the efficacy of chemical and biological control approaches; resolving issues associated with mapping and modeling the distribution and spread of *Tamarix* at local to national scales; developing protocols and metrics for revegetation and long-term site monitoring; improving our understanding of *Tamarix* effects on water quantity, water quality; and better understanding relationships between wildlife taxa distributions as they relate to patterns of *Tamarix* distribution and abundance. We will present all of the research needs identified during the break-out group discussions, and common themes found through these discussions.

Saltcedar management and water salvage estimates on the Pecos River in Texas, 1999-2005 (Session 5)

Charles R. Hart[1], M. Keith Owens[2], and Georgianne W. Moore[3]
[1]Texas Cooperative Extension, Stephenville, Texas 76401. [2]Texas Agricultural Experiment Station, Uvalde, Texas 78802.
[3]Department of Rangeland Ecology and Management. The Agriculture Program, Texas A&M University

Abstract:
A large scale ecosystem restoration program was initiated in 1999 on the Pecos River in Western Texas. Saltcedar (*Tamarix* spp.), a non-native invasive tree, had created a near monoculture along

the banks of the river by replacing most native vegetation. Local irrigation districts, private landowners, federal and state agencies, and private industry worked together to formulate and implement a restoration plan, with a goal of reducing the effects of saltcedar and restoring the native ecosystem of the river. An initial management phase utilizing state-of-the-art aerial application of herbicide began in 1999 and continued through 2005. Over 13,000 acres of saltcedar have been treated within the Pecos River Basin over 6 years. Intensive monitoring and research to assess the affects of saltcedar removal on water loss and water salvage has been conducted at a site near Mentone, Texas since the fall of 2000. Stand-level and stem-level water loss resulting from evapotranspiration, and water salvage from saltcedar control are being estimated. Stand-level losses are estimated by monitoring groundwater diurnal fluctuations within two saltcedar sites along the river channel. Shallow groundwater monitoring wells were installed at each site, each well equipped with a pressure transducer water level loggers to provide data on the diurnal fluctuation of the groundwater table. Mathematical models were developed to estimate total water loss from the sites based on the magnitude of the diurnal fluctuations. Sites were monitored for one growing season, then saltcedar was treated on one site and comparisons made between the treated and untreated sites through 2006. Additionally, sap flow measurements were made on individual trees during the growing seasons of 2004, 2005 and 2006. Heat dissipation probes were installed in 12 to 20 trees each year. The trees were selected in 3 groups based on the distance from the tree to the edge of the river. The probes were interrogated every 10 seconds and a 30 minute average sap flux was reported. Zero flow calculations were based on nighttime maximum temperature differences. The amount of sapwood per unit ground area was sampled by harvesting all stems in a 10 * 10 m area and recording sapwood using digital cameras. Diurnal fluctuation in sap flux was modeled and compared to the diurnal fluctuations from the monitoring wells. Transpiration was partitioned from evapotranspiration resulting in estimates of stand level water use.

Mapping *Tamarix* for the Canadian River Riparian Restoration Project (Poster)

Kelly D. Hendrick[1]
[1]Remme Corporation, Northstar Helicopters, and the Canadian River Riparian Restoration Project.
kelly.hendrick@remmecorp.com

Abstract:

Tamarix was mapped within the Canadian River watershed in northeast New Mexico in support of the Canadian River Riparian Restoration Project. Approximately 1200 river miles of main stem and named tributaries were photographed during *Tamarix* senescence and subsequently mapped. Mapping priorities included a generalized delineation of stands, the discovery of isolated stands, and a prediction of herbicide sprayable acres. *Tamarix* identified within the surveyed area totaled 15,319 acres. In 2006, an accuracy assessment compared predicted sprayable acres with actual spray records. On 67 river miles near the top of the watershed, sprayed acreage of *Tamarix* was correctly estimated with an error of less than 5%.

Effects of herbivory by *Diorhabda* leaf beetles on carbohydrate reserves of tamarisk (Poster)

Jeremy L. Hudgeons[1], Allen E. Knutson[2], Kevin M. Heinz[1], C. Jack DeLoach[3], and Tom L. Dudley[4]
[1]Department of Entomology, Texas A&M University, College Station, TX, 77843. Hudgeons, Jeremy L jhudgeons@tamu.edu, kheinz@ag.tamu.edu. [2]Texas Cooperative Extension, Dallas, TX, 75252. a-knutson@tamu.edu. [3]Grassland Protection Research Unit, USDA-ARS, Temple, TX, 76502. jdeloach@spa.ars.usda.gov. [4]Riparian InVasives Research Laboratory, UC Santa Barbara, Santa Barbara, CA, 93106. tdudley@msi.ucsb.edu

Abstract:

The reduction of tree carbohydrate reserves by defoliation can lead to reduced plant vigor, foliage yield and possibly tree death. The leaf beetle *Diorhabda elongata* (sensu lato) is being released for the classical biological control of exotic and invasive tamarisk (*Tamarix* spp.). The impact of *D. elongata* defoliation on tamarisk carbohydrate reserves was evaluated by measuring nonstructural carbohydrates (NCHO) in field cage and natural experiments. The field cage experiment was conducted in West Texas in 2004 and replicated in 2005. Root crown tissue was collected before and after beetle defoliation and analyzed for NCHOs. The natural experiment was conducted near Lovelock, Nevada where a *D. elongata* release in 2001 has resulted in widespread defoliation of tamarisk in the Humboldt sink. Root crown tissue was sampled in 2005 and 2006 from areas where trees had experienced 3-4, 2-3, 1-2, 0-1 and 0 seasons of beetle defoliation. In the field cage experiment, NCHOs were reduced in trees which had experienced one defoliation event, though the

difference was not statistically significant. In the natural experiment, NCHOs from trees defoliated 3-4, 2-3 and 1-2 seasons were significantly reduced when compared to trees which were defoliated less than 1 season. A majority of the trees defoliated 3-4 seasons are no longer producing foliage, indicating possible tree death due to starvation. These results suggest that a prolonged reduction in carbohydrate reserves (3 or more seasons) is necessary for tree death.

Middle Rio Grande Bosque Restoration Projects, U.S. Army Corps of Engineers, Albuquerque District (Poster)

Ondrea Hummel[1]
[1]U.S. Army Corps of Engineers Albuquerque District, Environmental Resources Section, Albuquerque, NM 87109. ondrea.c.hummel@usace.army.mil

Abstract:

The U.S. Army Corps of Engineers in collaboration with the Middle Rio Grande Conservancy District, the City of Albuquerque and the New Mexico State Parks Division has developed ecosystem restoration concepts and potential educational and recreational enhancements for the bosque. These projects are part of a comprehensive program by the U.S. Army Corps of Engineers to restore the Rio Grande river corridor as it winds through Bernalillo County and the City of Albuquerque.

The project area for this long-term restoration effort corresponds roughly with the Rio Grande Valley State Park. In addition to the larger study, there are three other projects with more focused areas and shorter timelines: the Bosque Wildfire Project (currently under construction and includes the Albuquerque Reach and Greater Albuquerque Area), Bosque Ecosystem Restoration @ Route 66 (which is between I-40 and Bridge Blvd.) and the Albuquerque Bio Park (construction complete). All of these projects are described in greater detail on the project website – www.bosquerevive.com.

The goal of the program is to develop a framework to restore the bosque (cottonwood riparian woodland) into a more functional and sustainable ecosystem. At the same time, the project will promote enhanced recreational and educational opportunities for local citizens and visitors to the region. A critical focus of the project will be to increase the diversity and quality of wildlife habitat. Another key focus of the effort will be to reduce the fire hazard and increase personal safety in much of the bosque through the removal of the metal jetty jacks, debris, and the dense thickets of non-native vegetation (salt cedar, Russian olive & Siberian elm).

In 2003, the project team documented the bosque's unique natural and cultural history using a combination of existing data, previous agency reports, fieldwork and historical research. This resulted in the 905(b) Reconnaissance Report and the Middle Rio Grande Bosque Supplemental Planning Document. In addition, the team held a series of community and stakeholder meetings during that time, which provided invaluable input for the project. Collectively, this input has become the basis for developing the initial restoration concepts. The input, analyses and concepts developed by the team were assembled in the reports mentioned above. The feasibility study for the Middle Rio Grande Bosque Restoration Project began in July 2004.

The project sponsor is the Middle Rio Grande Conservancy District. The project is being coordinated with the restoration efforts of other agencies and stakeholders, including the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, the Endangered Species Act Collaborative Group, Bernalillo County Open Space, the New Mexico State Land Office, Corrales Bosque Preserve, Pueblo of Sandia, Pueblo of Isleta, AMAFCA, the Bosque Improvement Group, Rio Grande Restoration, Tree New Mexico and the City of Albuquerque Planning and Open Space Divisions, to name a few. The poster will provide an overview and handouts regarding these projects.

New potential agents for tamarisk biocontrol in US (Poster)

R.V. Jashenko[1], I.D. Mityaev[1], C.J. DeLoach[2]
[1]Tethys Scientific Society, Institute of Zoology, 93 Al-Farabi St., Almaty, 050060, Kazakhstan. romajashenko@yahoo.com.
[2]USDA-ARS, Grassland, Soil & Water Research Lab, 808 E. Blackland Road, Temple, TX, 76502. jdeloach@spa.ars.usda.gov

Abstract:

The Almaty, Kazakhstan biological control research group has been involved in *Tamarix* biocontrol studies since 1994. This group has three goals: 1) to study the biology and phenology of *Diorhabda elongata* in its native area; 2) to find new biological agents of *Tamarix* and study their biological features under native conditions, and 3) to discover and test biological control agents of other weeds of the western U.S. According to our research in Kazakhstan, the 4 most preferable potential *Tamarix* biocontrol agents for introduction into U.S. (after *D. elongata*) are: 1) the stem-

galling moth, *Amblypalpis tamaricella* (Lepidoptera, Gelechiidae); 2) the foliage and flower galling psyllid, *Crastina tamaricina* (Homoptera, Psylloidea, Aphalaridae); 3) the gall midge, *Psectrosema noxium* (Diptera, Cecidomyiidae); and 4) the foliage-feeding weevil, *Coniatus steveni* (Coleoptera, Curculionidae). All can heavily damage *Tamarix* in Kazakhstan, and all have some protection from predators, and from drowning. *Amblypalpis tamaricella* inhabits riparian forests and deserts in south and southeastern Kazakhstan and heavy infestations are capable of killing entire trees.

The Almaty, Kazakhstan station is well situated to conduct explorations for control agents for biological control of saltcedar, Russian olive (*Elaeagnus angustifolia*), and several other weeds of the western U.S. and Canada that are native to Central Asia, such as perennial pepperweed (*Lepidium latifolium*), Russian thistle (*Salsola* spp.), Russian knapweed (*Acroptilon repens*), yellow starthistle (*Centaurea solstitialis*), medusahead (*Taeniatherum caput – medusae*) and other weeds, as well as for several serious introduced insect pests.

The close proximity of these weeds to the Almaty station allows for inexpensive, season-long studies of field ecology, behavior, host-range observations in the field, and no-cage formal testing, which cannot be done in the U.S. and which provide the most realistic evaluation of these critical factors. The presence of scientists in several scientific disciplines of the affiliated Tethys Scientific Society and the Kazakhstan Academy of Sciences provide the best scientific support for biological control available in Central Asia. Good relations between Kazakhstan and Russia and other Central Asian countries, and a common language (Russian) and cultural similarities, allows open travel and free scientific exchanges with these countries unavailable to most western scientists.

Biological control of tamarisk: Establishment, population increase, and impacts of *Diorhabda* spp. at experimental release sites in the western US (Session 3)

D.J. Kazmer[1], C.J. DeLoach[2], D. Bean[3], R.I. Carruthers[4], T.L Dudley[5], D. Eberts[6], A.E. Knutson[7], D.C. Thompson[8]

[1]USDA-ARS, Northern Plains Agricultural Research Lab, 1500 N. Central Ave, Sidney, MT 59270. dkazmer@sidney.ars.usda.gov. [2]USDA-ARS, Grassland, Soil and Water Research Lab, 808 E. Blackland Road, Temple, TX 76502. JDELOACH@spa.ars.usda.gov. [3]Colorado Dept. Agriculture, Biological Pest Control Program, 750 37.8 Rd., Palisade, CO 81526. Dan.Bean@AG.STATE.CO.US. [4]USDA-ARS, Exotic and Invasive Weeds Research Unit, 800 Buchanan St., Albany, CA 94710. ric@pw.usda.gov. [5]Marine Science Institute, Univ. of California, Santa Barbara 93106-6150. tdudley@msi.ucsb.edu. [6]USDI-Bureau of Reclamation, P.O. Box 25007, D-8220, Denver, CO 80225. deberts@do.usbr.gov. [7]Dept. of Entomology, Texas A&M University, Dallas, TX. a-knutson@tamu.edu. [8]New Mexico State University, MSC 3BE, Box 30003, Skeen Hall #N220, Las Cruces, NM 88003-8003. dathomps@nmsu.edu

Abstract:

An experimental release program for *Diorhabda elongata* sensu lato, a leaf beetle that is the first biological control agent for tamarisk, was approved in late 1998. The Fukang (China) and Chilik (Kazakhstan) ecotypes of *D. elongata* were first released in field cages starting in 1999 at 10 sites in California, Colorado, Nevada, Texas, Utah and Wyoming. Open field releases were first made in 2001 at 7 of the 10 sites. Additional experimental release sites have been added since 2001 in some of the latter states as well as Montana, New Mexico, and Oregon. Results to date have been extremely variable, ranging from failure of the beetles to establish viable populations outside of the field cages to spectacular outbreak populations that have defoliated tens of thousands of hectares of tamarisk. The long critical photoperiod for induction of reproductive diapause of the Fukang ecotype appears to have limited its ability to establish in southern locations. Ecotypes of *D. elongata* from Turpan (China), Greece, Uzbekistan and Tunisia have shorter critical photoperiods and some open field releases of 3 of these ecotypes in southern locations show signs of preliminary success. One northern California site where the Fukang ecotype failed to establish is dominated by *Tamarix* parviflora, a less suitable host plant of the Fukang ecotype. An alternate *D. elongata* ecotype from Crete, Greece appears to have established and increased in numbers at this site. Predation, by birds and a large suite of generalist arthropod predators, is also hypothesized to be a major cause of establishment failure or limited population growth. Research on new tamarisk biological control agents is focusing on species that are less susceptible to generalist predators. Where populations of the Fukang and Chilik ecotypes are established, increasing dramatically in numbers, and repeatedly defoliating the same tamarisk plants, the impacts on tamarisk include increased branch mortality, decreased flower and seed production, and some instances of apparent whole-plant mortality. No direct impacts on nontarget plants by *D. elongata* have been observed at these locations.

Evaluating remote sensing tools for mapping the distribution of saltcedar (*Tamarix* spp.) in a biocontrol study site (Poster)

Lisa Kennaway[1]
[1]Center for Plant Health Science and Technology, USDA Animal and Plant Health Inspection Service. Fort Collins, CO, 80526. lisa.kennaway@aphis.usda.gov

Abstract:
Within the USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ) division, image classification procedures for mapping weed distributions and their control efforts are not well documented. Specifically, mapping a biocontrol program's impact on a weed's populations is limited. This study evaluates the effectiveness of using remote sensing tools to map saltcedar (*Tamarix spp.*) distribution for a biocontrol study site in Wyoming using airborne collected hyperspectral image (HSI) data. Several data sets were evaluated, including 1 and 2 meter resolution data. Also, several approaches to mapping those distributions were evaluated including feature extraction with Feature Analyst software, and image classification with Erdas Imagine Spectral Analysis Workstation (SAW). Results of the analysis provide quantitative evidence of saltcedar distribution decrease for many parts of the study area. This has been evaluated with formal accuracy assessments and field observation validation. It is rare within PPQ that a biocontrol initiative has this type of data available for program planning and management. Developing a consecutive year dataset contributes to the ultimate goal of having a saltcedar distribution data series that program managers will use to evaluate the performance of the biocontrol treatment.

Tamarisk in the Pacific Northwest: Assessing reality and risk (Poster)

Becky K. Kerns[2], Catherine G. Parks[1], Bridgett J. Naylor[1], Alan A. Ager[2], and Jerome S. Beatty[2]
[1]Pacific Northwest Research Station, USDA, Forest Service, La Grande Forestry and Range Sciences Laboratory, La Grande, OR. cparks01@fs.fed.us, bnaylor@fs.fed.us
[2] Pacific Northwest Research Station, USDA Forest Service, Western Wildland Environmental Threat Assessment Center, Prineville, OR. bkerns@fs.fed.us, aager@fs.fed.us, jbeatty@fs.fed.us,

Abstract:
Tamarisk is becoming a dominant shrub along some streams of the Pacific Northwest Region of the United States (PNW) and can potentially threaten numerous economic and ecological values, including native plant communities, wildlife habitat, recreation, and agricultural and municipal water supplies. Tamarisk can also potentially alter wildfire frequency and intensity and stream morphology. Of particular concern is the alteration of stream food web dynamics and potential impacts on salmon recovery and management in the interior Columbia Basin. Despite a number of intense mapping efforts, the spatial distribution of tamarisk in the PNW is not well known. To address this gap, we completed a preliminary assessment of tamarisk occurrence in Idaho, Washington and Oregon. We contacted state and local weed experts to obtain known infestation locations. Data were acquired from multiple formats (point, line, and polygon geospatial data files; spreadsheets, hand-drawn on paper maps; and quarterquad summary values) and combined into a single GIS coverage. We then visually compared our map of known tamarisk infestations with the tamarisk habitat suitability map created by Morisette et al. (2006). The newly created map of tamarisk in the PNW contributes to other west wide tamarisk mapping efforts such as T-map. Our map will be refined with high resolution imagery and additional field observations. Future work will include a spatially explicit probabilistic risk assessment where risk is calculated as the expected value of the conditional probability of a tamarisk invasion occurring at a particular intensity and location times the ecological consequence of the invasion given that it has occurred. The risk assessment will quantify the threat from tamarisk in the PNW and provide needed information for developing mitigation policy.

Quantifying ground-water savings achieved by tamarisk control: A demonstration project in the riparian zone of the Cimarron River, Kansas (Session 5)

Gerard J. Kluitenberg[1], J.J. Butler, Jr.[2], D.O. Whittemore[2], and D. Arnold[3]
[1]Department of Agronomy, Kansas State University, Manhattan, KS 66506. gjk@ksu.edu. [2]Kansas Geological Survey, University of Kansas, Lawrence, KS 66047. jbutler@kgs.ku.edu, donwhitt@kgs.ku.edu. [3]Arnold Ranch, Ashland, KS 67831. darnold@ucom.net

Abstract:

Low streamflows are an increasing problem in Kansas and other areas of the U.S. One factor thought to be responsible for stream-flow reductions in western Kansas is the consumption of ground water by phreatophytes in riparian corridors. Extensive control measures, primarily focusing on invasive species such as salt cedar and Russian olive, are being considered in response to concerns about the impact of phreatophytes on water resources. At present, there is no generally accepted means of quantifying the ground-water savings that might be achieved through these measures. Recently, an approach based on diurnal fluctuations in the water table has been shown to have potential for quantifying ground-water consumption by phreatophytes. A demonstration project is underway to evaluate this method for assessing ground-water savings achieved through phreatophyte-control measures.

The site for the demonstration project is on the Arnold Ranch near Ashland in an area of salt-cedar infestation along the Cimarron River in southwestern Kansas. Four plots, each approximately four hectares in size, have been established at the site. Different salt-cedar control measures are being applied in three of the plots and one plot (background monitoring plot) is being used to collect data unaffected by control measures. Wells have been installed at the site to monitor water-table responses at the site; each is equipped with an integrated pressure-transducer and datalogger unit programmed to take a pressure head readings at 15-minute intervals. Water content in the vadose zone is monitored biweekly during the summer months using a neutron probe in access tubes located adjacent to each well. A weather station has been installed to collect the meteorological data required to estimate potential evapotranspiration. Salt-cedar control measures were initiated in March of 2005. At that time, three of the four plots were clear cut except for circles ranging from 20-30 m in radius, centered at each well. The radii of those circles of vegetation were progressively reduced through repeated cuttings in the summer of 2005. Only the invasive phreatophytes (salt cedar and Russian olive) were cut at the site; grasses, forbs, and low-lying bushes were largely unaffected. A chemical treatment (Remedy and diesel-fuel mix) was applied to the salt-cedar regrowth in one plot following the cutting. Water levels, soil moisture, and meteorological parameters were monitored during these activities.

Water levels from wells in the background-monitoring plot were compared with water levels from wells in the other plots prior to cutting. A similar comparison following cutting and chemical treatment shows a reversal in the relative magnitude of the fluctuations. The changes in the relationships between water levels in the background-monitoring plot and those in the cutting and chemical treatment plot enabled initial estimation of the reduction of ground-water consumption resulting from control measures. The reduction appears to be on the order of 30-40%. Apparently, the shallow depth to water at this site allows substantial ground-water consumption by other mechanisms, such as transpiration by shallow-rooted vegetation and direct evaporation from the water table. Work has been initiated to assess the relative importance of ground-water consumption by these other mechanisms. Unless the impact of these mechanisms is better understood, it will be difficult to reliably estimate the potential water savings to be achieved through control of invasive phreatophytes.

Implementing biological control of *Tamarix* with leaf beetles in West Texas (Poster)

Allen Knutson[1], Mark Muegge[2] and C. Jack DeLoach[3]

[1]Texas Cooperative Extension, Texas A&M University Research and Extension Center, Dallas, TX. [2]Texas Cooperative Extension, Texas A&M Extension Center, Ft. Stockton, TX. [3]USDA-ARS Grassland, Soil and Water Research Laboratory, Temple, TX.

Abstract:

The goal of this project is the establishment of saltcedar leaf beetles, *Diorhabda* species, as a biological control agent for saltcedar in Texas. The immediate objectives are to 1) establish field populations of saltcedar leaf beetles at 1-2 locations per county in the Upper Colorado River Watershed and the Pecos River Watersheds and 2) redistribute beetles from these sites to local landowners, land managers and water districts. During May through July, 2006, a total of 4,480 adult saltcedar leaf beetles were released at 15 sites in 10 counties in West Texas. All beetles were collected from the field population established near Big Spring, TX. Methods that optimize establishment of beetles at new sites were also evaluated and included: 1) sleeve cages caging beetles on branches, 2) 10 X 10 cages 7 feet tall which caged beetles onto a single tree and 3) open field release where beetles were released onto saltcedar trees without cages. Beetles completed one generation following release at all sites. Red imported fire ants and native ants are believed

responsible for the low survival of beetles at four sites. As of mid-August, several hundred eggs and larvae were present at each of three sites and less than 100 egg masses and larvae were present at each of the 8 remaining sites. With another generation to be completed in late August, it is hoped that numbers will increase at all release sites. Ultimately, success will be measured by the number of beetles present one year after the release.

Modeling aboveground biomass of *Tamarix* (*Tamarix ramosissima*) in the Arkansas river basin in southeastern Colorado, USA (Session 8)

Sunil Kumar[1,3], Paul Evalgelista[1,3],Thomas Stohlgren[1,2,3], Alycia Crall[1,3], Greg Newman[1,3]
[1]Natural Resource Ecology Laboratory, Colorado State University, Ft. Collins, CO 80523-1499, USA. sunil@nrel.colostate.edu, paulevan@warnercnr.colostate.edu, toms@nrel.colostate.edu, newmang@nrel.colostate.edu [2]USGS Fort Collins Science Center, 2150 Centre Ave, Bldg C, Ft. Collins, CO 80526-8118, USA. toms@nrel.colostate.edu. [3]National Institute of Invasive Species Science; www.niiss.org. sunil@nrel.colostate.edu, paulevan@warnercnr.colostate.edu, toms@nrel.colostate.edu, newmang@nrel.colostate.edu

Abstract:

We developed predictive models of total aboveground biomass of non-native *Tamarix ramosissima* using canopy area (m^2) and average height (m) as predictor variables. Destructive sampling was used to collect field data on 50 individuals and four 100 m^2-plots from Oxbow State Wildlife Area and Grenada State Wildlife Area, Colorado. Each sample was measured for average height (m) of stems and canopy area (m^2) prior to cutting, drying and weighing. Canopy area for each individual/plot was calculated by multiplying plot area (m^2) by the percent canopy cover (%) recorded in the field. From a set of candidate models, five competing regression models were evaluated using Akaike's Information Criterion corrected for small sample size (AICc). The best model explained 97% of the variation in total aboveground biomass of *Tamarix ramosissima* and included canopy area, average height (Ht), and Ht^2 as predictors ($F_{3, 53} = 494.99$, adjusted $R^2 = 0.97$, $P < 0.0001$). In this model canopy area was one of the best predictors (partial R2 = 0.95). Other four models explained 70% to 95% of the variation in total aboveground biomass. For example, the models that included only canopy area and only average height, explained 95% and 70% of the variation in total aboveground biomass, respectively. Since the response variable, total aboveground biomass, was log transformed, we also calculated correction factors for each model to correct for bias due to log transformation. Land managers can use these models directly to predict Tamarisk aboveground biomass.

Key factors and constraints in restoration of native plant communities in arid, monotypic infestations of saltcedar (*Tamarix* spp.) - strategies and techniques

(Session 1)

Kenneth D. Lair[1]
[1]Restoration Ecologist / Research Botanist, USDI Bureau of Reclamation, Invasive Species Management Team, Environmental Applications and Research Group, Denver Technical Service Center, P.O. Box 25007 (Mail Code 86-68220), Denver, Colorado 80225-0007; klair@do.usbr.gov.

Abstract:

Critical knowledge gaps exist regarding vegetative recovery in aridic, monotypic saltcedar (*Tamarix* spp.) stands with no (desirable) understory. Formulation of revegetation strategies that provide site stabilization, resistance to further saltcedar and secondary weed infestation, and acceptable habitat values for affected wildlife species becomes particularly problematic in monotypic saltcedar stands under biological, fire and herbicidal (i.e., non-mechanical) control scenarios. Amount and density of standing biomass (live and dead) remaining after control poses limitations in relation to seeding and planting techniques, seed interception in aerial (broadcast) applications, and seedbed preparation methods. Undisturbed soil surfaces impacted by saltcedar leaf litter accumulation, salinity, hummocky microxrelief, and nutrient limitations restrict potential for successful revegetation. Long duration of saltcedar occupation may deplete desirable microbial communities, particularly arbuscular (endo)mycorrhizae symbiotic and host-specific to native revegetation species. Selected results of innovative revegetation strategies at study sites on the Rio Grande and the Colorado River will be discussed that address three primary requisites for successful restoration on these site types: a) moisture capture and conservation; b) proper native species selection; and c) growth medium augmentation. These factors often include: soil surface and rhizosphere manipulation methods to facilitate removal of standing dead biomass, increase precipitation capture, improve soil moisture retention, and create micro-sites exhibiting lower salinity and increased protection from environmental extremes for improved seed germination;

salinity remediation; seeding methodologies, including use of seed coating techniques; and mycorrhizal inoculation methods.

Native species displacement and dominance by saltcedar (*Tamarix* spp.) over time - is it a continuous, linear process? A conceptual framework for assessing ecological restoration potential, strategies and techniques (Session 8)

Kenneth D. Lair[1], Anna A. Sher[2], Scott O'Meara[1], and Michelle K. Cederborg[2]
[1]Primary contact: Restoration Ecologist / Research Botanist, USDI Bureau of Reclamation, Invasive Species Management Team, Environmental Applications and Research Group, Denver Technical Service Center, P.O. Box 25007 (Mail Code 86-68220), Denver, Colorado 80225-0007; klair@do.usbr.gov. [2]Department of Biological Sciences, University of Denver, 2199 S. University Blvd., Denver, CO 80208. asher@du.edu, MKCederborg@aol.com

Abstract:

Numerous layers of riparian resource data (habitat structure, condition and suitability; soils; consumptive water use; surface and groundwater hydrology), compiled by various agencies and research entities, exist in the literature. Little effort, however, has been placed on synthesizing these diverse and often incomplete or segmented data across land ownership and use boundaries into a multi-agency decision-support framework and tool for use in management of saltcedar-infested lands. Utilitarian methods for development of habitat suitability classifications, risk assessment, treatment prioritization, and restoration potential assessment are needed to serve as models for evaluation of similar riparian ecosystems infested by saltcedar. Control of saltcedar without prioritization based on expected response to treatment and feasible objectives for recovery of beneficial use(s) is not sound, scientifically or environmentally.

Of more specific interest regarding treatment prioritization in ecological terms - is saltcedar simply one of several symptoms reflecting more basic underlying “drivers” (i.e., anthropogenic floodplain hydrologic alteration), or does saltcedar independently modify the soil environment as stands increase and mature? This concept needs scientific study in lieu of ongoing anecdotal evidence. Related questions include: If this process of self-induced soil modification is occurring, is it linear? Is the soil microbial community depleting at linear rates in relation to age and nature of infestation, physiology of saltcedar (e.g., salt exudation rates), and displacement of native species? Are there temporal and spatial (stand age / density) scenarios of saltcedar infestation in relation to soils at which the native plant and microbial communities "crash", having reached a threshold of adverse soil alteration? How is this correlated with / separated from effects of competition, shading, and hydrologic impacts? Is this soil modification permanent as long as these stands of saltcedar remain intact, or does the soil alteration process rate decline or even reverse itself under older age classes (i.e., very mature saltcedar with long-term, undisturbed canopy closure)?

In research initiated this summer (2006), state-of-the-art sampling design and techniques, remote sensing, soils and vegetation inventories, cost:benefit assessment, present and potential land use and management, and statistical analysis are incorporated into GIS-based depictions and decision support criteria that will a) correlate saltcedar presence, treatment response, canopy characteristics, and distribution with site environmental conditions; and b) assess habitat suitability, risk, treatment priority, and restoration potential. Current research results and technology from universities and agencies on quantification of evapotranspiration rates and groundwater salvage will be incorporated into these models to project estimated water savings based on plant community structure and composition, prioritized treatment prescriptions, and projected restoration response toward desired habitat goals.

Precision application of aerially applied herbicide (Session 6)

Barney G Lee[1]
[1]North Star Helicopters, Inc. North Star VMS. 16049 North Windsor Ave. Gardendale, TX 79758. blee222@hotmail.com

Abstract:

Why should land managers care about aerial application technology? Precision application improves our ability to address problems with the least effects on our environment. With advancements in equipment, we can improve productivity as well as improve the environment. When most people think of aerial application, they only think of helicopters and airplanes. However, ground support equipment has also seen great improvements too. Trucks with DOT spec 406 certification, provides the highest standards in case of an accident or roll over. Doubled walled tanks, measuring devices and rinse capabilities all contribute to quality application. Additional

support technology that has benefited the application industry comes from the use of computers in the field. Lap tops and hand held GPS units on the ground complement the GPS systems used by the pilots in the air. Aerial GPS systems, flow meters, flow controllers using ground speed calibrations, and the use of avoidance zones, gives us the precision application needed today. Improvements in boom and nozzle configurations give us more control of where and how herbicides are applied. By using the USDA computer drift model in conjunction with the improved system set up, we are able to minimize the potential of herbicides being applied outside the target area. In most cases using a helicopter with the specifically configured equipment, potential drift can be reduced to approximately .33% of the total spray volume. In conclusion, by the incorporation of all the available technology, we can effectively and safely apply herbicide by the aerial method.

Collection, storage and release of *Diorhabda elongata* for the biocontrol program of tamarisk (Poster)

Terri Locke[1], Nina Louden[1], Brian Swedhin[1], and Richard Hansen[2]
[1]Colorado Department of Agriculture, Biological Pest Control, 750 37.8 Rd., Palisade, CO 81526. Terri.Locke@ag.state.co.us, ninalouden@hotmail.com, bswedhin@hotmail.com. [2]USDA-APHIS-PPQ, Western Region 2150 Centre Avenue, Building B, 3E10 Fort Collins, Colorado 80526. Richard.W.Hansen@aphis.usda.gov.

Abstract:

The Colorado Department of Agriculture and USDA APHIS PPQ are collaborating in the regional implementation of tamarisk biocontrol; a program that requires large scale collection, handling, storage and release of the leaf beetle, *Diorhabda elongata*. Observations made during field collections and methods developed for handling beetles in the lab are presented in this poster. Field collections were made at the Lovelock and Walker River sites in western Nevada over a period of three years and were done in the spring, summer, and fall. Collections were made from swarms of reproductive beetles in the spring and summer as well as from aggregations of prediapause beetles in the fall. In the laboratory, storage conditions were varied and it was found that survival rates increased as storage temperatures were decreased. Most of the implementation releases were made with freshly collected beetles that had been held for short periods in the laboratory under conditions that stimulated reproduction. Implementation releases were made primarily with adults. Methods for release are discussed.

Effects of tamarisk invasion and biological control on birds (Session 7)

William S. Longland[1], Tom L. Dudley[2], Derek Hitchcock[3], Daniel Harmon[4]
[1]USDA, Agricultural Research Service, Reno, NV. longland@unr.nevada.edu. [2]University of California, Santa Barbara and University of Nevada, Reno. tdudley@msi.ucsb.edu . [3]University of Nevada, Reno. hitch771@yahoo.com. [4]USDA, Agricultural Research Service, Reno, NV. dharmon@wncc.edu

Abstract:

Riparian corridors in the arid western states become conspicuously more homogeneous when they are invaded and dominated by saltcedar (*Tamarix ramosissima*). In contrast to the multi-canopy structure of most native riparian systems, saltcedar generally occurs as a single woody canopy layer with a depauperate herbaceous understory. Bird species diversity is known to be positively associated with foliage height diversity across a wide variety of environments, and riparian corridors tend to be among the most productive habitats for birds in the western states, because they offer more structurally distinct canopy layers than surrounding arid land vegetation. Consequently, bird diversity may be reduced considerably when native riparian vegetation is replaced by saltcedar. Despite this possibility, the implementation of a saltcedar biological control program has been hindered by concerns that a decline in saltcedar populations along invaded riparian corridors could negatively impact local bird populations. To address these issues, we first compared numbers and species richness of passerine birds between paired native and saltcedar-invaded stretches of three western Great Basin river systems during the breeding seasons of 2001 and 2002. With the exception of one river system in one year, all of these comparisons showed significantly greater numbers and species richness of passerines in native riparian vegetation relative to paired saltcedar sites. In 2005, we compared adjacent areas of a saltcedar-invaded stretch along one of these rivers -- one area with an extremely high density of saltcedar leaf beetles (*Diorhabda elongata*) and the other lacking these biological control insects. Numbers and species richness of passerine birds were significantly greater in the presence of *Diorhabda* than in their absence. Finally, we compared frequencies of bird fecal deposits in neighboring saltcedar-invaded areas with versus without *Diorhabda*. Bird droppings occurred significantly more frequently under saltcedar trees in stands

with *Diorhabda* present. Taken together, our results indicate that saltcedar invasions reduce local numbers and diversity of passerine birds and that efforts at biological control of saltcedar can incur at least short-term benefits for passerine birds.

Saltcedar control with rotary and fixed wing aircraft (Session 6)

Kirk C. McDaniel[1], Charles R. Hart[2], and Alan McGinty[3]

[1]Department of Animal and Range Sciences, New Mexico State University, Las Cruces, NM, 88003. kmcdanie@nmsu.edu. [2]Stephenville Research and Extension Center, Texas A&M University, Stephenville, TX, 76401 cr-hart@tamu.edu. [3]San Angelo Research and Extension Center, Texas A&M Uninversity,San Angelo, TX, 76901. mcginty@tamu.edu

Abstract:

Rotary- and fixed-wing aircraft have been compared in various research, demonstration and commercial trials on saltcedar since the late 1980's in Texas and New Mexico. For this presentation saltcedar control data following treatments with imazapyr or imazapyr + glyphosate spray mixtures are standards for comparison. Success and failure in controlling saltcedar have occurred with both aircraft types. Two specific trials in Texas and two conducted in New Mexico that directly compared spray results from these aircraft suggest that results are easily influenced by the experimental protocol. This is especially true when experiments are applied in situations that are favorable or advantageous to one platform or the other.

Experience gained from comparative spray trials indicate that aircraft model and its guidance system, coupled with how the spray delivery system is configured, directly influence spray results. Application timing and plant coverage with the optimal herbicide mixture are key reasons for success. Plant coverage is enhanced when medium to large sized droplets (750 -1000µm) are applied with a relatively high spray volume (7 to10 gpa fixed wing; 15 gpa rotary). Saltcedar control using either platform has varied by year, weather conditions at the time of spraying, pilot/operator experience and various logistical factors. Fixed-wing aircraft are suited to relatively large monoculture saltcedar stands where the swath overlap pattern provides maximum herbicide coverage. Rotary- aircraft are well suited to areas requiring precise coverage such as along river edges, spraying among desired vegetation and areas where few swaths can be made. Economics is an important consideration but choice of which aircraft to employ for spraying saltcedar should be determined mainly by the type of work to be undertaken.

Upper Colorado River Saltcedar Management Program - A case history (Session 8)

Allan McGinty[1], Ben Brooks[2], Jack DeLoach[3], Allen Knutson[4], Mark Muegge[5] and Okla Thornton[6]

[1]Texas Cooperative Extension, San Angelo, TX, 76903. [2]Texas Soil and Water Conservation Board, San Angelo, TX, 76903. [3]U. S. Department of Agriculture - Agriculture Research Service, Temple, TX, 76502. [4]Texas Cooperative Extension, Dallas, TX, 75252. [5]Texas Cooperative Extension, Ft. Stockton, TX, 79735. [6]Colorado River Municipal Water District, Big Spring, TX, 79720

Abstract:

The Colorado River, measured in length and drainage area, is the largest river wholly in the State of Texas. The river begins in northeastern Dawson County, and then flows southeast for 600 miles until it drains into Matagorda Bay. At present, saltcedar has invaded the upper Colorado River and its tributaries from the headwaters above Lake J.B. Thomas to the dam at O.H. Ivie Reservoir, a distance of more than 240 river miles.

Phase 1. To address the issue of saltcedar control along the upper Colorado River, Texas Cooperative Extension (TCE) organized a task force in 2001 to develop a saltcedar control plan. Represented on the task force were Texas Parks & Wildlife Department (TPWD), Colorado River Municipal Water District (CRMWD), Natural Resources Conservation Services (NRCS), Texas State Soil & Water Conservation Board (TSSWCB), North Star Helicopters, BASF Chemical Co., Texas Department of Agriculture (TDA), Texas Agricultural Experiment Station (TAES), Upper Colorado River Authority (UCRA), Lower Colorado River Authority (LCRA), Texas Farm Bureau, U.S. Army Corps of Engineers (USACE), U. S Department of Agriculture – Agriculture Research Service (USDA-ARS), U.S. Fish & Wildlife Service (USFWS) and Dow AgroSciences.

The highest priority issue identified by the Task Force was the current Arsenal 24(c) label restriction that prohibited spraying within 2 miles of the Colorado River in 3 counties that lay within the middle of the Colorado River saltcedar infestation. To address this issue, task force members from TCE, CRMWD, and TDA began informal consultation with the USFWS to investigate control options that would allow treatment of saltcedar without risk to the Texas poppy-mallow. For two years these task force members worked on this issue culminating in an amended Arsenal 24(c) label

that reduced the spray buffer from 2 miles on either side of the river down to 60 ft. from known Texas poppy-mallow habitat. Under this amended label saltcedar along the Colorado River was now legal to treat with Arsenal.

Phase II. In 2003 a proposal ($2.2 million) was submitted through the TSSWCB to obtain Clean Water Act Section 319(h) funding to control saltcedar from the headwaters of the Colorado River to the Lake Spence dam. The proposal was funded in 2004. With TSSWCB providing leadership and working through local SWCD's, herbicide spraying was initiated in August, 2005, beginning at the Lake Thomas Dam and extending to the confluence of Beals Creek (2416 acres). Herbicide spraying continued during 2006, reaching the top of the Lake Spence basin (1700 acres), and will continue during 2007 extending treatment to the Lake Spence dam (6000 acres). All herbicide applications have been applied using rotary wing aircraft, the herbicide Arsenal at a rate of ½ gal/ac and a total spray volume of 15 gal/ac. All herbicide spraying to this date has been conducted on private land, requiring a landowner easement. Initially, 85% of the targeted landowners in 2006 participated. As of this date, the percentage of eligible landowners participating has increased to 95%.

Phase III. Biological control is an important part of this project to extend treatment life following herbicide applications and to provide a control option for small localized populations of saltcedar,. Under the direction of USDA/ARS, TCE and TAES, the first release (within cages) of saltcedar leaf beetles, *Diorhabda* species, were made at Lake Thomas and Beals creek in 2003. The immediate objectives of Phase III are to 1) establish field populations of saltcedar leaf beetles at 1-2 locations per county in the Upper Colorado River Watershed and 2) redistribute beetles from these sites to local landowners, land managers and water districts.

A total of about 3,280 adult saltcedar leaf beetles were released at 10 sites in 7 counties during May through July, 2006. All saltcedar leaf beetles were collected from the field population established (2003) on Beals Creek near Big Spring, TX.

Beetles completed one generation following release at all sites. As of mid-August, several hundred eggs and larvae were present at each of three sites and 20-40 egg masses and larvae were present at the 7 remaining sites. Predation by red imported fire ants and native ants significantly reduced beetle numbers at three sites. With another generation to be completed in late August, it is hoped that numbers will increase at all release sites. Ultimately, success will be measured by the number of beetles present one year after the release.

Influence of saltcedar and associated woody vegetation on channel geomorphology of the upper Verde River (Poster)

Alvin L. Medina[1], Tyler D. Johnson[1], and Jackson M. Leonard[1]
[1]USDA Forest Service, Rocky Mountain Research Station, Flagstaff, AZ 86001. ALMEDINA@FS.FED.US, TDJOHNSON@FS.FED.US, JLEONARD@FS.FED.US

Riparian vegetation response to control of invasive plant species: restoration or retrogression (Session 1)

David M. Merritt[1,2], Mike L. Scott[3], Bradley J Johnson[4]
[1]US Forest Service Watershed, Fish, and Wildlife Program, Natural Resource Research Center, 2150 Centre Ave., Bldg A, Suite 368, Fort Collins, CO 80526. [2]Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523 dmmerritt@fs.fed.us. [3]US Geological Survey, Fort Collins Science Center, 2150 Centre Ave, Bldg C. Fort Collins, CO 80525. mike_l_scott@usgs.gov. [4]Department of Biology, Colorado State University, Fort Collins, CO 80523. bjohnson-jec@comcast.net.

Abstract:

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.

Native and exotic riparian leaf litter as food for aquatic macroinvertebrates: Tamarisk, Cottonwood, and Russian olive (Session 7)

Angela B. Moline[1] and LeRoy N. Poff[1]
[1]Graduate Degree Program in Ecology and Department of Biology, Colorado State University, Fort Collins, CO.
amoline@lamar.colostate.edu, poff@lamar.colostate.edu

Abstract:

Non-native tamarisk and Russian olive are the third and fourth most frequently occurring tree species in Western riparian zones (Friedman *et al*. 2005). The invertebrate shredders that live in streams derive a large portion of their diet from riparian allochthonous inputs (e.g. autumn leaf fall). These larval invertebrates are consumed by aquatic invertebrate predators and fish. Emerging insects are in turn consumed by terrestrial predators such as bats, birds, and spiders. Despite the link between riparian vegetation and stream food webs, the effect of exotic tamarisk and Russian olive on invertebrate shredders is unknown.
Tamarisk differs from native vegetation in its chemical composition and leaf morphology, and previous research has suggested that tamarisk may be a poor food for stream invertebrates. Bailey *et al.* (2001) studied in-stream tamarisk leaf pack colonization and suggested that tamarisk is less palatable to aquatic invertebrates than native cottonwood because of its high salt content. They also suggested that because fragile tamarisk leaves decompose more quickly than cottonwood, they provide relatively poor habitat. Other researchers, however, have found no difference between

invertebrate colonization of tamarisk and native leaf packs (Pomeroy *et al*. 1999, Moline *unpub. data*).

We compared the relative growth rates of aquatic insect shredders on diets of cottonwood (*Populus deltoides*), Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix* spp.). Cranefly larvae (Diptera: *Tipula* sp.) that are found in Western streams were used as a model shredder in the lab. *Tipula* larvae were maintained in the lab in individual aquaria and fed a single species of leaf material *ad libitum*. The leaf material was soaked in stream water for two weeks prior to the experiment to allow for aquatic biofilm colonization. Tipulid larvae were weighed weekly over a 7-week period. The aquatic insects grew significantly faster (average = 2x) and to a larger final size when fed tamarisk compared to either Russian olive or cottonwood, which were statistically indistinguishable from one another.

Contrary to our expectations, tamarisk appears to be a good food for this common aquatic invertebrate shredder. We did not run the experiment to pupation/emergence, so we are uncertain what effect tamarisk has on *Tipula* fitness. The ecosystem scale effect of tamarisk on stream invertebrates is still unclear, as Western streams tend to be flashy and leaf litter is frequently flushed from the system. Tamarisk leaves are small and may be easily transported downstream. In the laboratory, by contrast, tamarisk leaf litter was retained in the foraging arenas and was constantly available for consumption. In addition, aquatic shredders constitute a relatively small portion of the aquatic invertebrate fauna in Western streams, so the positive overall impact of tamarisk on stream food webs may be small.

Hydrogeomorphic factors influencing the establishment and distribution of *Tamarix* in Grand Canyon National Park (Session 2)

Susan G. Mortenson[1], Peter J. Weisberg[1], and Lawrence E. Stevens[2]
[1]University of Nevada Reno. mortens7@unr.nevada.edu, pweisberg@cabnr.unr.edu. [2]Museum of Northern Arizona. farvana@commspeed.net

Abstract:

Geomorphology and hydrology influence the establishment, persistence, and spread of invasive riparian plants. In turn, riparian plant invasions affect hydrogeomorphology by stabilizing river banks and narrowing river channels. We are interested in the present establishment and distribution patterns of *Tamarix* and the hydrogeomorphic factors that favor *Tamarix* over native riparian woody species in Grand Canyon National Park (GCNP). Following the completion of Glen Canyon Dam in 1963, *Tamarix* colonized the newly available habitat adjacent to the river that was now protected from annual floods. However, new germination surfaces have been limited due to decreased flooding and sedimentation. Current conditions appear to favor new *Tamarix* establishment on cobble bars and silty-sand beaches.

In order to elucidate the influence of geomorphology on *Tamarix* distribution patterns, we estimated *Tamarix* density on random 100 m "floating transects" from Lee's Ferry to Diamond Creek (364 km). The average *Tamarix* density was 0.29 m-2. The maximum (1.65 m-2) and minimum (0 m-2) *Tamarix* densities were sampled in the Upper Granite Gorge geomorphic reach which has the lowest mean reach width of the sampled reaches. We analyzed the influences of distance to nearest upstream tributary, channel sinuosity, geomorphic reach, substrate resistivity, and channel width on *Tamarix* density using multiple linear regression models. In a previous study we found higher cover of *Tamarix* in geomorphic reaches of moderate resistivity. Additionally, straighter channels are more likely to have higher relative *Tamarix* cover due to this shrub's unique ability to colonize cliffs and rocky channel margins. We hypothesized that transects located closer to tributary mouths would have a higher density of *Tamarix* as a consequence of added sediments. However, initial analyses (scatterplots) reveal no significant effect of distance to major upstream tributary on *Tamarix* density (p=0.39). These findings corroborate earlier research finding no significant difference in vegetation cover one mile above and one mile below the Little Colorado River tributary.

In addition, historical aerial photo analyses were used to explore the importance of tributary sediment input for facilitating *Tamarix* establishment. We used historical aerial photos of the Colorado River in GCNP from 1965, 1973, 1980, 1985, 1988, 1990, 1995, and 2002 to relate intervals of *Tamarix* establishment to the annual hydrograph record. Specifically, we investigated the effect of tributary flooding on the establishment of *Tamarix* by focusing on four debris fan complexes (DFC) located above and below the Little Colorado River (LCR) / Colorado River confluence. The LCR

flooded in 1993 causing inundation, scouring, addition of sediments, and creation of new surfaces for establishment of riparian vegetation downstream. We expected to find a higher proportion of young (post 1993) cohorts (i.e. patches) of *Tamarix* at sites below the LCR when compared with sites above the LCR. In the same way, we investigated the potential for *Tamarix* establishment events related to the managed flood of 1996.

Locations of present-day *Tamarix* patches were mapped in the field in spring 2006 and used to identify *Tamarix* patches in historical aerial photos. Orthophotos from 2002 were used to count the total number of *Tamarix* patches or cohorts at each site with a focus below the 1,274 m2s-1 inundation line (defined by the USGS flow stage reconstruction model) that represents maximum post-dam flows. We compared aerial photos from 1990/1995 with 1995/2002 photos at each DFC, and the number of young cohorts (those patches that were absent in earlier photos but present in the later photos) were counted. The majority of *Tamarix* patches below the 1,274 m2s-1 inundation line originated in the 1990s. Between three and seven percent of the identified patches appeared between 1995 and 2002. This suggests that the 1996 flood did not incite major establishment events at the sampled DFCs.

Thus far, our results indicate that long-term *Tamarix* establishment is not influenced by proximity to upstream tributaries. Sediment aggradation from tributary inputs may occur far downstream from tributary confluences. This suggests a possibly minor influence of tributary flooding and sedimentation on vegetation patterns along the main channel. Thus, appropriate management of flow regime from Glen Canyon Dam might be able to prevent further *Tamarix* establishment in GCNP, given knowledge of flows that have favored *Tamarix* establishment in the past. Clearly we need annually precise data to be able to relate particular flow events to establishment events, so we will age trees on varied geomorphic surfaces to obtain the year of establishment. Dendroecological techniques in combination with analysis of historical aerial photography will allow us to precisely correlate specific *Tamarix* establishment events with key aspects of flow regime and geomorphology.

Evapotranspiration by tamarisk from three 1-km^2 sites at Cibola NWR on the lower Colorado River (Session 5)

Pamela Nagler[1], Edward Glenn[2], Kamel Didan[2], Doyle Watts[3], John Osterberg[4], and Jack Cunningham[4]

[1]U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, BioSciences East Building, Room 125, University of Arizona, Tucson, AZ 85721. [2]Soil, Water, and Environmental Science Dept., University of Arizona, Tucson, AZ 85721. [3]Department of Geological Sciences, Wright State University, Dayton, OH 45435. [4]U.S. Bureau of Reclamation, Denver Federal Center, Denver, CO 25007

Abstract:

Saltcedar (*Tamarix ramosissima*) has become the dominant plant species on the Lower Colorado River. Over 90% of the riparian corridor is classified as saltcedar habitat, growing in monocultures or in association with other salt tolerant shrubs such as arrowweed (*Pluchea sericea*) or saltbushes (*Atriplex* spp.). There is concern that saltcedar uses large amounts of water that could otherwise be used for agriculture or municipal water needs. Foliage density, leaf area index and evapotranspiration rates of saltcedar have been measured at the plant or small-plot scale, but little information is available for these parameters at the landscape level of measurement from which water budgets can be constructed. We used remote sensing methods and ground surveys to characterize the stand structure and evapotranspiration (ET) of three large (1 km^2), densely vegetated stands of saltcedar in the Cibola National Wildlife Refuge on the Lower Colorado River near Blythe, California. The centers of the plots were 200 m (Plot 1), 800 m (Plot 2) and 1600 m (Plot 3) from the river channel. Depth to groundwater varied from 3.0 m for Plot 1 to 3.7 m for Plots 2 and 3, and salinities of the groundwater varied from approximately 2,000 ppm for Plot 1 and 10,000 ppm and 5,000 ppm for Plots 2 and 3, respectively. All plots were virtual monocultures of saltcedar and were selected as typical of the large, dense stands of saltcedar that grow along the river within this wildlife refuge. Percent vegetation cover, determined by aerial photography, was 56%, 71% and 85%. LAIs for individual plants averaged 5.0 for all plots, and global LAIs for plots ranged from 2.8 to 4.3, as determined by % cover times LAI of individual plants. Plants in Plot 1 exuded copious amounts of water from leaves each summer morning, and appeared to moisten the soil in the vadose zone at 1-3 m depth through hydraulic lift. These phenomena were not as pronounced in the other two plots, which had deeper and more saline water tables. ET was estimated by an algorithm developed for

saltcedar and other riparian plants on southwest rivers, which regressed moisture flux tower data against MODIS Enhanced Vegetation Index values from the Terra satellite and ground-level air temperature measurements. Applied to these stands, peak ET rates ranged from 7-9 mm d-1 among sites. Projected annual rates were 1.6 m, 1.9 m, and 1.8 m for Plots 1-3, respectively. Annual ETo is about 2.0 m at this location. These rates compare to annual rates of 0.8 m to 1.2 m measured for dense stands on the Middle Rio Grande (LAI 3.0-3.5), and 0.8 m to 1.0 m for mixed arrowweed/saltcedar stands at the Havasu National Wildlife Refuge on the Lower Colorado River near Needles, CA. For whole river stretches, rates projected from MODIS imagery are approximately 0.8 m yr-1, as they incorporate areas of sparse vegetation as well as saltcedar stands.

Aerial application methods to reduce imazapyr impacts on riparian restoration (Session 6)

Scott J. Nissen[1], Galen R. Brunk[1], and Dale L. Shaner[2]

[1]Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO. [2]USDA-ARS, Fort Collins, CO. snissen@lamar.colostate.edu, dale.shaner@ars.usda.gov, pwestra@lamar.colostate.edu, gbrunk@lamar.colostate.edu

Abstract:

Imazapyr (Habitat™, BASF) is the most commonly used herbicide for large-scale tamarisk management. The most consistent control has been achieved by applying two quarts of imazapyr in a carrier volume of 15 gallons per acre by helicopter. This technique results in spray droplets in the range of approximately 800 to 1000 µm and was adopted to minimize drift to non-target riparian species. We evaluated the impact of this application technique on imazapyr retention by tamarisk by placing five cm petri dishes within a closed tamarisk canopy and in areas without tamarisk to estimate spray retention. We then collected and analyze soil samples from replicated helicopter applications at three different research sites near Florence, CO. The initial herbicide applications were made late September 2004 and soil samples were taken in October 2004 and October 2005. Control soil collected from one of three research sites near Florence was used to conduct laboratory dissipation studies to establish a half-life for imazapyr. Imazapyr was extracted from petri dish and soil samples with water and analyzed using reverse phase HPLC with UV detection.

The recommended helicopter application technique resulted in tamarisk retaining only 42% for applied herbicide, while the remaining 58% passed through the canopy. This finding was subsequently verified by collecting soil samples within and outside the tamarisk canopy. Across the three research sites there was no statistical difference between imazapyr residues in the upper six-inch soil layer within and outside the plant canopy. Imazapyr residues ranged between 113 and 337 ng/g (ppb). One year after application imazapyr residues decreased by 70 to 87%, but the trend was for less dissipation within the tamarisk canopy. Our initial laboratory study indicates an imazapyr half-life of approximately 28 days, which is at the lower end of published range of 25-142 days.

Our initial working hypothesis was that the tamarisk canopy would intercept and retain a large portion of the applied imazapyr; therefore, passive restoration efforts could begin with more herbicide tolerant warm season grasses perhaps as early as the spring following application. We found that a significant amount of herbicide reaches the soil surface even in a closed canopy and this will negatively affect restoration efforts. Changes to this high volume application technique could result in much greater herbicide retention by the tamarisk canopy, less herbicide reaching the soil surface, reduced application costs and more rapid restoration.

Response of saltcedar and native grasses to five years of mowing or herbicide applications (Session 1)

Alex Ogg[1], Steve Christy[2], and Mike Wille[3]

[1]Big Horn Basin Exotic Plant Steering Committee, Ten Sleep, WY, 82442. ogga@tctwest.net. [2]Big Horn Basin Exotic Plant Steering Committee, Worland, WY, 82401. schristy@yahoo.com. [3]Fremont County Weed and Pest District, Riverton, WY, 82501. mwille@wyoming.com

Abstract:

A site heavily infested with saltcedar near Manderson, WY was burned in March of 2001 and then mowed with a brush hog to remove standing burnt stems. The area was disked twice and seeded in April 2001with desirable grasses and forbs. Exceptionally dry conditions prevented the establishment of desirable species. However, there was vigorous regrowth of the saltcedar in 2001. The area was again mowed in October 2001 to remove the new stems. On July 30, 2002, long-term field plots were established to compare mowing to herbicide application for the control of saltcedar and response of native grasses. Individual plots were 20 by 30 feet and each treatment, mowing or

herbicide application, was replicated four times. The percent cover of Inland saltgrass (*Distichlis spicata*) and alkali sacaton (*Sporobolus airoides*) was estimated visually before treatments were applied. A hand-held power brush cutter was used to mow the saltcedar to within 2 to 4 inches of the soil surface. Plots were mowed once in 2002, twice in 2003 and once in 2004, 2005 and 2006. Pasturegardä (triclopyr + fluroxypyr) was applied at 2 qts/acre plus 1/4% nonionic surfactant in 15 gallons total solution with a held-held boom sprayer as the herbicide treatment. Pasturegard was applied annually in late July thereafter until all saltcedar was killed. In July 2002, Inland saltgrass cover varied from 3 to 20% and alkali sacaton cover varied from 1 to 20% in the plots. Saltcedar populations varied from 50 to 200 per plot in July 2002. In July 2004, after two annual applications of Pasturegard, saltcedar populations were reduced 98% compared to annual mowing. There was no saltcedar in the Pasturegard plots in 2005 or 2006. After 3 years of mowing, saltcedar populations were reduced about 50%, and after 4 years of mowing they were reduced about 60%. In 2005 and 2006, saltcedar in the mowed plots was noticeably reduced in vigor. Based on the results of this study, annual mowing is relatively ineffective method for eliminating saltcedar, whereas 2 or 3 annual applications of herbicide appears highly effective for killing saltcedar. Between 2002 and 2006 there was a four-fold increase in Inland saltgrass in both treatments. Alkali sacaton increased two-fold in the mowed plots and three-fold in the herbicide plots.

How much water can a tree really use? (Poster)

M. Keith Owens[1] and Georgianne W. Moore[2]
[1]Texas Agricultural Experiment Station, 1619 Garner Field Road, Uvalde, TX, 78801. m-owens@tamu.edu. [2]Department of Rangeland Ecology & Management, Texas A&M University, College Station, TX, 77843. gwmoore@tamu.edu

Abstract:

Riparian vegetation has ready access to moisture throughout the growing season and has been reported to transpire more water than upland vegetation. In fact, *Tamarix* has been reported to use 200 gallons of water each day, and this number has been the basis for much discussion and even legislation. It is used in Extension publications from North Dakota to Arizona, a coloring book teaching children about the plant, and in a legislative bill in Colorado. However, a thorough literature search could not reveal the manuscript, with the experimental methods, which reported this number. We investigate the potential water use of woody vegetation in general, and of *Tamarix* in particular, to demonstrate that it is highly unlikely that a plant could transpire that much water. The first line of evidence is a literature review of woody plant water use. The mean water use of over 100 species of woody plants from around the world is 38 gallons per day. If a value is greater than the mean plus 3 times the standard deviation (150 gallons), then it is generally a statistical outlier and is dropped from analyses. The reported 200 gallons is clearly outside of this limit and should be viewed skeptically. The second line of evidence is using reported levels of sap flux for *Tamarix* and the sapwood area of the plants. To achieve a flow of 200 gallons per day with the reported sap flux rates, a tree would need over 1800 cm2 of sapwood area. Actual sapwood measured at 2 sites of mature *Tamarix* on the Pecos River and 3 sites on the Rio Grande River is only one tenth of this amount. The entire amount of sapwood from a 200 m2 plot was not sufficient to allow water use of 200 gallons per day. The third line of evidence is to compare the amount of water lost from pan evaporation to the reported water use. Assuming an average canopy diameter of 20 feet, the energy available for evaporation from a free water surface can account for up to 120 gallons of evaporation over most of the distribution of *Tamarix*. *Tamarix* often supports a high leaf area index which would increase the surface area for water loss, but after accounting for conductance restrictions and conduit size, it is clear that these plants cannot transport that much water. These 3 lines of evidence will be presented in detail to demonstrate that it is extremely unlikely, or even impossible, for *Tamarix* to transport 200 gallons of water per day.

Basin-scale hydrology, vegetation, and patch selection by the southwestern willow flycatcher along the Lower San Pedro and Gila Rivers, Arizona (Session 7)

Charles E. Paradzick[1] and Julie C. Stromberg[2]
[1]Environmental Division, Salt River Project, Phoenix AZ 85072. ceparadz@srpnet.com. [2]School of Life Sciences, Arizona State University, Tempe AZ 85287. jstrom@asu.edu

Abstract:

The southwestern willow flycatcher (*Empidonax traillii extimus*, SWFL) is an endangered riparian obligate songbird whose habitat has been greatly altered by large-scale damming, flow diversion, and groundwater pumping that substantially changed hydrology, riparian vegetation, and nesting habitat quality. To develop long-term conservation strategies for the bird, managers need data that links river processes to breeding habitat suitability. We assessed the relationships between hydrogeomorphic conditions (surface and groundwater hydrology) and riparian vegetation, and assessed SWFL patch selection patterns, along the free-flowing lower San Pedro River and the regulated Gila River in southeastern Arizona. Riparian forest near the confluence of these rivers supports one of the largest concentrations of SWFL in the subspecies range. Results indicated that the Gila River has low patch and structural diversity, and an abundance of tamarisk (*Tamarix ramosissima*) forest, compared to the free-flowing San Pedro River, which had high patch and structural diversity with co-dominant cottonwood-willow (*Populus* spp. – *Salix* spp.) and tamarisk forest. On the San Pedro River, SWFL selection patterns suggested that willow forest was used more than expected, tamarisk less often than expected, and cottonwood in equal proportion based on availability. On the Gila River, most of the limited cottonwood-willow patches were utilized but were too sparse to allow for determination of selection preference. Willow forest patches were located at lower floodplain elevations, inundated more frequently, and had shallower groundwater compared to tamarisk forest patches. Substantial alteration to the hydrograph and interruption of characteristic fluvial processes by regulation probably are the causes of the low structural diversity of vegetation patches on the Gila River, and could limit temporal availability of SWFL nesting habitat. Preference for willow forest on the San Pedro River highlights the need to further examine the impact to SWFL of plant community shifts from cottonwood-willow to tamarisk forest. For land and water managers, conservation and restoration of SWFL breeding habitat should consider hydrogeomorphic conditions across multiple scales including the influence of basin-scale hydrology on riparian floodplain forests and its constraint on local patch vegetation structure and floristic characteristics.

Impacts of the saltcedar leaf beetle on saltcedar (*Tamarix* spp.) water use in central Nevada (Session 1)

Robert R. Pattison[1], Carla M. D'Antonio[2], Tom Dudley[3], Kip Allander[4]
[1]USDA-ARS Exotic and Invasive Weeds Research Unit, Reno, Nevada. rpattiso1@hotmail.com. [2]Department of Ecology, Evolution and Marine Biology, UC Santa Barbara. dantonio@es.ucsb.edu. [3]Marine Science Institute, UC Santa Barbara. tdudley@msi.ucsb.edu. [4]USGS Carson City, Nevada. kalland@usgs.gov

Abstract:

In this study we document the impacts of the saltcedar leaf beetle (*Diorhabda elongata*) on the water use of saltcedar trees (*Tamarix* spp.) at two field sites in central western Nevada. *Diorhabda elongata* is the first approved biological control agent for saltcedar in the U.S.A. Within 3 years from release beetles defoliated most to all of the trees at each field site and had spread over 25 km.

We used stem sapflow gauges and canopy evapotranspiration towers to measure the impacts of defoliation by *D. elongata* on saltcedar water use. We document that during the first year of defoliation by *D. elongata* transpiration decreased by up to 55% over the course of a season. During the second year the reduction in transpiration was 33%. However, in locations closer to the release site where beetle activity was more intense and little canopy foliage remained, the reductions in water use was over 95%. Across a broader area the impacts of beetles on saltcedar water use are dependent on a variety of factors including the timing and intensity of beetle defoliation and the canopy coverage of trees. In this study the greatest impacts on water use occurred closer to the release site. Beetle impacted trees did not have higher rates of water use per unit leaf area therefore estimates of canopy cover provide useful insights into reductions in water use. Collectively these results indicate that *D. elongata* is effective in reducing saltcedar water use across a large area. More information is needed to understand how to effectively establish *D. elongata* in other sites throughout the western U.S.A.; and how its impacts will alter long term community dynamics and ecosystem level water use.

Effects of mixing Greek and Chinese saltcedar leaf beetles in large field cages (Poster)

Beth Petersen[1] and David Thompson[1]
[1]New Mexico State University, Department of Entomology, Plant Pathology, and Weed Science, Las Cruces, NM 88003-8003. betpeter@nmsu.edu

Abstract:

Saltcedar (*Tamarix* sp.) is an invasive riparian shrub/tree spreading through the western US. *Diorhabda elongata* (Coleoptera: Chrysomelidae) is a biological control for saltcedar. Ecotypes from

China and Greece have been released in the western US. Ecotypes from Fukang, China have established in northern locations and ecotypes from Posidi and Crete, Greece are establishing in southern locations. It is likely that distribution of these ecotypes will overlap in the future. The objective of this experiment was to monitor the differences between Fukang and Posidi ecotypes in field cages and to determine the effects of mixing populations.

Fukang and Posidi ecotypes will mate and produce viable eggs when confined; however, all of the F1 offspring are sterile. The consequences of hybrid matings could disrupt long-term population dynamics in a mixed field population, slowing population growth or causing localized extinction of one ecotype. While it is still unknown if the Fukang and Posidi ecotypes can coexist, in a no-choice controlled environment the two ecotypes will readily mate with each other.

Population and mating studies were carried out in a two year experiment. Large field cages were setup with three different beetle treatments: pure Crete/Posidi, pure Fukang, and mixed Crete/Posidi and Fukang. Saltcedar defoliation, and the density of adults, eggs and larvae were estimated in all cages. During the first year, Crete populations peaked at 500 adults and defoliated 100% of the saltcedar in the cage. The Fukang population reached 120 adults resulting in 60% defoliation. While the mixed Crete and Fukang cage had no population growth and no defoliation.

Invasion process of tamarisk and Russian olive into Canyon de Chelly National Monument (Session 4)

Lindsay V. Reynolds[1]

[1]Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO. lindsayr@warnercnr.colostate.edu

Abstract:

Canyon de Chelly National Monument in northeastern Arizona has been invaded by tamarisk and Russian olive, resulting in the development of predominantly exotic riparian vegetation and river channel change. Tamarisk and Russian olive first established in the canyons between 1920 and 1940, and have since expanded throughout the canyons. Concurrent with the introduction of these exotic plants has been dramatic stream channel change. Historically, the stream beds in Canyon de Chelly contained wide, open, braided channels, as evidenced in historical photographs. In most of the upper canyons the stream beds are channelized and incised. This appears to have resulted in a water table decline on floodplains. Irrigation and traditional farming practices of the Navajo canyon residents have become nearly impossible. The changes in vegetation and stream channel morphology have inspired efforts to study the causes of these changes and develop strategies to mitigate their negative effects. I am investigating three components of exotic plant invasion in Canyon de Chelly and the role of exotic plants in the riparian landscape; (1) the historic patterns and processes of exotic plant invasion to understand the timing of exotic plant invasion relative to the timing of climate changes, river regulation and purposeful introductions, (2) processes that allowed tamarisk and Russian olive to successfully invade Canyon de Chelly and the characteristics of the floodplain that made it invasible, and (3) the biotic and abiotic characteristics of the floodplain that will shape future plant communities, and whether native riparian plant communities could be restored.

Historic establishment patterns of exotic plants throughout the canyon will be determined by precision aging of tamarisk and Russian olive plants in selected locations around the canyon to understand the temporal and spatial pattern of invasion, correspondence with climate, and whether tamarisk and Russian olive invaded before or after they were planted in the canyon. To understand why tamarisk and Russian olive were successful, I am testing research questions involving seedling establishment requirements of both native and exotic riparian plants as well as assessing available habitat in the canyon to understand where empty ecological niches exist in the canyon. I am also studying the biotic and abiotic characteristics of the riparian habitat that will shape future plant communities after tamarisk and Russian olive have been removed from our study sites. I am comparing the effect of two removal methods (cut-stump and whole-plant extraction) on the composition of vegetation in our study sites, as well as on airborne seed availability and the ground water table. Preliminary results suggest tamarisk seed rain is dramatically reduced in cleared areas and the ground water table is too deep for riparian plant establishment in the future. Thus, in areas cleared of tamarisk and Russian olive there may only be potential for the return of a xeric, rather than a riparian plant community. I am analyzing the soil seed bank throughout the canyon to understand the role of the seed bank in recovery of the native vegetation following exotic plant removal. Preliminary seed bank results indicate the existence of historic wetland plant species as well as native and exotic grasses. These results allow me to develop an understanding of why

tamarisk and Russian olive have been successful colonists in southwestern floodplains, and inform future management and restoration of riparian habitats.

Tamarix removal for successful native revegetation along the Las Vegas Wash, Clark County, Nevada (Poster)

Nicholas A. Rice[1], Shanahan A. Seth[1], Keiba Crear[1]
[1]Southern Nevada Water Authority, Las Vegas, NV. nick.rice@snwa.com, seth.shanahan@snwa.com, keiba.crear@snwa.com

Abstract:
Woody riparian vegetation along the Las Vegas Wash, Clark County, Nevada consists predominately of the invasive *Tamarix ramosissima*. Restoration initiatives along this stream channel have been conducted over the past several years by removing T. *ramosissima* and replacing it with native riparian vegetation. Bulldozers and excavators have been used exclusively to remove below- and above-ground woody biomass. Although these mechanical removal options are efficient, they result in large debris piles that we are required to remove prior to revegetation. Along the Las Vegas Wash, permanent biomass removal has included controlled burning, loading drop boxes to be delivered to the landfill, and biomass grinding followed by drop box loading and landfill delivery. The efficiency of each option has been determined from practical field experience and is addressed using a multi factor matrix that incorporates both time and materials. Estimates of efficiency have been evaluated on an acreage basis and have helped inform restoration managers in charge of removing T. *ramosissima* from the Las Vegas Wash.

Saltcedar control by grazing with goats compared to herbicides (Poster)

Ruth Richards[1] and Dr. Ralph E. Whitesides[2]
[1]Big Horn County Weed and Pest District, Greybull, WY. bhcwp@tctwest.net. [2]Utah State University, Department of Plants, Soils, and Biometerology, Logan, UT. ralphw@ext.usu.edu

Abstract:
The objective of the field portion of this study was to compare two herbicide treatments and grazing by Boer goats for effectiveness in controlling saltcedar in an irrigated pasture in Lake Shore, Utah. Triclopyr amine or imazapyr was applied at the rate of 1% v/v plus MSO. Plots not treated with herbicide were grazed by goats. Grazing occurred four times throughout the summer of 2004. Visual evaluations estimated grazing to be the best control at the end of the treatment year.

In 2005 the regrowth in the plots that were grazed in 2004 was treated with one of the test herbicides, either imazapyr or triclopyr. Both herbicides were applied at 2% v/v plus MSO. Fifteen months after the initial treatments, visual evaluations showed that grazing in the first treatment year followed by imazapyr in year two gave a higher level of control than grazing followed by triclopyr amine or grazing with no further treatment., no treatment was more effective than imazapyr alone.

Grazing reduced the amount of plant biomass, reducing the amount of herbicide required per acre and increasing site accessibility. Goats are a potential component in an integrated management plan for saltcedar control.

Importance of understanding sedimentation for tamarisk control efforts (Session 2)

Jesse D. Roberts[1], Scott C. James[1], Craig A. Jones[2], and David Groeneveld[3]
[1]Soil and Sediment Transport Group, Sandia National Labs, NM, 88220. jdrober@sandia.gov, scjames@sandia.gov. [2]Sea Engineering Inc., Santa Cruz, CA, 95060. cjones@seaengineering.com. [3]HydroBio, Santa Fe, NM, 87501. David@hydrobio.org

Abstract:
Non-native phreatophytes, such as tamarisk, are an invasive tree species infesting and seriously impacting millions of acres of land in the American West. These species have no natural enemies in the United States, and are swiftly replacing native vegetation thus impacting livestock/wildlife habitat, increasing wildfire intensity, decreasing recreational activities, and most notably, consuming significantly more water than native species.

Although the motives for tamarisk control are born from a desire to promote healthy ecosystems and watersheds, it is vital to recognize that tamarisk provides important value, at a minimum for; a) stabilizing the banks of Western rivers prone to avulsion and erosion and, b) endangered species habitat (although often considered poor-is better than no habitat). Destroying these trees without rational planning may produce negative impacts such as inducing severe, costly erosion and displacing endangered species. All western states have begun or completed strategic management

plans to control non-native phreatophytes. Difficulties in tamarisk management lie in formulating and implementing effective/efficient tactical control plans (built from the foundations provided by strategic plans) suited for any given riparian environment or watershed, while minimizing negative risk or creating new problems.

If tamarisk removal successfully frees water that would otherwise be lost to evapotranspiration, a portion of this extra water must flow into the river and be stored in reservoirs to be available for beneficial use. Recently, salt cedar control efforts along the Pecos River have been conducted through application of herbicides by aerial spraying. This has resulted in defoliation and presumably killing of thousands of acres (14,000-16,000) of salt cedar in this area. Brantley Reservoir is the primary repository of salvaged water of current tamarisk control efforts. There are approximately 160 river miles between Brantley and the next upstream reservoir, Ft. Sumner. The Bureau of Reclamation cleared the flood plain of saltcedar on most of this 160 mile reach thirty years ago. However, the Bureau of Reclamation left a 50 foot buffer of salt cedar growing on each river bank for wildlife cover and stream bank stabilization. Once this saltcedar is removed from the river banks, so too will be the root system that has stabilized the banks for many years. This will leave the banks of the river susceptible to mobilization during subsequent significant flood flows until native plants and trees can be restored. With over 320 miles of banks (accounting for both sides of the river) and many significant bends and lots of potential high flows due to thunderstorm runoff, these bank sediments threaten to be eroded into the river and transport to and accumulate in Brantley reservoir. Sediments are not the only concern. Dead tamarisk biomass left on the rivers edge could be washed downstream during large flow events and accumulate at river crossings, significantly increasing chances for over bank flooding.

In this study, erosion has been assessed in a variety of ways, including field measurements and aerial/satellite imagery. Stream bank erosion in the forms of lateral migration (channel widening/narrowing) and bank slope degradation were assessed. Field measurements included repeated, detailed bathymetric surveys at several locations across the river channel as well as repeated GPS measurements used to map large sections of river at the top and bottom of a stream bank to assess lateral migration and bank slope patterns. Measurements of texture and observations of plant types (dead and new growth) were also made. Aerial photography for the entire state of New Mexico was taken between 1996 and 1998. Since then only scattered aerial images existed, until now. In 2005 the entire state was flown again, which has enabled investigation of pre-saltcedar control images (1996-1998) in comparison to post-saltcedar control images (2005).

Predictions of sediment stability and transport are made using a combined hydrodynamic and sediment transport model recently developed at Sandia (called SNL-EFDC). The Adjustable Shear Stress Erosion and Transport (ASSET) Flume is a unique Sandia developed device for measuring erosion and transport of sediments at depth, under high flow conditions, and because the device is mobile, in the field for ex-situ measurements. The data from the ASSET Flume is directly input into the SNL-EFDC model and the monitoring data described above will help to calibrate model results. The model is used to predict under what conditions the Pecos River bed and bank sediments become mobile as well as where and how far sediments are transported downstream.

Modeling of *Diorhabda elongata* dispersal during the initial stages of establishment for the eontrol of *Tamarix* spp. (Poster)

J. Sanabria[1], C.J. DeLoach[2], J.L. Tracy[2], and T.O. Robbins[2]

[1]Texas Agricultural Experiment Station, Temple, TX, sanabria@brc.tamus.edu. [2]USDA-ARS, Grassland, Soil and Water Research Laboratory, Temple, TX, jdeloach@spa.ars.usda.gov; jtracy@spa.ars.usda.gov; trobbins@spa.ars.usda.gov

Abstract:

Some of the critical questions associated with the use of *Diorhabda* for the control of *Tamarix* are: How far and how fast the insect will move defoliating the saltcedar trees in infested areas, after the release of the beetle? And, what are the factors that affect the dispersal of the insect and the severity of the saltcedar defoliation by the saltcedar beetle?

One of the most effective ways to answer those questions is modeling the dispersal of the saltcedar beetle and the defoliation that it causes on saltcedar. Modeling strategies depend on whether we are in the initial stages of the *Diorhabda* establishment in saltcedar infested areas (the *Diorhabda* population is relatively low), or in later stages when *Diorhabda* is well established (the *Diorhabda* populations are high). In the first case the insect movement from one tree to close by trees is the dominant way of dispersal, in the second case the tree to tree dispersal is combined with

other mechanism that consists in the grouping (swarming) of large number of beetles, and the wind carrying of the swarms over the saltcedar canopy to establish satellite *Diorhabda* populations in distant areas.

At this time we are using two types of models on data from Big Spring, TX. Diffusion (physically based) models, and statistical models. The diffusion models that we are trying initially are a model developed in Russia by Kovalev for the dispersal of ragweed beetles, and a model developed in Japan by Okudo for the dispersal of Colleoptera pests on hardwood trees. The statistical models that will be used employ saltcedar characteristics, environmental, and spatial variability variables as predictors of *Diorhabda* population along the experimental transects in Big Spring.

Data from transects at Big Spring describe the spatial variation of *Diorhabda* in waves having larvae or adult number in the y axis and distance in the x axis. Data from the 2005 growing season was used to develop parameter for the Kovalev model and to estimate a statistical model. The statistical model (with distance as only predictor variable) showed better prediction of number of larvae per meter of tree branch than the Kovalev model, the first was able to reproduce the location of the observed population peaks, the second missed the location of population peaks and overestimated the magnitude of population in the peaks. Possible poor performance of the diffusion model may be associated with the irregular and discontinuous distribution of *Tamarix* trees in the experimental area. *Diorhabda* is reaching areas of homogeneous and continuous *Tamarix* distribution in the 2006 growing season, application of diffusion models on this data may show better performance of this type of model.

Use of morphometrics and multivariate analysis for classification of *Diorhabda* ecotypes from the Old World (Poster)

J. Sanabria[1], J.L. Tracy[2], T.O. Robbins[2], and C.J. DeLoach[2]
[1]Texas Agricultural Experiment Station, Temple, TX, sanabria@brc.tamus.edu. [2]USDA-ARS, Grassland, Soil and Water Research Laboratory, Temple, TX, jtracy@spa.ars.usda.gov; trobbins@spa.ars.usda.gov; jdeloach@spa.ars.usda.gov

Abstract:

Six years of field data have shown a very high potential of *Diorhabda elongata* as an effective biological control of *Tamarix* spp. in some regions of the United States. The success of *Diorhabda* in some of the locations seems to be associated with a good match of *Diorhabda* ecotypes and environmental conditions. There is evidence that these ecotypes may represent different sibling species with different biogeographic traits. Consequently, taxonomic studies of the saltcedar beetle are critical in *Tamarix* control programs. Another justification for the need of working in *Diorhabda* taxonomy is the disagreement between taxonomists about the existence and number of *Diorhabda elongata* sibling species. Several of us are in progress of a taxonomic review of the primarily Palearctic *Diorhabda elongata* species group. Five genitalic morphotypes (putative sibling species) have been identified based on morphology of the genitalia: *elongata*, *carinata*, *sublineata*, *carinulata*, and *meridionalis*. These morphotypes may be suitable for the control of *Tamarix* in differing corresponding biogeographic areas of the western U.S. We are investigating the potential to correctly identify genitalic morphotypes of *Diorhabda* using only combinations of external characters in order to dispense with the time consuming process of dissecting and examining internal genitalia. Additionally, morphological groupings are needed for comparison with groupings from ongoing genetic studies of these morphotypes. We develop a classification system of *Diorhabda* morphotypes based upon measurements of both internal genitalic and external structures using a combination of Multivariate Factor Analysis and Cluster Analysis. Measurements of five genitalic and four external body structures on 85 specimens generated the data for the analysis. The factor analysis indicated four factors to be used in the classification. The first factor associated with 59% of the variability in the data is explained by external body parts, the other three factors are associated with genitalic measurements and together explained 31% of the data variability. The cluster analysis was able to reproduce a good separation of the 85 specimens into the five morphotypes. A dendrogram constructed from the analysis shows the highest affinity between the *carinata* and *sublineata* morphotypes. Misclassifying a specimen from any of these two groups has a probability of 0.23, misclassifying a specimen from the rest of the groups has a probability of 0.09.

Restoration planning in the context of tamarisk control in the western US (Session 1)

Patrick B. Shafroth[1], Vanessa B. Beauchamp[1], Mark K. Briggs, Kenneth D. Lair[2], David M. Merritt[3], Michael L. Scott[1], and Anna A. Sher[4]

[1]USGS Fort Collins Science Center, Fort Collins, CO, 80526. pat_shafroth@usgs.gov, vanessa_beauchamp@usgs.gov. [2]Ecological Research Group, National Technical Service Center, Bureau of Reclamation, P.O. Box 25007, Denver, CO 80225-0007. klair@do.usbr.gov, someara@do.usbr.gov. [3]dmerritt@fs.fed.us. [4]Department of Biological Sciences, University of Denver, 2199 S. University Blvd., Denver, CO 80208. asher@du.edu

Abstract:

There are an unprecedented number of ongoing and planned programs aimed at controlling non-native vegetation along rivers in the western US. The primary reasons stated for control efforts are to increase water yield, improve wildlife habitat and restore native vegetation. Central to all of these desired outcomes is the composition of the vegetation that occupies a site following control -- i.e., water yield changes depend on ET differences between cleared vegetation and replacement vegetation, and wildlife habitat values depend on relative suitability of replacement vegetation vs. controlled vegetation. Given the central role of replacement vegetation, a key component in planning and site selection for control efforts should be consideration of the range of likely replacement vegetation types and the range of revegetation or restoration activities and associated costs that might be implemented in conjunction with non-native vegetation control. We synthesize information on different trajectories of vegetation change associated with tamarisk control and different management activities across multiple river systems in the western US. Our work will culminate in a planning framework to assist land and water managers with their efforts to prioritize sites for tamarisk control, based on the probability of converting different site types to various alternative vegetation types, and the likely associated restoration and maintenance costs.

Environmental flows for riparian restoration and *Tamarix* management (Session 4)

Patrick B. Shafroth[1]

[1]USGS Fort Collins Science Center, Fort Collins, CO, 80526. pat_shafroth@usgs.gov

Abstract:

River scientists have increasingly advocated managing streamflow downstream of dams for ecological benefits. Flow management efforts that specifically target riparian vegetation have been relatively uncommon, however. The Bill Williams River in western Arizona, USA, has been dammed by a large flood control structure since 1968 (Alamo Dam). Dam operators and land and water managers along the river have been implementing managed flows, primarily to benefit native riparian vegetation, since the 1990's. To understand the dynamics of riparian vegetation and to evaluate the effects of flow management on the Bill Williams River system, we have analyzed historical and contemporary aerial photography and conducted various field studies over the past decade. Pulse flood releases from Alamo Dam in the early 1990's widened the river channel and resulted in the establishment of a new cohort of woody vegetation (primarily in the genera *Populus, Salix, Tamarix*). For the following nine years, low inflows did not allow for pulse flow releases, but baseflows were maintained at fairly high levels, largely to promote survival of the mid-1990's vegetation cohort. These steady low flows resulted in channel narrowing, extensive beaver pond creation, and dense vegetation growth. In 2005, extremely wet conditions and high inflows required large flow releases on the Bill Williams R., which were managed to promote establishment of a new cohort of the native *Populus fremontii* and *Salix gooddingii*, while discouraging establishment of the non-native *Tamarix ramosissima*. Whole river seedling surveys and analysis of post-flood aerial photography indicate that these flows again widened channels, destroyed beaver ponds, and created conditions suitable for new vegetation establishment. Seedlings of all three species commonly became established along the main channel and associated surfaces, but the early-dispersing *Populus* established three times more frequently on side channels and low floodplain surfaces than the later dispersing *Salix* and *Tamarix*. The mean height of the tallest *Populus* or *Salix* in sampled patches was more than twice that of the tallest *Tamarix*, potentially providing a competitive advantage of the native taxa over the alien. Our results illustrate the efficacy of this approach to influence riparian vegetation dynamics, including management of exotic species.

Tamarix as symptom versus driver of ecosystem change: a review of the 2006 Ecological Society of America special session (Tuesday Lunch)

Anna A. Sher[1,2]
[1]Department of Biological Sciences, University of Denver, Denver, CO, 80208. asher@du.edu. [2]Department of Research and Conservation, Denver Botanic Gardens, Denver, CO, 80206. asher@du.edu

Abstract:

A recent feature article in BioScience was titled, "Tiff over tamarisk: Can a nuisance be nice, too?", regarding whether the recent negative attention to *Tamarix* has been warranted. The article highlighted the fact that research on this species appears to be contradictory, suggesting at once that it is the cause of environmental problems while also being the symptom of it. Research to investigate these different faces of *Tamarix* has experienced literally exponential growth over the last ten years, and with this growth, the expected diversity in thought. This attention corresponds with increased public awareness of *Tamarix*, such that we now two congressional bills and literally millions of federal dollars on the line. Thus one may argue that we must be careful as scientists in the way that we both consider the data and present it to the public. Motivated by these concerns, I brought together six *Tamarix* scientists with varying opinions on this subject for a panel discussion at this year's Ecological Society of America meeting in Memphis, TN. As one who has researched this species for over a decade, I chaired the *Tamarix* special session so as to provide a forum for debate, with the hope of reaching agreement on the scientific points of most import to the public and the politicians who represent them. Julie Stromberg, the scientist who holds the distinction of having most published papers on *Tamarix* ecology, acted as my co-chair; fitting perhaps, as she and I were quoted on opposing sides in the aforementioned article. The session was attended by over seventy scientists, some of whom contributed to the discussion that followed a presentation by each panelist. I will give an overview and synthesis of both the presentations and discussion, with an aim to provide a picture of the landscape of *Tamarix* research in ecology today and its possible ramifications for management and public policy.

Tamarisk flowering and seed release phenology in relation to climate and Colorado River hydrography (Session 4)

Gibney Siemion[2] and Lawrence E. Stevens[1]
[1]Curator of Ecology and Conservation, Museum of Northern Arizona, 3101 N. Fort Valley Rd., Flagstaff, AZ, 86001. farvana@aol.com. [2]Grand Canyon Wildlands Council, Inc., P.O. Box 1594, Flagstaff, AZ, 86002. Gibneysiemion@aol.com

Abstract:

Non-native tamarisk (*Tamarix ramosissima*) colonized riparian habitats and reservoir shorelines throughout the western United States during the 20th Century; however, basic life history and regeneration requirements information are still lacking. We compiled elevation, date, and phenological data from 609 tamarisk specimens in southwestern herbaria to relate its reproductive phenology across elevation to hydrography and flow management in the Colorado River basin. We calculated the percentage of specimens releasing seed as a function of elevation and Julian day in three elevation belts: low (300-600 m), middle (1200-1500 m), and high (1800-2100 m) elevation. We compiled field observations on its distribution and phenology from 1984-2006, and monitored recruitment on several debris-fan complexes. We compared recruitment responses in the pre- and post-dam Colorado River mainstream, Lake Mead and Lake Powell reservoirs, and in tributaries with low- or high-elevation headwaters. Flooding timed with seed release may result in tamarisk germination events. Conversely, planned floods that specifically avoid the May-June peak tamarisk seed release period permit little tamarisk recruitment. Failing recruitment in the post-dam Colorado River in Grand Canyon has occurred because the spring-summer hydrograph is generally unsuitable for tamarisk seedling establishment and mean sand particle size has coarsened. Hydrograph management may be used to manage tamarisk recruitment; nonetheless, flow regimes coupled with poorly-timed planned or unplanned floods can quickly reverse long-term trends in reduced tamarisk recruitment in the Colorado River.

The suitability of tamarisk as habitat for riparian breeding birds; data and perspectives from the Southwest (Session 7)

Mark K. Sogge[1], Eben H. Paxton[1], and Susan J. Sferra[2]
[1]U.S. Geological Survey Southwest Biological Science Center, Flagstaff, AZ. [2]U.S. Bureau of Reclamation, Phoenix Area Office, Phoenix, AZ

Abstract:

Saltcedar eradication and control projects often have the stated goal of improving habitat values for wildlife, especially birds. An underlying assumption for this goal is that saltcedar is unsuitable as bird habitat, or that it is less suitable than the habitat that will replace saltcedar. While not all bird species use saltcedar to the degree that they use native habitats, many species do breed in saltcedar, and few studies have been conducted to determine if saltcedar control efforts actually benefit the local bird community.

To evaluate the assumption that saltcedar is unsuitable or poor-quality habitat for birds in the Southwest, we synthesized data from avian inventory work, research projects, and bird species accounts. It has long been known that Southwestern Willow Flycatchers breed in some saltcedar habitats; recent research demonstrates extensive use of saltcedar, with no discernible negative effects to flycatcher productivity, survivorship, or physiological condition. Flycatcher use of saltcedar has sometimes been portrayed as a “single species issue”, and an aberration among birds. However, Yellow-billed Cuckoos are widespread and abundant breeders in saltcedar habitat on the Pecos River. Interestingly, cuckoo use of saltcedar is less common along the Rio Grande, and they are not known to breed in saltcedar along the Lower Colorado River. This pattern illustrates that the habitat value of saltcedar can vary across the landscape, even for a single bird species. From a bird community standpoint, use of saltcedar is well documented. Studies from the Colorado River in the Grand Canyon show that populations of many bird species using the saltcedar habitats that now dominate the riparian zone have increased. In addition, the area and volume of saltcedar in a habitat patch was one of the best predictors in models of breeding bird community abundance, diversity, and richness. At a state-wide level, data from the recently completed Arizona Breeding Bird Atlas show that 22 of 29 lowland and mid-elevation riparian breeding species are recorded as nesting in saltcedar. Similarly, data gleaned from the Birds of North America project also show that many species of birds will breed in saltcedar, including important game birds such as White-winged Dove and Mourning Dove. Overall, these data demonstrate that a universal benefit of saltcedar control can not be assumed, as a wide range of birds species use tamarisk for breeding with no universal negative effect.

Given the likelihood that not all saltcedar control sites will support high-quality native vegetation as replacement habitat, a key question will be whether the replacement habitat will provide greater wildlife value (in both quantity and quality) than the saltcedar that was removed. In order to learn from saltcedar control efforts, and provide managers with information for Adaptive Management practices, projects need to (a) articulate local and specific objectives, (b) include measurable response criteria, and (c) assure adequate post-control data collection. Ultimately, effective monitoring will be required to determine if the project's goals have been met, if local and regional bird populations have benefited, and to provide useful information for future saltcedar control efforts.

A groundwater modeling tool for estimating water salvage (Session 5)

Josh S. Stein[1], David P. Groeneveld[2], Jesse D. Roberts[3]
[1]Subsystems Performance Assessment, Sandia National Labs, NM, 87185. jsstein@sandia.gov. [2]HydroBio, Santa Fe, NM, 87501. david@hydrobio.org. [3]Soil and Sediment Transport Group, Sandia National Labs, NM, 88220. jdrober@sandia.gov

Abstract:

A groundwater modeling tool based on the water balance approach can be used to estimate changes in net infiltration/potential recharge when salt cedar is replaced by other plant associations. Net infiltration, defined as the water that passes out of the active soil zone or root zone into the underlying soil/bedrock, is estimated based on a daily water balance calculation of the near-surface soils. The water balance includes net precipitation as input, water storage and movement within the soil including evapotranspiration, and water moving from the active zone into the underlying soil/bedrock. The model domain is composed of a number of cells that extend from the surface to the contact with the underlying soil/bedrock. The description of each cell includes the cell depth as defined by the soil layer depth; soil type and associated properties; cell elevation, azimuth and slope; fraction of the surface covered by the vegetation canopy; and vegetation related characteristics.

Each cell is composed of one to three soil layers, depending on the active soil zone depth. Downward water movement from layer to layer within a cell is based on the field capacity concept. Estimation of evapotranspiration (ET) is derived from the dual crop version of the FAO-56 method, which produces separate estimates of evaporation and transpiration. Both the field capacity approach and the FAO-56 method are computationally straightforward and do not require iterative numerical solutions. The water balance modeling tool has been implementedanted in MathCad, a widely available commercial software package

***Tamarix* abundance in arid basins of Arizona reflects prevailing hydrology** (Poster)

Julie C. Stromberg[1], Sharon J. Lite[1], Charles Paradzick[2], Patrick B. Shafroth[3]
[1]School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501. [2]Salt River Project, Phoenix AZ 85072-2025. [3]US Geological Survey, Ft Collins, CO 80526

Abstract:

Stream flow regimes are strong determinants of riparian vegetation structure, and altered hydrologic conditions can drive changes in species composition. For many rivers of southwestern USA, ground water levels have declined, floods have been suppressed, and timing of flow peaks have changed. Such hydrologic changes have been implicated as the drivers of compositional shifts from *Populus fremontii* and *Salix gooddingii*, the historically common pioneer riparian trees in the region, to *Tamarix*, an introduced shrub/tree. To test this idea, we examined woody riparian vegetation patterns along 24 river reaches in the Gila and Bill Williams drainage basins of Arizona. Reaches varied in stream flow permanence (perennial vs. intermittent), presence or absence of an upstream flow-regulating dam, and presence or absence of effluent as a water source. *Populus fremontii* and *Salix gooddingii* were the dominant pioneer trees along the reaches with perennial flow and a natural flood regime. In contrast, *Tamarix ramosissima* had high abundance (patch width and basal area) along reaches with intermittent stream flows (caused by natural and cultural factors), as well as those with dam-regulated flows. Forest patterns on reaches with effluent-dominated flow were similar to those on non-effluent reaches. Deep alluvial groundwater on intermittent rivers favors deep-rooted, stress-adapted species such as *Tamarix* over shallower-rooted, more competitive species such as *Populus* and *Salix*. On flow-regulated rivers, increased variability in flood timing favors reproductive opportunists such as *Tamarix* over reproductive specialists with narrow germination windows such as *Populus* and *Salix*.. Thus, the prevailing hydrologic conditions do appear to favor a new dominant pioneer species in the riparian corridors of southwestern USA. These results reaffirm the importance of flow regime restoration for re-establishing *Populus-Salix* as the dominant pioneer forest type.

Mapping tamarisk biocontrol monitoring sites and the expansion of *Diorhabda elongata* populations (Session 3)

Brian Swedhin[1,2], Levi Jamison[1], Tom L. Dudley[2], and Daniel W. Bean[1]
[1]Colorado Department of Agriculture, Biological Pest Control, Palisade Insectary, 750 37.8 Road, Palisade, Colorado 81526. bswedhin@hotmail.com, LRJAMISON@fortlewis.edu, dan.bean@ag.state.co.us. [2]Marine Science Institute, University of California, Santa Barbara, CA 93106. tdudley@msi.ucsb.edu

Abstract:

Mapping and monitoring tamarisk at release sites for the tamarisk leaf beetle *Diorhabda elongata* as well as following population expansion after beetle release are critical components of the tamarisk biocontrol program. In this study we tested the feasibility of using relatively simple and low cost methods for routine mapping and monitoring of biocontrol releases. Beginning in 2006 the Colorado Department of Agriculture has used GPS and GIS to establish and monitor *Diorhabda elongata* release sites in Mesa County, CO and at Dinosaur National Monument. Hand-held GPS units containing mapping software, maps and aerial imagery were used to set up monitoring sites, store coordinates of marked trees and collect data throughout the season. In addition, we have used mapping software and aerial imagery to follow the dispersal of *D. elongata* in Nevada and Utah.

Release and monitoring sites were selected by first examining aerial photos, choosing a potential site or sites and selecting trees based on distance from the potential release site. Our protocol calls for monitoring 25 trees comprising a release tree, 12 trees within 100 meters of the release and 12 trees between 100 and 200 meters of the release. Trees were selected and coordinates were programmed into the hand-held units prior to going into the field, which allowed us to rapidly locate potential release and monitoring trees once in the field. This was possible, in part, because we were

able to check the points with a downloaded aerial photo or DRG (topo map). The results were an even distribution and correct spacing of monitoring trees and increased efficiency of the process such that an entire site could be set up and initial monitoring done in less than 4 hours. Using a drop-down menu monitoring data, such as condition of the plant, presence and stage of the beetles and the presence of predators, were entered directly into the hand-held GPS units which simplified data collection and later storage and analysis.

GPA and GIS has proven useful in the fine scale mapping of monitoring sites. Stands of tamarisk as well as isolated individual trees were mapped at a monitoring site where tamarisk density is very heterogeneous, some areas having solid monocultures and other areas having more open and dispersed stands. The movement of beetle populations through these areas will provide information on host selection as a function of stand density.

Large scale dispersal of *D. elongata* was also mapped using GPS and GIS. Using previous observations the expansion of *D. elongata* from the Lovelock, NV site was mapped over a three year period. Two release sites near Moab, UT have experienced major expansions of *D. elongata* populations in 2005-2006 following initial releases in 2004. These dispersal events, as well as major defoliations that have accompanied beetle population expansion, were mapped. There were less than 2 acres of defoliated tamarisk at the end of 2005. By August 2nd, 2006 there were 109.02 acres defoliated, covering 4.09 river miles upstream of the primary release site, and the defoliated area was still expanding. Final results for 2006 will be compiled in mid September and presented. These results will be used to predict the timing of entry of the beetles into Colorado from release sites on the Colorado River in Utah. We anticipate that *D. elongata* will enter Colorado through the Colorado and Dolores River corridors by mid summer, 2007.

Open field host choice test of *Diorhabda elongata* (Coleoptera: Chrysomelidae) in Northern California (Session 3)

Hillary Thomas[1]
[1]UC Davis. hqthomas@ucdavis.edu

Abstract:

USDA-ARS has proven successful in establishing an efficacious biological control agent against *Tamarix* spp. at multiple release sites across the Western United States. However, a well climatically matched population of the agent, *Diorhabda elongata* (Coleoptera: Chrysomelidae) has failed to establish at Northern California release sites. Past laboratory host range testing and observational field evidence suggest that *D. elongata* exhibits differential host preferences amongst several invasive species of *Tamarix* but the contribution of host choices to establishment failure has remained speculative. I conducted an open field host choice test in July, 2006 between the dominant invasive, *Tamarix ramosissima*, and the host species present at California release sites, *Tamarix parviflora*. Thirty marked adult beetles were released onto each of three treatments, (1) *T. parviflora* only (2) T. *ramosissima* only and (3) A mixed treatment with both host species conterminous. *D. elongata* showed marked ovipositional preference for T. *ramosissima* over *T. parviflora* (F=6.57, df=2,10, p=.015), with no significant difference between the mixed and T. *ramosissima* only treatment. Adult presence was also significantly higher on the mixed and T. *ramosissima* only treatments than on the *T. parviflora* only treatment (repeated measures MANOVA - F=7.93, df=2,14, p=.005). These results show that the presence of a preferred host plant can dramatically increase oviposition and adult presence over time, suggesting that differential host preferences could be contributing to establishment failure at Northern California release sites.

Systems approach for riparian management (Session 1)

Vincent C. Tidwell[1], Jesse D. Roberts[2], David P. Groeneveld[3]
[1]Geohydrology, Sandia National Labs, NM, 87185, vctidwe@sandia.gov. [2]Soil and Sediment Transport Group, Sandia National Labs, NM, 88220. jdrober@sandia.gov. [3]HydroBio, Santa Fe, NM. david@hydrobio.org

Abstract:

Tamarisk management is a growing issue for millions of acres of infested land across the American West. Tamarisk have no natural enemies in the United States, and are swiftly replacing native vegetation thus degrading livestock/wildlife habitat, increasing wildfire intensity, decreasing recreational activities, and most notably, competing for limited water supplies.

There are no simple answers on how best to manage tamarisk population. Decisions are complicated by the complex riparian systems that the tamarisk live and the contentious social

context in which planning is conducted. For example, tamarisk have been successful in replacing native vegetation, so they now provide important value in stabilizing the banks of Western rivers prone to avulsion and erosion as well as endangered species habitat (although considered poor-is better than no habitat). Destroying these trees without rational planning may induce severe, costly erosion and displace endangered species.

As such, efficient management defies myopic, piecemeal approaches driven by political whim. Rather, planning benefits from the fusion of knowledge and experience widely distributed across physical and social scientists, engineers, resource managers, decision-makers, stakeholders, and the general public. Ideally, an environment is established that promotes shared learning leading to cooperative and adaptive management. Success requires a process for inclusive and transparent sharing of ideas complimented by tools to structure, quantify, and visualize the collective understanding and data, providing an informed basis of dialogue and exploration. System dynamics provides a unique mathematical framework for integrating the physical and social processes important to resource management, and for providing an interactive environment for engaging the public. System dynamics models are predicated on the classical formalisms of physical and social science; albeit, at reduced spatial and temporal resolution. This tradeoff in resolution and thus computational burden, allows real-time analysis over an extended decision space.

Our objective is to ease resource related conflict through the application of computer-aided dispute resolution methods. We promote the use of decision-support technologies within a collaborative process to help stakeholders find common ground and create mutually beneficial resource management solutions. Such decision support models implemented within a dispute resolution context have been developed and applied in a number of river basins within the United States (Middle Rio Grande, Gila, Mimbres, and Willamette) and are actively being extended to water resource issues in Jordan. Such models have been used in sustainable water use planning; exploration of water use efficiencies in irrigated agriculture; cost-benefits analysis for alternative water conservation strategies; assessing tradeoffs in water allocations between irrigated agriculture, instream water use, and urban development; design of water markets; and, trans-boundary water resource planning. A key element in many of these efforts is the role of tamarisk management within the broader context of water planning.

In this presentation we will provide a basic overview of our computer-aided dispute resolution approach. Application will be drawn to several different projects for which decision support models will be demonstrated and results presented. Emphasis will be placed on projects involving tamarisk management.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Southwestern willow flycatcher mitigation land management and Endangered Species Act requirements: implications of salt cedar control (Poster)

R.A. Valencia[1] and C.E. Paradzick[1]

[1]Environmental Division, Salt River Project, Phoenix AZ 85072. ravalenc@srpnet.com, ceparadz@srpnet.com

Abstract:

Salt River Project Agricultural Improvement and Power District ("SRP") operates a series of dams and reservoirs on the Salt and Verde Rivers in central Arizona to supply water and power to the Phoenix metropolitan area and surrounding agricultural lands. The largest of these reservoirs, Roosevelt Lake, was created in 1911 and accounts for 71% of the total storage capacity in the SRP reservoir system. The amount of runoff entering Roosevelt Lake, and subsequent storage and release of that water for downstream delivery and hydropower generation, result in fluctuating lake levels. These conditions support the establishment and growth of varying amounts of riparian vegetation, primarily tamarisk. Recent severe drought conditions in this watershed caused lake levels to drop precipitously low, providing favorable conditions for the colonization of tamarisk on the exposed lakebed.

In 1993, southwestern willow flycatchers (*Empidonax traillii extimus*) ("flycatchers") were discovered at Roosevelt Lake. In 1995, the species was listed as endangered under the Endangered Species Act of 1973 (as amended) ("ESA"). Since that initial discovery, the population of flycatchers in the conservation space of the reservoir increased from 48 territories in 1998 to 153 in 2006. SRP's "action" of capturing and storing run-off in the reservoir would inundate or "take" a significant

portion of the habitat, thus resulting in a violation of Section 9 of the ESA. A violation of the ESA could have resulted in injunction of use of the storage space jeopardizing the reliability of the water supply. To address this issue, SRP applied for an Incidental Take Permit ("ITP") under Section 10(a)(1)(B) of the ESA in 2000, which necessitated the development of the Roosevelt Habitat Conservation Plan (Roosevelt HCP). The plan specifies measures to minimize and mitigate incidental take of flycatchers. The U.S. Fish and Wildlife Service issued an ITP to SRP in February 2003.

Under the terms of the Roosevelt HCP, one of SRP's obligations is to acquire, manage and monitor, in perpetuity, at least 1500 acres of replacement riparian habitat along the Gila (Safford Valley), lower San Pedro and Verde rivers. The cost of acquisition of these lands is estimated at $4M to $6M; management and monitoring is estimated to cost SRP more than $10M over the life of the permit. Riparian vegetation communities on the San Pedro and Verde properties are dominated by native Fremont cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*) trees. However, approximately 1100 acres of habitat acquired on the Gila River near Fort Thomas support large, dense stands of tamarisk interspersed with stands of Fremont cottonwood, coyote willow (*Salix exigua*), and Goodding's willow. Flycatchers have been detected and recorded breeding on all the properties purchased with the highest concentration found on the tamarisk dominated Safford Valley lands.

SRP is obligated to manage the property for the benefit of flycatchers. However, recent efforts to eradicate tamarisk in the southwest have captured local interest in the Safford Valley. Communities are evaluating costs of eradication against perceived benefits of increased water yield, reduced risk of wildfire, and increased channel capacity for flood waters. While restoration of native riparian plant communities is a critically important need ecologically, tamarisk eradication projects within river corridors that support our mitigation lands that fail to address the ultimate causes of degradation could jeopardize our ITP. SRP lists a number of research needs and issues that should be addressed prior to the development and implementation of a large-scale attempt to eradicate tamarisk from the upper Gila River in Arizona. The effects of soil and water salinity, altered hydrology (water diversions, agricultural run-off), groundwater pumping and fluctuating water tables on vegetation must be carefully evaluated to determine whether a tamarisk eradication program would be successful and cost-effective. "Costs" in the form of impacts to wildlife, both short term and long term, must be considered.

Novel herbicide combinations for tamarisk control with minimal ecosystem impact

(Session 6)

Philip Westra[1]

[1]Dept. of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523.
pwestra@lamar.colostate.edu

Abstract:

Relatively few novel herbicides or herbicide combinations are evaluated specifically for the control of salt cedar. This may be partially due to the perception that such herbicide use represents a relatively small market, or there may be concerns regarding adverse desirable plant impacts in riparian ecosystems. However, herbicides that completely defoliate salt cedar within 1 month of herbicide application could simulate the defoliation provided by biocontrol agents, thereby weakening the plants over time and minimizing water use by salt cedar. In the summer and fall of 2005, two studies were initiated on the St. Vrain river to evaluate the potential utility of herbicides or herbicide combinations that included Escort (a sulfonylurea herbicide), Krenite, Glyphosate as different formulations, Vengeance Plus (which contains garlon plus two PGR herbicides), Edict, and Arsenal. Treated plants were clumps of 10-20 large shoots ranging in size from ½" to 2" in diameter arising from a common crown. Most treated plants were 15 to 20 feet tall. Mixtures containing Vengeance Plus or Arsenal generally provided the longest control of salt cedar. Several treatments provided greater than 90% control 1 year or more after application. Several treatments provided control of older stems that were leafed out at the time of application, but in some cases, profuse new 2006 growth came from the crown area of treated plants. Several treatments had minimal effect on `understory plants while providing good control of salt cedar. Many of the novel treatments in this study completely eliminated salt cedar flowering and seed production in 2006.

Hydrogeomorphic effects of a controlled flood release on Tamarisk and *Salix*, Bill Williams River, AZ (Session 2)

Andrew C. Wilcox[1] and Patrick B. Shafroth[2]

[1]US Geological Survey, Geomorphology and Sediment Transport Laboratory, Golden, CO, 80403. awilcox@usgs.gov. [2]US Geological Survey, Fort Collins Science Center, Fort Collins, CO, 80526. pat_shafroth@usgs.gov

Abstract:

We examined geomorphic and vegetation responses to a controlled flood releases on the Bill Williams River (BWR) in western Arizona. In March 2005, a controlled flood release resulted in the widespread establishment of woody riparian seedlings, including many seedling patches co-dominated by *Tamarix* spp. and *Salix gooddingii*. In March 2006, a controlled flood of 56 m3/s for two days, followed by a gradual daily drawdown of approximately 1 m3/s, was released from Alamo Dam on the BWR. We investigated whether this relatively small flood release (1.1–1.2 year event compared to pre-dam peak flows) would result in greater damage to and mortality of *Tamarix* versus *Salix*, and affect geomorphic changes associated with vegetation responses. Physical data collection included pre- and post-flood topographic surveys, bed sediment sampling, and deployment of scour chains and velocity and stage measurements during the flood at two field sites. Biological data collection included pre- and post-flood density, diameter, and height of 1 year-old *Tamarix* and *Salix* seedlings growing on channel bars at the sites. At the upstream site, approximately 18 km downstream from Alamo Dam, the flood caused scour of *Tamarix* seedlings and their substrates from mid-channel bars, lateral shifting of bars, and coarsening of bed sediment. In the downstream reach, approximately 48 km downstream from Alamo Dam, we observed burial of *Tamarix* seedlings as a result of aggradation, but no significant change in bed sediment sizes. In both cases, *Tamarix* suffered greater reductions in density than *Salix*. Our results suggest that this is largely due to the substantially greater first-year height and diameter growth of *Salix* relative to *Tamarix*. Although boundary shear stresses during the flood were lower in the downstream reach than in the upstream reach, total suspended sediment concentrations were approximately half as large in the latter reach, perhaps as a result of downstream decreases in the effect of dam-induced reductions in sediment supply. Our observations suggest that in a dynamic, sand-bed river such as the Bill Williams, even relatively small floods can generate sufficient forces and/or geomorphic changes to cause higher mortality of first-year *Tamarix* than *Salix*. These results also illustrate how the effect of floods or other components of hydrologic regimes on riparian vegetation are mediated by geomorphic processes on both a reach scale, where local bed gradients and geomorphic characteristics influence shear stress dynamics, and on a basin scale, where sediment supply dynamics may have important influences on morphologic and vegetation responses.

Control of saltcedar with Pasturegard™ and other herbicides in north central Wyoming (Poster)

Mike Wille[1], Steve Christy[2], and Alex Ogg[3]

[1]Fremont County Weed and Pest District, Riverton, WY 82501. mwille@wyoming.com, [2]Big Horn Basin Exotic Plant Steering Committee, Worland, WY, 82401. stevejc@bresnan.net, [3]Big Horn Basin Exotic Plant Steering Committee, Ten Sleep, WY 82442. ogg@tctwest.net

Abstract:

In late July or early August of 2004 and 2005, replicated, small-scale plots and non-replicated, large-scale plots were established in a riparian site along the Big Horn River just south of Manderson, WY. This site was heavily infested with saltcedar (*Tamarix ramosissima*), Russian knapweed (*Centaurea repens*), hoary cress (*Cardaria draba*), and scattered patches or individual plants of inland saltgrass (*Distichlis spicata*) and alkali sacaton (*Sporobolus airoides*). The plot area had been mowed with a heavy-duty brush hog in the fall of 2003 or the spring of 2004. By late July 2004, regrowth of saltcedar was mostly 3 to 5 feet tall. For small-scale plots, herbicides were applied with a backpack sprayer equipped with a 10-foot boom and TeeJet™ 8002 flat-fan nozzles, and calibrated to apply 15 gallons per acre at 25 psi and 3 miles per hour. These small-scale plots were retreated in July 2005. For large-scale plots, herbicides were applied with either a power sprayer equipped with an adjustable-nozzle handgun and operated at 50 psi, or with a tractor mounted sprayer equipped with broadjet nozzles and calibrated to apply 20 gallons or 100 gallons per acre. Plants treated with the handgun were sprayed to give thorough coverage without runoff. Besides Pasturegard™, other herbicides evaluated were Opti-Amine 2,4-D™, Tordon™, Opti-Amine plus Tordon, Arsenal™ and Habitat™. Methylated seed oil at 0.5%, non-ionic surfactant at 0.5% or crop

oil concentrate at 5.0% v/v were added to spray solutions depending on the treatment. Large-scale plots treated with Pasturegard or only Oti-Amine 2,4-D in 2004 were retreated in late July 2005. Pasturegard desiccated all saltcedar soon after treatment. One year after the initial application of Pasturegard to small-scale plots, percent kill of saltcedar ranged from 0 to 13%, and after 2 years of treatment, ranged from 25 to 55%. Highest level of kill of saltcedar was in plots sprayed with Pasturegard plus Arsenal at 4 qts + 1 pt per acre. This treatment also controlled Russian knapweed and hoary cress 95 to 98%. In large-scale plots, Oti-Amine, after two annual applications with a handgun sprayer, killed about 75% of the saltcedar without injuring desirable grasses. After 2 years of application, Pasturegard applied with the tractor sprayer had killed about 25% of the plants. Increasing the spray volume from 20 gallons per acre to 100 gallons per acre did not increase kill of saltcedar with Pasturegard significantly. Pasturegard applied at 2 qts per 100 gallons with a handgun to non-mowed, mature saltcedar killed about 35% of the plants. Retreating plants that survived the first year treatment increased percent kill to only 38%. Pasturegard did not appear to harm desirable grasses. Opti-Amine 2,4-D plus Tordon at 2 qts + 1 qt per acre killed 97% of the saltcedar and nearly 100% of the Russian knapweed and hoary cress with a single application. Use of Tordon in sites with shallow water levels is not recommended, therefore its usefulness in riparian sites is limited greatly. A single application of Habitat at 2 qts per acre in September 2005 killed 86% of the plants and surviving plants were injured severely. However, Habitat injured desirable grasses severely. Pasturegard and Opti-Amine 2,4-D appear to be a useful treatments for controlling saltcedar without harming desirable grasses, but more than 2 years of treatment will be required to eliminate all saltcedar plants.

Biologically-based integrated management of saltcedar on western rangeland watersheds
(Poster)

Livy Williams, III[1], Keirith A. Snyder[1], William S. Longland[1], Robert R. Blank[1], James A. Young[1], and Raymond I. Carruthers[2]. [1]USDA-ARS Exotic and Invasive Weeds Research Unit, 920 Valley Rd., Reno, NV 89512. [2]USDA-ARS Exotic and Invasive Weeds Research Unit, 800 Buchanan St., Albany, CA 94710

Abstract:

This poster describes research recently begun at the USDA-ARS Exotic and Invasive Weeds Research Unit in Reno, Nevada. Our goal is to develop ecologically-sustainable means of suppressing saltcedar, as well as other exotic, invasive weeds on the temperate watersheds of the Intermountain West. The investigations we propose include basic and applied studies using detailed hypothesis-driven experiments conducted in the laboratory, greenhouse, and field. We have adopted a "weed management pipeline" approach that integrates classical biological control with studies aimed at understanding how to optimize the beneficial effects of biological control agents while minimizing their potential detrimental effects on the soil and native flora and fauna. This includes work using remote sensing and other tools to characterize the spatio-temporal dispersal and impact of biological control agents on a region-wide, long-term scale. Our research approach then extends to address ecological interactions between biological control agents, weeds, and soil to understand plant ecophysiology and hydrology, and finally with studies on restoration-rehabilitation of degraded watersheds. Successful control of a target weed usually requires decades of research effort, and the research proposed here will be an important step towards ecologically-rational management of some of the most important invasive weeds in western U.S.A.