# Tackling Tamarisk on the Purgatoire

## *A Consolidated Woody Invasive Species Management Plan for Colorado's Purgatoire Watershed*

2008

Tamarisk Infestation on the Purgatoire River

Prepared by
Colorado State Forest Service
Colorado Water Conservation Board
Southeastern Colorado Water Conservancy District
The Nature Conservancy
Tamarisk Coalition

## A Joint Effort

The Tackling Tamarisk on the Purgatoire (TTP) plan was prepared with the input of a multitude of partners from several counties in southeastern Colorado representing state and federal agencies, local communities, private landowners, industry, and non-governmental organizations (NGOs). This comprehensive management plan addresses the Purgatoire watershed from Trinidad Lake to the John Martin Reservoir. This partnership was led by the Colorado State Forest Service and The Nature Conservancy, with the Tamarisk Coalition providing staff to assemble the plan based on inputs from the other partner organizations. Funding to develop the Plan was provided by the Colorado Water Conservation Board. Funding for the comprehensive tamarisk inventory and mapping was provided by the Purgatoire River Water Conservancy District, The Colorado Water Conservation Board, and The Nature Conservancy. Endorsement of this plan by the TTP partners in no way limits any government's, agency's, industry's, landowner's, or organization's existing legal authority or responsibilities.

The Plan is provided in two parts – the body of the TTP Plan contained herein and the comprehensive tamarisk inventory and mapping Data-DVD located in the back of the Plan.

For more information on the TTP Plan, contact the Tamarisk Coalition at (970) 256-7400 or tcarlson@tamariskcoalition.org

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# Executive Summary

The TTP Plan is structured around a set of guiding principles that focus on ecological, social-cultural, economic, education, and research considerations. In summary, the guiding principles recognize that successful riparian restoration must include: 1) all restoration components—planning and design, control, revegetation, biomass reduction, monitoring, and long-term maintenance; 2) respect for private property rights, state water rights, existing infrastructure, and endangered species; 3) education to gain public support and funding; 4) research to identify the most effective and efficient techniques for restoration through the practice of "adaptive management"; and 5) partnerships to optimize and leverage existing and future funding.

# Introduction

**Tackling Tamarisk on the Purgatoire (TTP) –** In 2003, a partnership formed to develop a strategic plan for the Purgatoire River's riparian areas impacted by non-native invasive trees, principally tamarisk (*Tamarix* spp., aka salt cedar) and Russian olive (*Elaeagnus angustifolia*). This partnership, known as Tackling Tamarisk on the Purgatoire, was initiated through the leadership of the Colorado State Forest Service and The Nature Conservancy. These combined efforts have involved state and federal agencies, local communities, private landowners, industry, and non-governmental organizations (NGOs). The Tamarisk Coalition provided the staff to assemble the plan.

This progressive leadership compliments the efforts of counties in the Gunnison/Uncompaghre, Dolores, Arkansas and Colorado River Watersheds that prepared their own woody invasive species watershed restoration plans in 2007.

### TTP Vision Statement

The overall vision of Tackling Tamarisk on the Purgatoire is to assist with the restoration and maintenance of the native riparian communities of the Purgatoire River by controlling the non-native woody species, tamarisk and Russian olive. This effort will serve to protect our water resources, protect native riparian communities and the wildlife that depend on them, protect our watershed and communities from wildfire and flooding, and to enhance agricultural production.

This planning effort, including a comprehensive tamarisk inventory/mapping component, will be finalized in 2009, and will guide restoration work for approximately 10,000 acres of infested riparian lands on nearly 300 miles of the river system.

## TTP Strategic Plan Goals

**TTP's Goals** are described below with details on specific tasks that will help to achieve these goals presented in Appendix A.

Goal 1: Ensure all management activities reflect the knowledge of experts by providing access to research and expert advise to practitioners, and will add to this body of knowledge by capturing and demonstrating the effects of restoration activities on multiple scales.

Goal 2: Develop a watershed scale strategic plan; i.e., *Tackling Tamarisk on the Purgatoire – A Consolidated Woody Invasive Species Management Plan for Colorado's Purgatoire Watershed.*

Goal 3: Fully fund the TTP project to control tamarisk and Russian olive infestations while reestablishing and maintaining sustainable native plants and habitat.

Goal 4: Through education and outreach 1) heighten awareness of tamarisk and Russian olive issues to stakeholders, and 2) ensure effective, accurate, and precise communication about the project.

Goal 5: Plan and implement projects that translate the watershed plan to effective, on-the-ground restoration.

The long-term **Objectives** of TTP are to:

1. Provide a mechanism for communication and coordination among diverse parties and land managers throughout the watershed to enact the ideas set forth in the vision statement;

2. Maintain information databases, by utilizing the ARKWIPP program, such as partnerships, funding opportunities, intellectual and private industry resources, infestation levels, volunteer efforts, on-the-ground project areas, and control, restoration, monitoring, and maintenance actions; and

3. Support basin-wide coordination through strong "grass-roots" leadership and initiative to successfully realize our vision.

The TTP plan will function as the backbone of future riparian restoration work within the Purgatoire watershed. The plan is a collaborative document to assist in the development and implementation of future, objective driven, restoration designs for each area within the watershed impacted by tamarisk and Russian olive. While not the only non-native invasive species present or the only problems impacting riparian areas, tamarisk and Russian olive serve as the "poster children" for gaining public support.

# Section 1 – Background

## TPP and How it Fits with Other Planning Efforts

Effective watershed management and invasive species control efforts rely on a coordinated approach that transcends artificial boundaries such as political jurisdictions. However, to get one's "arms around the problem" planning efforts are organized within the confines of political jurisdictions or at least reasonable land masses. The TTP planning area was developed geographically to focus on the Purgatoire River mainstem from Trinidad Lake to the confluence with the Arkansas River. The Purgatoire River enters the Arkansas River in an agricultural region at the upper end of John Martin Reservoir. This area constitutes the largest infestation of tamarisk in the entire Arkansas River watershed. The TTP plan stands alone, but it is also a key component within the larger Arkansas River Basin plan, ARKWIPP.

**Figure 1: Purgatoire River Watershed in Colorado**

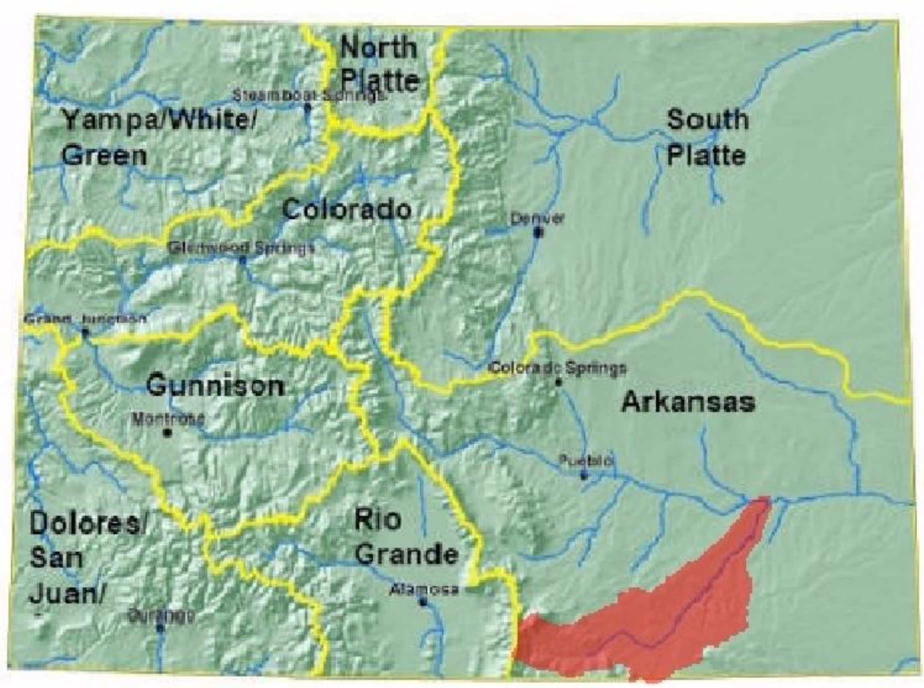
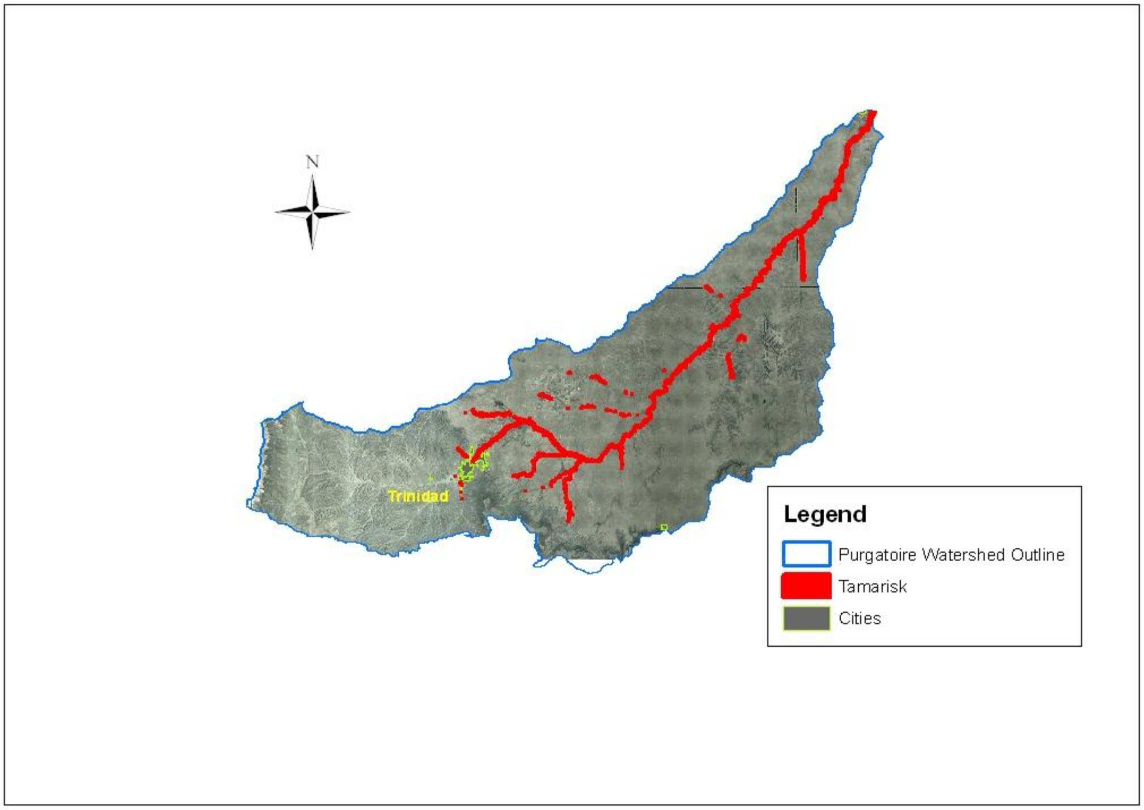


**Figure 1b: Tamarisk Infestation in the Purgatoire River Watershed**




## Partners

- Baca Co. Conservation District
- Bent Co. Commissioners
- Bent Co. Tamarisk Working Group
- Bent Co. Conservation District
- Branson-Trinchera Conservation District
- City of Trinidad
- CO Dept. of Agriculture
- Colorado Division of Wildlife/Lamar
- Colorado Division of Wildlife/Pueblo
- Colorado Farm Bureau
- Colorado Legends & Legacies Youth Corps
- Colorado State Conservation Board
- Colorado State Forest Service/La Junta
- Colorado State Forest Service/La Veta
- Colorado State Forest Service/SO
- Colorado State Parks/Denver
- Colorado State Parks/John Martin Reservoir State Park
- Colorado State Parks/Lake Pueblo
- Colorado State Parks/Trinidad State Park
- Colorado State University

- Colorado State University/Natural Resource Ecology Lab
- Denver Botanic Gardens
- Farm Services Agency
- JE Canyon Ranch
- Kansas Water Office
- Lower Arkansas Valley Water Conservancy District
- Lower Arkansas Valley Watershed Association
- National Park Service/ Bent's Old Fort
- Natural Resources Conservation Service/La Junta
- Natural Resources Conservation Service/Las Animas
- Natural Resources Conservation Service/Pueblo
- Natural Resources Conservation Service/Rocky Ford
- Natural Resources Conservation Service/Springfield
- Natural Resources Conservation Service/Trinidad
- Natural Resources Conservation Service/Walsenburg
- USDI/Bureau of Reclamation
- Colorado Water Conservation Board
- Denver University
- Private Land Owners
- Purgatoire River Water Conservancy District
- RC&D, Sangre de Cristo
- RC&D, Southeast CO
- River Canyon Ranch
- Rocky Mountain Bird Observatory
- Southeastern Colorado Water Conservancy District
- Spanish Peaks-Purgatoire River CD
- Tamarisk Coalition
- The Nature Conservancy
- US Army Corps of Engineers/John Martin
- US Army Corps of Engineers/Trinidad
- US Fish and Wildlife Service
- US Forest Service/ Comanche National Grassland
- US Geological Survey

# Guiding Principles

The TTP Strategic Plan is structured around a set of guiding principles that were drawn from the *Team Tamarisk Conference* in Albuquerque in April 27, 2004 and are identical to those found in the ARKWIPP plan.

The guiding principles are part of this living document to provide the foundation which can direct ecological restoration efforts into the future. They reflect a broad agreement between partner organizations, agencies, communities, and individuals that are cooperating to develop this management plan. The guiding principles also reflect the priorities of many stakeholders in adjoining watersheds in both Colorado and Kansas. These principles will adjust and change as additional information becomes available.

The effort recognizes that non-native invasive plants cause economic and environmental harm, negatively affect public health and welfare, and require active long-term management programs with sustainable funding. Thus the partners subscribe to the following guiding principles:

**Ecological** – Promoting ecological integrity, natural processes, and long-term-resiliency is important for success.

- Where appropriate, non-native invasive vegetation will be replaced with sustainable native plant species.
- Restoration will take into account the overall condition of the system, including presence of native species, species diversity, hydrologic regime, water quality, streambank integrity and wildlife habitat.
- Best management practices utilizing Integrated Pest Management techniques will be used and, as research and experience dictates, updated through adaptive management.
- Changes to hydrologic conditions can support native plant restoration efforts. These efforts will be considered, where possible, within the constraints of state and federal water law and the Colorado/Kansas Compact. Actions will also be carried out with the cooperation of private landowners and local water districts.
- Efforts will be made to understand the historical, present, and future role of fire and flood in riparian areas.
- The removal of tamarisk and Russian olive overstory may promote the growth of other invasive plants. Management strategies will be developed to avoid or address additional noxious plant infestations.
- Restoration and maintenance efforts will be monitored and evaluated on an ongoing basis to ensure effectiveness.
- In certain circumstances, the protection of threatened and endangered species can be enhanced through well planned efforts to establish native riparian communities and restore natural processes. In areas of concern, threatened and endangered species surveys will be encouraged.

- If no action is taken, tamarisk and associated non-native invasive plants will continue to spread and increase the environmental damage throughout the Purgatoire River watershed.

**Social and Cultural** – The values of the Purgatoire River watershed's diverse human communities will be supported and sustained by ecological restoration.

- A comprehensive strategic approach throughout the watershed is important for success. However, the Purgatoire River watershed is a mix of publicly managed lands, industry owned lands, and private property. Federal land management policy will be adhered to and private property rights, local customs and local uses will be respected.
- The Purgatoire River watershed has been altered by human actions to improve their capability to store and supply water for beneficial use. Tamarisk and Russian olive control and restoration can be performed without impeding these systems or uses. Effective control should result in preservation of water resources for human and environmental uses.

**Economic** – Economic productivity is dependent on healthy ecosystems and will be leveraged to full potential in support of long-term ecological health.

- Existing frameworks of funding, technical assistance, and expertise will be identified, used, and publicized to optimize resources and maximize local effectiveness.
- Partnerships will be developed to leverage existing and future funding.
- Improvements to agricultural production will be supported by increasing and improving grazing areas, accessibility to water, and enhancing water resources for irrigation.
- Tourism and outdoor recreation are vital economic components of the Purgatoire River watershed. Visitors come from all over the state and country to experience these recreational activities. Enhancing the visitor's experience and promoting a safe recreational experience is important.
- Private sector involvement in restoration efforts can lead to employment and economic benefits to the local communities of the Purgatoire River watershed area. Efforts will be made to encourage the use of local resources.

**Education** – Public education and outreach efforts will increase the understanding of the impacts from non-native invasive plants, safe methods for control, benefits of restoration, and the need for appropriate levels of funding to effectively manage the problem.

- Educational materials will be developed that address the aspects of the restoration process. This is especially important and critical for highly visible treatment areas.
- Community outreach and volunteer efforts will be used to aid the public and land owners in gaining first-hand knowledge of the problem and establishing ownership of the solution.

- Appropriate outreach will also be used to communicate successes and failures to other regions and the scientific community.

**Research/Monitoring** – Research and monitoring can provide mechanisms to improve the effectiveness and efficiency of restoration actions and will be evaluated on an ongoing basis to ensure effectiveness.

- Universities, federal and state agencies, and private industry will be encouraged to use riparian restoration efforts within the Purgatoire River watershed as "living laboratories" to monitor changes and provide scientific support to enhance success.
- To improve management decisions, data from inventories, monitoring, and control actions will be comparable (standardized and consistent) and shared at all levels through the ARKWIPP program.
- Performance measures for all phases of the restoration effort will include quantifiable units (e.g., acres treated and restored, fuel reduction) leading to the long-term recovery of healthy, productive ecosystems.

## Relevant Legislation and Government Actions

**Colorado Governor Actions –** In 2003 Governor Bill Owens issued Executive Order D-002-03 directing state agencies to coordinate efforts for the eradication of tamarisk on public lands (see Appendix A). As a result of the action, the Colorado Department of Natural Resources, in cooperation with the Department of Agriculture, completed the *10-Year Strategic Plan on the Comprehensive Removal of Tamarisk and the Coordinated Restoration of Colorado's Native Riparian Ecosystems, January 2004* (see "State Plans" at www.tamariskcoalition.org ).

**Colorado Department of Agriculture's Conservation Services Division, Noxious Weed Management Program** – The goals of the Colorado Noxious Weed Program are to: prevent the introduction of new invasive plant species, eradicate species with isolated or limited populations, and contain and manage those invasive species that are well established and widespread. Tamarisk falls under this last goal in most circumstances in Colorado. Tamarisk and Russian olive are found under List B Noxious Weed Species for the State of Colorado. For more information on Colorado's Noxious Weed Act, please see Appendix J (Colorado Noxious Weed Act) and Appendix K (Rules Pertaining to the Administration and Enforcement of the Colorado Noxious Weed Act). For more information on Colorado's Noxious Weed Management Program please visit http://www.colorado.gov/cs/Satellite/AgricultureMain/CDAG/1167928159176.

**Colorado Proposed Cost-sharing Grant Program –** The Colorado Water Conservation Board (CWCB) has included a provision in its 2008 "Projects Bill" to allocate $1,000,000 from the severance tax trust fund operational account to the Board's Construction Fund to be used in implementing a Cost-sharing Grant Program for Tamarisk Control. CWCB's intent for these funds is:

1. Tamarisk and Russian olive control, revegetation, and monitoring to ensure successful restoration of riparian lands.
2. Local match of a minimum of one half of the costs of restoration as non-state cost-sharing, which may consist of a combination of in-kind and cash match.
3. Grants available to communities, conservation districts, non-profits, and other eligible entities through a competitive process with input from the Colorado Department of Agriculture.
4. A portion of the appropriated funds, not to exceed 10 percent, will be used for grant program administration, scientific research, and monitoring to better target projects and to assess their effectiveness. The supervisory financial management role shall remain with the CWCB.
5. Use the Cost-sharing Grant Program as seed funds to take full advantage of other grant programs from Federal sources such as EPA, Corps of Engineers, and USDA; and from private foundations.

It is CWCB's intent that upon demonstration of the grant program's success, the CWCB will request additional funding in future fiscal years.

**Federal Legislation** – After 4 years of diligent work by the House and Senate, the *Salt Cedar and Russian Olive Control Demonstration Act* was signed into law by the President on October 11, 2006. It is referenced as Public Law 109-320 (see Appendix B). Colorado's congressional delegation was instrumental in its passage. Senators Wayne Allard and Ken Salazar, Congressmen John Salazar and Mark Udall, and former Congressman Scott McInnis were all involved as co-sponsors to make this law a reality. The principal components of the Act include:

- ✓ Authorization to fund $80 million for large-scale demonstrations and associated research over a five year period;
- ✓ Assessment of the tamarisk and Russian olive problem during the first year;
- ✓ Assessment of bio-mass reduction and utilization;
- ✓ Demonstration projects for control and revegetation that serve as research platforms to assess restoration effectiveness, water savings, wildfire potential, wildlife habitat, biomass removal, and economics of restoration;
- ✓ Project funding will be 75% federal and 25% local (cash and/or in-kind) with up to $7,000,000 per project for the federal share. Demonstration projects on federal lands and research will be funded at 100%;
- ✓ Development of long-term management and funding strategies; and
- ✓ Department of Interior will be the lead and will work with the USDA through a Memorandum of Understanding to administer the Act.

Congressional delegations from Colorado and many western states are working to include appropriations to fully fund the Act in 2007. Several organizations and states are currently working with Interior and Congress on this measure.

## Tamarisk and Russian Olive Background

### Tamarisk and Russian Olive Species

Riparian lands are especially integral and fragile aspects of western ecosystems due to their role in maintaining water quality and quantity, providing ground water recharge, controlling erosion, and dissipating stream energy during flood events (NRST 1997). Unfortunately, many of these water systems and associated riparian lands have been severely degraded over the past 150 years by anthropogenic activities (damming, road building, irrigation, etc.) and invasive plant species, resulting in reduced water quality, altered river regimes and reduced ecological systems and habitats.

Tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) are invasive species of particular interest due to their high profile status and negative environmental impacts.

**Tamarisk Ecology and Impacts –** Tamarisk is a deciduous shrub or small tree that was introduced to the western U.S. in the early nineteenth century for use as an ornamental, in windbreaks, and for erosion control. Originating in central Asia and the Mediterranean, tamarisk is a facultative phreatophyte with an extensive root system well suited to the hot, arid climates and alkaline soils common in the western U.S. These adaptations have allowed it to effectively exploit many of the degraded conditions in southwestern river systems today (e.g., interrupted flow regimes, reduced flooding, increased fire). By the mid-twentieth century, tamarisk stands dominated many low-elevation (under 6,500 feet) river, lake, and stream banks from Mexico to Canada and into the plains states. Tamarisk cover estimates range from 1 to 1.5 million acres of land in the western U.S. and may be as high as 2 million acres (Zimmerman 1997).

The exact date of introduction is unknown; however, it is generally understood that tamarisk became a problem in western riparian zones in the mid 1900's (Robinson 1965, Howe and Knopf 1991). Genetic analysis suggests that tamarisk species invading the U.S. include *Tamarix chinensis*, *T. ramosissima*, *T. parviflora*, *T. gallica*, and *T. aphylla* (Gaskin 2002, Gaskin and Schaal 2002). A hybrid of the first two species appears to be the most successful intruder. There are several ornamental varieties of tamarisk still marketed in the western United States. While these species are non-invasive they do contribute genetic diversity to invasive populations.

Tamarisk reproduces primarily through wind and water-borne seeds, but a stand may also spread through vegetative reproduction from broken or buried stems.

Seeds are viable for approximately six weeks (Carpenter 1998) and require a wet, open habitat to germinate. In the presence of established native vegetation or sprouts, tamarisk seedlings are not strongly competitive (Sher, Marshall and Gilbert, 2000; Sher, Marshall and Taylor, 2002; Sher and Marshall, 2003). Therefore, if native plant communities are intact or conditions favor native plant establishment or growth, tamarisk invasion by seed is not likely to occur. However, the following several conditions coinciding with the removal of the native canopy due to natural or anthropogenic causes will allow new infestations to occur: 1) Late flooding - Tamarisk seed production generally has a longer season than native vegetation, and therefore is able to take advantage of overbank flooding at times of the year when native vegetation is not dispersing seed. 2) Suppression of native vegetation - Herbivory (e.g., cows will eat native saplings), drought, fire, lack of seed, or other disruptive processes can prevent native plants from establishing, and thus allow tamarisk to invade. Once tamarisk seedlings are established (as great as 1,000 indivduals/$m^2$ initially), thick stands are very competitive, excluding natives (Busch and Smith 1995, Taylor *et al.* 1999). Any disruption of the riparian ecosystem appears to make invasion more likely, especially alterations of hydrology (Lonsdale 1993, Décamps Planty-Tabacchi and Tabacchi 1995, Busch & Smith 1995, Springuel *et al.* 1997, Shafroth *et al.* 1998). However, there are also numerous documented cases of tamarisk stands where no known disruptions have occurred.

Once a tamarisk stand is mature, it will remain the dominant feature of an ecosystem unless removed by human means. Tamarisk has a higher tolerance of fire, drought, and salinity than native species (Horton *et al.* 1960, Busch *et al.* 1992, Busch and Smith 1993 & 1995, Shafroth *et al.* 1995, Cleverly *et al.* 1997, Smith *et al.* 1998, Shafroth *et al.* 1998). Tamarisk can increase fire frequency and intensity, drought (Graf 1978), and salinity (Taylor *et al.* 1999) of a site. Hence, a strong initial infestation will promote a positive feedback mechanism that will lead to more tamarisk invasion.

In addition to affecting abiotic processes, tamarisk dominance dramatically changes vegetation structure (Busch & Smith 1995) and animal species diversity (Ellis 1995). High invertebrate and bird diversity has been recorded in some tamarisk-dominated areas and tamarisk is valued highly by the bee industry for its abundant flower production. Although some forms of tamarisk (primarily younger, highly branching stands) are favored by cup nesting bird species such as the endangered southwestern willow flycatcher, many endemic species are completely excluded by it, including raptors such as eagles (Ellis 1995). Because of its potential usefulness to some species, stands of tamarisk mixed with native vegetation were found to have high ecological value in Arizona study sites (Stromberg 1998). In contrast, mature monocultures of tamarisk have a much lower ecosystem value.

In general, the following is an assessment of tamarisk and its impacts on riparian systems throughout the West (Carpenter 1998, McDaniel *et al.* 2004).

- Tamarisk populations develop in dense thickets, with as many as 3,000 plants per acre that can prevent the establishment of native vegetation (e.g., cottonwoods (*Populus spp*), willows (*Salix spp*), sage, grasses, and forbs).

- As a phreatophyte, tamarisk invades riparian areas, potentially leading to extensive degradation of habitat and loss of biodiversity in the stream corridor.

- Due to the depths of their extensive root systems tamarisk draw excess salts from the groundwater. These are excreted through leaf glands and deposited on the ground with the leaf litter. This increases surface soil salinity to levels that can prevent the germination of many native plants.

- Tamarisk seeds and leaves lack nutrients and are of little value to most wildlife and livestock.

- Tamarisk acts as an unnatural ladder fuel (or mid fuel) that serves as a "step" for wildfire to travel up into the canopies of cottonwood trees. Leaf litter from tamarisk also increases the frequency and intensity of wildfires which kill native cottonwood and willows but stimulate tamarisk growth.

- Dense tamarisk stands on stream banks accumulate sediment in their thick root systems gradually narrowing stream channels and increasing flooding. These changes in stream morphology can impact critical habitat for endangered fish.

- Dense stands affect agricultural production by invading rangeland, reducing forage, and preventing access to surface water. The non-beneficial use of water also affects irrigation practices as well.

- Aesthetic values of the stream corridor are degraded, and access to streams for recreation (e.g., boating, fishing, hunting, bird watching) is lost.

- Tamarisk has a reputation for using significantly more water than the native vegetation that it displaces. This non-beneficial user of the West's limited water resources has been reported to dry up springs, wetlands, and riparian areas by lowering water tables (Carpenter 1998, DeLoach 1997, Weeks *et al.* 1987).

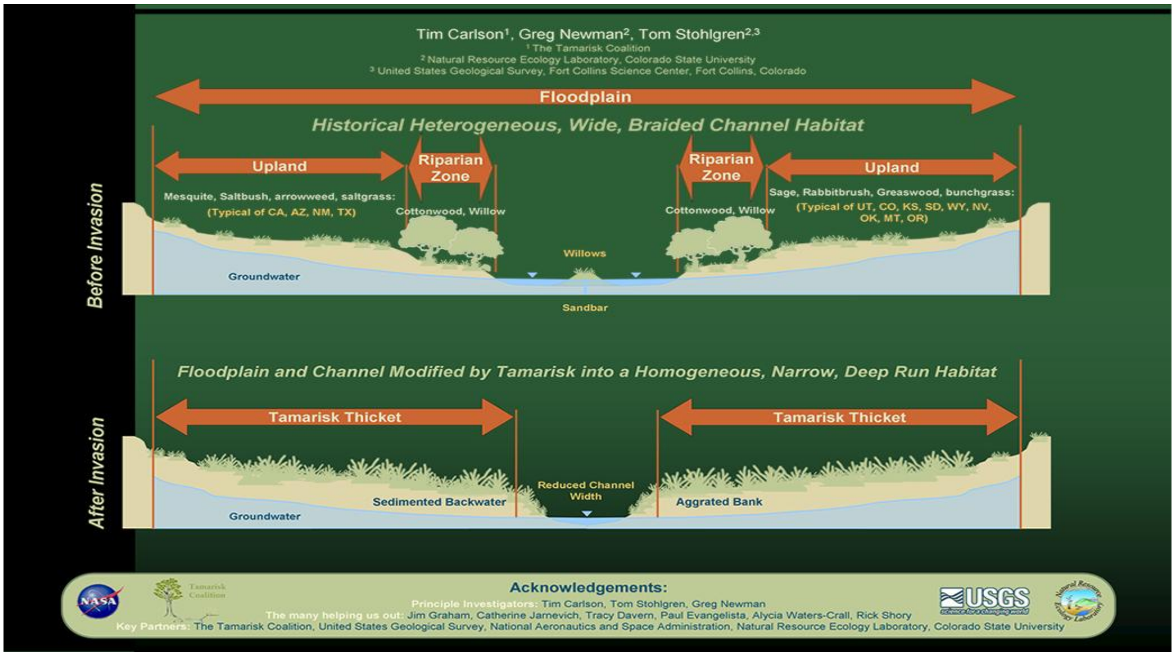
**What are the Local Impacts? –** The most critical impacts for the TTP study area are aesthetics, wildlife habitat loss, fire, and water usage. Aesthetics are highly valued due to the tourism, hunting, and fishing industry. Wildlife habitat loss is important from the ecological standpoint, while fire is a safety concern to communities. Water loss, however is considered the most critical issue. The following section provides a brief explanation of how this water loss occurs.

**How much Water is Lost? –** Limited evidence indicates that water usage per leaf area of tamarisk and the native cottonwood/willow riparian communities is very similar. However, because tamarisk grows in extremely dense thickets, the leaf area per acre may actually be much greater than native stands; thus, water consumption could be greater on a per acre basis (Kolb 2001). Another aspect of tamarisk water consumption is its deep root system. Tamarisk roots can extend down to 100 feet, much farther than healthy cottonwoods and willows stands which reach a depth of only a few meters (Baum 1978, USDI-BOR 1995). This allows tamarisk to grow further back from the river, occupy a larger area, and use more water across the floodplain than native phreatophytes. This is significant because the upper floodplain terraces adjacent to the riparian corridor typically occupy an area several times larger than the riparian zone itself. In these areas, mesic and xeric plants (such as bunch grasses, sagebrush, rabbit brush, four-wing salt bush, and skunk bush) can be replaced by tamarisk resulting in overall water consumption several times the ecosystem's natural rate (DeLoach *et al.* 2002).

Water consumption estimates vary a great deal depending on location, maturity, density of infestation, water quality, and groundwater depth. In 27 research plots, tamarisk had an average annual water usage of 4.2 acre-feet/acre (95% confidence interval = 3.85 to 4.86) (NISC 2006). This agrees strongly with the most sophisticated evapotranspiration studies using eddy-covalence measurements performed for the Bureau of Reclamation (King and Bawazir 2000) of 4.35 feet per year. Water use by Russian olive was found to be approximately the same. In many situations this water consumption is equivalent to that of cottonwood/willow vegetation at a similar density. For dry-land vegetation such as grasses/sage/rabbit brush communities, which are shallow-rooted and get their water primarily from precipitation, the difference in water use is a function of the precipitation received for the area. In the TTP study area's riparian lands, annual precipitation ranges from a low of 8 inches to approximately 14 inches per year at the higher elevations where tamarisk exists (6,500 feet) (NOAA). For areas that could support native phreatophytes, it is estimated that only approximately 25% would actually be occupied by these species based on a number of factors. Water loss calculations are based on these findings. Future water losses assume complete infilling of tamarisk with no expansion of range.

Figure 2 represents the differences in vegetative cover with and without tamarisk and illustrates tamarisk occupation of an area much greater than the riparian zone which typically would support phreatophytes. Significant water losses may occur as tamarisk occupy upland areas within the floodplain that would normally support only upland mesic and xeric vegetation such as grasses, sage, rabbit brush, etc.

**Figure 2: Tamarisk Induced Changes in Channel Structure and Habitat**




**Russian Olive Ecology & Impacts –** Russian olive (*Elaeagnus angustifolia*) was introduced to the United States in the late nineteenth century as an ornamental shrub or small tree and has since spread from cultivation (Ebinger and Lehnen 1981, Sternberg 1996). Originating in southern Europe and central and eastern Asia (Hansen 1901, Shishkin 1949, Little 1961), Russian olives are long-lived and resilient plants. They are adapted to survive in a variety of soil types and moisture conditions, grow between sea level and 8,000 feet, can grow up to 6 feet in one year (Tu 2003), are shade tolerant (Shafroth et al. 1995), and can germinate over a longer time interval than native species (Howe & Knopf 1991).

Until the 1990's several state and federal agencies promoted the distribution of Russian olives for windbreaks and horticulture plantings in the western U.S. and in Canada (Tu 2003, Olson and Knopf 1986, Haber 1999). The seedlings were touted for their use in controlling erosion (Katz and Shafroth 2003), providing wildlife habitat (Borell 1962), and serving as a nectar source for bees (Hayes 1976). As a result, Russian olives were distributed widely in the west and continue to spread through natural sexual and vegetative reproduction (Tu 2003).

Russian olives are reach maturity begin producing seeds 3 to 5 years after establishment (Tu 2003). Seeds are encased in a fleshy fruit providing an attractive food source for wildlife, especially avian species. As the outer layer of the seed is impervious to digestive fluids (Tesky 1992), seed predators are a significant factor in Russian olive recruitment. Plant establishment has been documented following seed consumption by birds (USDA 1974, Shafroth et al. 1995, Lesica and Miles 1999, Muzika and Swearingen 1998). Coyotes, deer, and raccoons have also been observed consuming and distributing the seeds (USDA 2002). The seeds are dispersed in a dormant state during the cool months in fall and winter. They prefer an after-ripening period of moist conditions lasting roughly 90 days at 5 degrees Celsius to successfully germinate (Hogue and LaCroix 1970, Belcher and Karrfalt 1979). In average conditions, seeds are viable for up to 3 years (USDA 2002). This lengthy seed viability allows Russian olive more time to utilize optimal germination conditions than most native plants giving Russian olive another competitive edge (Howe and Knopf 1991, Shafroth et al 1995).

Russian olive seeds can germinate on undisturbed soils. Thus, they are not highly dependent upon the flood disturbances that sustain native species (Shafroth et al. 1995, Lesica and Miles 1999, Katz 2001) and are able to exploit the degraded conditions of southwestern rivers today (e.g., interrupted flow regimes, reduced flooding, increased fire, etc.).

Russian olives grow and compete with native plants well in dry, upland soils (Laursen and Hunter 1986) and in wet-saline soils. However, non-saline, hydric soils and soils with elevated sodium levels favor native species and the invasive plant tamarisk recruitment (*Tamarix spp.*) over Russian olive respectively (Carman and Brotherson 1982).

Russian olives, once established, will remain a dominant feature of riparian systems. The shade tolerant seedlings are able to germinate and thrive in the understory of native trees. As the native trees die, Russian olive becomes the upper canopy of the system, shading out native tree recruits (Shafroth et al.1995).

In general, the following is an assessment of Russian olives and their impacts on riparian systems throughout the West (Tu 2003):

- Russian olives form dense, monotypic stands that affect vegetative structure, nutrient cycling, and ecosystem hydrology.
- Presence of Russian olive can modify plant succession in a system.
- Russian olive results in lower native plant and animal diversity
- Widespread Russian olive invasions can connect riparian forests with upland areas stabilizing floodbanks, increasing overbank deposition, and limiting cottonwood regeneration sites.
- The evapotranspiration rates of Russian olives are higher than native species, thus they consume more water resources (Carman and Brotherson 1982)
- The invasives can convert riparian areas to relative drylands with Russian olive as the climax species (Olson and Knopf 1986).
- Dense stands of Russian olives increase fuel loads leading to more frequent and intense wildfires that kill native plants (Caplan 2002).

- Russian olive trees provide inferior habitat to native vegetation and reduce abundance and diversity of wildlife (Knopf and Olson 1984, Brown 1990)

The difficulty of controlling or removing mature stands of Russian olive makes it almost impossible to eradicate from a watershed once it is established. Thus, it is important to detect new infestations of Russian olive early on and to rapidly respond to remove them. There are methods available to control Russian olives on a small scale, but the cost and intense labor demands of the work can be expensive. Techniques used include mowing, cutting, and girdling combined with herbicide application; basal bark herbicide application; and burning, excavating, and bulldozing with no herbicide application (Tu 2003).

In general, Table 1 provides an overview of adverse characteristics and potential impacts widely attributed to tamarisk (T) and Russian olive (RO). For more detailed information the reader is referred to Carpenter 1998 and Tu 2003.

It should be noted that various other non-native invasives are intermixed with tamarisk and Russian olive such as Russian knapweed, whitetop, Russian thistle, and purple loosestrife and should be considered throughout the planning and implementation of restoration actions.

Table 1: Characteristics of Tamarisk (T) and Russian Olive (RO)

| **CHARACTERISTICS** | | **DESCRIPTION** |
|---|---|---|
| Origin | T | Central Asia/Mediterranean |
| | RO | Europe/Western Asia |
| Estimated Cover | T | 1 to 1.5 million acres in the western United States |
| | RO | Unknown |
| Elevation | T | Sea Level to 6,500 feet |
| | RO | Sea Level to 8,000 feet |
| Habitat/Range | T | Western U.S. along riverways, springs, drainages |
| | RO | Throughout U.S. – most dense in western states |
| Tolerant | T | Floods, droughts, close shearing, and burning |
| | RO | Floods, droughts, close shearing, burning in dormancy, seedlings and saplings are shade tolerant |
| Intolerant | T | Shade |
| | RO | Acidic conditions (pH<6.0) |
| Reproduction/ Distribution | T | Sexual and vegetative; seeds need moist soils/water and wind |
| | RO | Sexual and vegetative; seeds can propagate in undisturbed soils/water and wildlife |

| CHARACTERISTICS | | DESCRIPTION |
|---|---|---|
| Growth patterns | T | Dense monotypic stands, clumps or stringers |
| | RO | Dense monotypic stands or scattered occurrences |
| Soils | T | Seedling require moist soils; ranges widely as adult; highly tolerant of and actually increases surface salinity |
| | RO | Can tolerate bare mineral or nitrogen poor soils, prefers sandy floodplains and open, moist riparian habitats, tolerant of prolonged inundation |
| Vegetation Impacts | T | Once established, grows densely and excludes natives |
| | RO | Shade tolerate allowing it to out compete natives through succession and exclusion |
| Water Use | T | Equivalent evapotranspiration to riparian native phreatophytes such as willows and cottonwoods, but deep root systems uses water even in drought, high leaf area index and tendency to grow in dense thickets can result in more water usage per acre than natives, and grows in mesic and xeric areas due to deep root depths |
| | RO | High rates of evapotranspiration similar to other phreatophytes, but uses more water than native upland mesic and xeric vegetation |
| Wildlife Impacts | T | Reduced insect prey and habitat structure negatively impacts most bird species with some exception, and poor habitat for raptors such as bald eagles; channelization of streams reduced native riparian recruitment and reduces backwaters and spawning areas for endangered fish |
| | RO | Provides inferior habitat in the long-term resulting in loss of species richness |
| Wildfire | T | Increases frequency and intensity, extremely fire tolerant |
| | RO | Increases fuel load; fire tolerant |
| Management | T | Difficult and expensive for mature stands |
| | RO | Difficult and expensive for mature stands |
| Forage | T | Poor nutrition |
| | RO | Poor nutrition, birds and other wildlife can feed on fruit |
| Livestock | T | Reduces forage area, surface water, and impedes access to flowing water |
| | RO | Reduces forage area, surface water, and impedes access to flowing water |
| Stream/River Morphology | T | Dense stands stabilize river banks, change stream structure by narrowing and deepening channels, and decreasing number and size |

| CHARACTERISTICS | | DESCRIPTION |
|---|---|---|
| | | of backwaters needed to sustain a properly functioning ecosystem with native riparian communities and wildlife habitats. Reduced carrying capacity of river channels can increase flood damage |
| | RO | Stabilizes river banks, increasing overbank deposition, and limit native cottonwood regeneration |
| Recreation | T | Can be aesthetically pleasing though generally degrades aesthetic value, obstructs access to streams/rivers, reduces native ecosystems and diversity |
| | RO | Can be aromatically, aesthetically pleasing, obstructs river access, reduces native ecosystems and diversity |

## Environmental Setting

**Purgatoire River:** The Purgatoire River flows east from Culebra Peak, a 14,069 foot mountain high in the Sangre de Cristo Range, to its confluence with the Arkansas River in Colorado. As the Purgatoire River exits the Sangre de Cristo Mountains and their foothills, the river takes on a more gentle gradient and begins to meander downstream of Trinidad. This area consists mostly of prairie grasslands divided into small parcels under private ownership. The riparian zone found here contains many large, dense cottonwood galleries lining the river mainstem. Near the Purgatoire River confluence with San Francisco Creek, the river changes character as it enters a more incised canyon geological formation. For approximately the next 50 miles, the canyon becomes more remote and has very few vehicle access points. This canyon geologic configuration persists downstream until Nine-Mile Bottom, where the canyon opens into a broader floodplain hosting a wide swath of mature tamarisk infestation. Downstream of Nine-Mile Bottom, the river again changes back to a meandering, broad floodplain. This configuration is consistent until the Purgatoire River bends northeast to Las Animas, Colorado where it enters the Arkansas River at the west end of John Martin Reservoir. The river mainstem in this area is characterized by extensive agricultural irrigation and infrastructure, as well as significantly greater vehicle access than the upstream canyon reaches.

On both the northwest and southeast sides of the Purgatoire River mainstem, many tributaries enter the canyon. In general, tributaries from the north are shallower, broad washes and arroyos (i.e. entering from Piñon Canyon Maneuver Site and Comanche National Grassland), while those approaching from the south are more narrow, incised canyons.

Tributaries of the Purgatoire River have created lush side canyons that sustain several rare plant species including leafy goldenweed (*Oonopsis foliosa var. foliosa*) and Sandhill Goosefoot (*Chenopodium cycloids*). Above the canyons lie shale outcrops, piñon/juniper woodlands, and extensive prairie uplands that support native grasses and shrubs, creating a diverse prairie mosaic. The riparian zones associated with the Purgatoire River mainstem and its tributaries are traditionally dominated by cottonwood and willow.

The Purgatoire's globally rare riparian plant communities are threatened by the invasion of aggressive, non-native, woody plants including tamarisk and Russian olive. Tamarisk has choked the river and transformed the plains riparian areas. These areas have been altered from healthy, viable habitat with mixed plant communities supporting 90% of the area's wildlife, into crowded monocultural forests with little biodiversity value.

The site supports one of the best native fisheries in the Central Shortgrass Prairie east of the Rocky Mountains. The habitat that the Purgatoire River provides for fisheries is unique; the following species all occur together within the Purgatoire River: Black bullhead, central stoneroller, longnose sucker, white sucker, brook stickleback, red shiner, Arkansas darter, plains killfish, plains minnow, channel catfish, green sunfish, orangespotted sunfish, speckled chub, sand shiner, flathead chub, longnose dace, and creek chub.

Referencing the Prairie and Wetlands Focus Area Strategic Plan (Rocky Mountain Bird Observatory), birds that will benefit from tamarisk control within the Purgatoire River Watershed include: Wilson's snipe, spotted sandpiper, Mississippi kite, Lewis's woodpecker, and red-headed woodpecker. Amphibians that will benefit from an increase in the availability of water for wet meadow habitat include: Northern leopard frog, canyon tree frog, Great Plains narrowmouth toad, and plains leopard frog. Waterfowl and some water birds will also benefit from an increase in wet meadow habitat.

Mean annual average precipitation in the watershed varies from 8 to 14 inches per year, depending on location. Nearly 75 percent of the precipitation falls during the growing season, lasting from mid-April to late-September. Temperatures in the watershed can range from as low as -35 degrees F up to 108 degrees F. Powerful storms may occasionally generate winds in excess of 60 miles per hour.

Tamarisk infestations occur primarily in the riparian zone habitat stretching to the extent of the 100 year floodplain. The infestations begin in earnest at Trinidad Lake, or generally below 6,500 feet in elevation. There are isolated pockets at higher elevations, such as areas in the nearby foothills. Side canyons, perennial and ephemeral streams, springs, and tributaries support isolated stands of tamarisk. Upland tamarisk infestations outside of the floodplain also occur in stock ponds or naturally occurring low areas, but are typically not as common or dense.

Several tamarisk removal projects are planned or have been completed in areas of the watershed ranging from Trinidad Lake to the confluence with the Arkansas

River near John Martin Reservoir. In 2006 and 2007, Trinidad Lake State Park removed tamarisk around the lake and in a few of the nearby tributaries. Several landowners and ranchers in the watershed have undertaken similar projects. At the lower end of the watershed, both the Comanche National Grassland and the Army Corps of Engineers at John Martin Reservoir completed tamarisk control projects on their lands.

## Extent of the Problem

**Inventory Background & Objectives –** In 2005 and 2006, on behalf of the Colorado Water Conservation Board (CWCB), the Tamarisk Coalition performed an inventory of tamarisk infestations on the Arkansas River and Purgatoire River watersheds and their main tributaries. In 2007, the Tamarisk Coalition completed a supplementary inventory of tamarisk for the entire Arkansas Watershed in Colorado as outlined in the ARKWIPP plan. The purpose of this work was to establish and implement an inventory protocol that would be economical to perform and would provide a clear understanding of the extent of the tamarisk problem. These inventory/mapping protocols (attached) proved to be successful and were used in 2006 and 2007 to identify tamarisk throughout the remainder of the state.

**Inventory Approach –** Inventory and mapping were coordinated with the U.S. Geological Survey's (USGS) efforts to establish a national on-line database conforming to the weed mapping standards developed by the North American Weed Management Association. The basic approach (see Appendix C for mapping protocols) utilized existing aerial photography, satellite imagery, and local knowledge available from counties, river districts, soil and water conservation districts, state agencies, Army Corps of Engineers, National Resources Conservation Service, USGS, CSU, and The Nature Conservancy. This information was then "ground-truthed" by a 2-man team to confirm infestation density, maturity, height, accessibility, presence of native species, and miscellaneous site characteristics. GPS data and digital photo records were taken and shapefiles were developed using GIS. Over **351** miles on the Purgatoire River and its major tributaries in Colorado were surveyed using this approach. The starting point for the Arkansas River was the Upper Arkansas area near Salida, and for the Purgatoire River it was Trinidad Reservoir dam. This constituted the river mainstem mapping efforts. Additionally, mapping efforts were expanded in 2007 to include all major infested tributaries, reservoirs, wetlands, canals, and dry land stands in the Arkansas watershed. This information, in the form of shapefiles and characteristics data, has been transformed into a digital GIS database which is now available on the USGS National Institute of Invasive Species Science website, www.niiss.org.

**Findings –** The inventory for the Purgatoire River and its major tributaries are presented in Tables 1-4 in Appendix G, and represent a summary of the detailed information collected which is found on the supplementary Data-DVD. Tables 1-

4 provide the most current assessment of acreage of tamarisk and its impacts on water resources. Table 1 presents the general mapping data; whereas, Table 2 provides estimates on current and future water losses associated with the tamarisk infestations and the estimated costs for tamarisk control and revegetation. Tables 3 and 4 provide detailed information on each infested area (shapefiles) and its unique attributes. The water losses and cost estimates are based on the most recent research and statistical analysis available through the USDA, NOAA, USGS, CSU, National Invasive Species Council, Tamarisk Coalition, and others.
The inventory process focused on efficient, economical mapping/inventory protocols to identify 85 to 90 percent of tamarisk within these watersheds. The remaining percentage represents small pockets of infestations that are scattered throughout the region and would be proportionately very expensive to map. Thus, the inventory and water loss calculations are somewhat conservative.

The following summarizes the findings depicted in Tables 1 – 4 in Appendix G:

1. General Description of Main stem Tamarisk Infestations:

    a. The **Purgatoire River** from the Arkansas River confluence to Trinidad Lake Dam (**179 miles**) has approximately **9,250** total acres of tamarisk infestation at approximately **30%** average density.

2. General Descriptions of Tributary Tamarisk Infestations:

    a. The major tributaries for the **Purgatoire River** had an additional **763** acres of infestation with an average density of approximately **26%**.

3. Current water losses are based on the amount of water tamarisk is currently using under observed densities minus the water that would be used by native plants. **Figure 2** illustrates the differences in vegetative cover with and without tamarisk and shows that tamarisk is able to occupy a much greater area than the riparian zone that supports cottonwoods and willows, also phreatophytes. The significant water losses occur as tamarisk occupies terrace areas within the floodplain that would normally have dryland xeric vegetation such as grasses, sage, rabbit brush, etc. The overall Purgatoire River system and its tributaries generally have terrace areas of approximately 52%. Based on these conditions, the estimates of current water losses above and beyond what native vegetation would use are approximately:

    a. Purgatoire River Main Stem from Arkansas River confluence to Trinidad Lake Dam = **8,000** acre-feet a year.
    b. Tributaries = **580** acre-feet a year.

4. Future water losses assume an infilling of the existing infestation areas will likely occur over the next several decades based on similar conditions observed in other states (NM, UT, and NV). Future water losses from infilling only (with no expansion from existing infested areas) are estimated to be approximately:

    a. Purgatoire River Main Stem from Arkansas River confluence to Trinidad Lake Dam = **27,300** acre-feet a year.
    b. Tributaries = **2,200** acre-feet a year.

5. If tamarisk control and revegetation occurs on any of these river or tributary sections, the water normally lost to the atmosphere through evapotranspiration will be conserved and will remain within the groundwater and/or surface water regimes.

6. Throughout these watersheds it is common to have Russian olive coexist with tamarisk especially in the urban corridor where Russian olive has escaped from landscape plantings.

**Expected Ecosystem Changes to Riparian Areas –** Expected conditions following tamarisk and Russian olive control projects in the Purgatoire River watershed include enhanced aquatic, riparian, and floodplain habitat. The quantity and quality of these habitats would be improved, resulting in increased habitat for fish and wildlife including endangered fish species. Opportunities for environmental education, improved aesthetics, recreation, agricultural use, and improved management of flood flows would exist in project areas. Significant conservation of water resource would also result from tamarisk and Russian olive control in these watersheds. These expected changes will occur only if all aspects of restoration are part of the solution; i.e., site specific planning and design, control, revegetation, biomass reduction, monitoring, and long-term maintenance.

Beneficial impacts of restoration also include increased resilience to future stresses such as fire, drought, climate change, or other invasive plants; creating a more self-sustaining ecosystem; providing the benefits of improved water resources; and reducing future riparian management costs.

## Control, Biomass Reduction, Revegetation, Monitoring, and Long-term Maintenance

Management of non-native phreatophytes generally consists of five components – planning with inventory/mapping, control and biomass reduction, revegetation, monitoring, and maintenance. Without all five components it is unlikely that tamarisk and Russian olive control projects will be successful over time. Successful management also depends on flexible approaches open to experiential learning and new technologies. This is referred to as “adaptive management.”

For the discussion on the control component of management, the focus is on tamarisk because it is the principal non-native phreatophyte in the Purgatoire watershed. In general, the following discussion also applies to Russian olive but may be slightly different for each (e.g., type of herbicide used). A detailed comparison of major control technologies implemented throughout the West can be found in **Appendix H** which describes in more detail effectiveness, impacts, applicability, cost algorithms, and time distribution of costs.

Appendix E, Templates and Protocols, provides a suggested approach to select appropriate techniques for control and biomass reduction, revegetation, monitoring, and long-term maintenance. Biomass reduction and revegetation approaches are not always needed because in many situations natural revegetation can occur and biomass reduction may not be needed. For the purposes of this Plan the term *template* defines what actions should be taken, and the term *protocol* defines how the actions could be performed. These templates and protocols are intended as suggested guidance and criteria for decision making while carrying out the activities associated with various aspects of tamarisk and Russian olive control and biomass reduction, revegetation, monitoring, and long-term management. Thus, the intent is to ensure that selected approaches are effective and efficient, and decisions are well documented.

## Monitoring

For riparian restoration activities, “monitoring” is the act of observing changes that are occurring or expected to occur with, or without, remediation actions. The purpose of monitoring is to provide information in response to objectives, to make informed decisions to initiate, continue, modify, or terminate specific actions, remediation activities or programs – better known as “adaptive management.”

Two considerations important to the TTP monitoring efforts to gauge ecological changes are scale and ownership. In general there are two divisions in each of these elements: large-scale versus small-scale projects; and public ownership versus private ownership. For the purposes of this discussion it will be assumed that parcel sizes large enough to support large-scale projects are located on both private and public lands and that small scale projects will be located primarily on private lands. Coordination between private land owners and public land managers is essential to gain access to private lands, create a standard monitoring protocol, and to develop and execute training in monitoring methods. Depending on the objectives of each restoration site, varying combinations of monitoring approaches may be designed based on intensity of restoration, site specifics, or capability of collaborators.

Large-scale monitoring allows policy makers, land managers, and the public to evaluate the potential impacts of remediation on water resources, vegetation, wildlife habitat, biodiversity, economic health, society, and culture. These are essential considerations for determining what level of funding should be committed to the control efforts by the local, state, and/or federal agencies. Pre-restoration monitoring is important to establish baseline data to determine if goals and objectives are being achieved on the landscape scale.

Small-scale monitoring provides useful information on the effectiveness of control and remediation activities. This information allows for modifications, if necessary, to achieve the remediation goals. In general, small-scale monitoring criteria should consist of simple and inexpensive monitoring techniques based on the needs of the management objectives.

## Long-term Maintenance

Long-term maintenance is a dynamic management process, carried out over years to decades to achieve social, economic, and ecological goals associated with a watershed. The process of management encompasses the strategic implementation of actions to identify, maintain, remediate, improve, and monitor the ecological processes of the watershed. Actions, and the tools required to accomplish them, are chosen because they are consistent with and likely to achieve the watershed goals, and because they address the results of monitoring.

Monitoring is related to maintenance in that it is the act of observing changes that are occurring with, or without, remediation actions. Monitoring provides information for making informed decisions to ensure "maintenance" will continue to remediate or improve the ecological processes of the watershed. For tamarisk and Russian olive restoration these measures are important for effective control on a long-term basis and that the desired outcomes of revegetation and prevention of other noxious weed infestations are successful.

**Research shows that if resources are spent only on control with no cohesive approach to long-term revegetation, monitoring, and maintenance, the potential for successful riparian restoration is limited.**

## Current Tamarisk Management Efforts in the Purgatoire River Watershed

**<u>Las Animas County—TTP supported projects</u>**

- **Trinidad State Park Reservoir**
  *158.5 acres treated along waterways, 11 acres on other Park property*
  --2.2 miles-Riley Creek
  --1 mile-Long's Creek

--11 additional acres on Park property
--2.25 miles along the Purgatoire River

- **Private lands along Purgatoire River**
  --~40 acres-NRCS EQIP Invasives Plant Program-3 Landowners (10 year contracts for a total of 100 acres)
- **Private lands within the Chacuaco Creek drainage**
  --CDOW Wetlands Funds-Chacuaco Creek Drainage (upcoming in 2008)-~10 landowners (3 year funding, for a total of 160 acres)

**<u>Las Animas County</u>**

- USFS Comanche National Grassland
  --~1000 acres-Picketwire Canyonlands

**<u>Bent County--Bent Co. Tamarisk Working Group</u>**

- NRCS EQIP and WHIP projects with Private Land Owners
  ~100 acres

**<u>Bent County—John Martin Reservoir</u>**

- ~5-10 acres along river corridor east of dam

**<u>Bent County—Boggsville National Historic Site</u>**

- ~10 acres along river corridor

## Proposed Strategies for Control, Biomass Reduction, Revegetation, Monitoring, and Long-term Maintenance of Watershed Sections

The mapping and inventory work completed for the Colorado Water Conservation Board (Appendices D and H), in coordination with county weed managers and the economic algorithms developed by the Tamarisk Coalition (Appendix H) identify a range of costs for tamarisk and Russian olive control and restoration. The cost algorithms were developed to provide a "planning-level" range of costs for tamarisk control along each river segment.
They employ tamarisk infestation information for each segment (acres infested, percent cover, accessibility, and width) to estimate costs based on which control strategies would be appropriate for the area, and how much these strategies would cost for the given acreage. Therefore, the cost algorithm data tables reflect which tamarisk control strategies will be used, and to what extent, on a given river segment. As a result, the percentage that each control strategy will likely be used on a section can be continually adjusted using the algorithms to find more accurate, or updated, cost estimates. This detailed information is presented in the supplementary Data-DVD.

# Proposed Watershed Strategies

The following discussions articulate the proposed strategies for tamarisk control, biomass reduction, and revegetation for specific geographic settings in the Purgatoire River watershed. These strategies were developed in coordination with county weed managers and land managers throughout the region.

The restoration recommendation for areas not specifically addressed below is as follows: Biological control using the tamarisk leaf beetle, *Diorhabda elongata*, coupled with natural biomass decomposition for light infestations, biomass reduction for moderate to heavy infestations, and revegetation for areas where biomass is reduced.

Biological control should be considered the priority approach for the Purgatoire River watershed. However, at present, it is uncertain how effectively the tamarisk leaf beetle will achieve large scale tamarisk mortality. Until that efficiency is known the methods described below should be used on high priority areas to ensure success regardless of the bio-control's effectiveness. If bio-control is unsuccessful as a large-scale approach, the methods described below would be appropriate to control tamarisk throughout the watershed.

In general biomass reduction should not be needed for light infestations and some moderate infestations but should be performed for all other situations to reduce the fuel load in riparian areas. This is especially important to protect the valuable cottonwood galleries in many of these areas as well as native shrubs.

As a component of these strategies, revegetation will likely occur naturally for lightly infested sites with some minor weed control. For moderate infestations, some reseeding will be necessary while heavy infestations will require substantial revegetation efforts. Any revegetation efforts will be very site specific, and will vary, depending on local conditions such as soil type and use. Site specific revegetation plans will be developed for sites requiring revegetation. In general, revegetation efforts for all areas, when required, may consist of:

1. Pole cuttings for cottonwoods and willows in areas with shallow groundwater (less than 10 feet).

2. Longstem planting using tall pot techniques to revegetate upper terrace sites that have deeper groundwater and lack overbank flooding. This approach is very useful for some trees and shrubs such as currants and skunkbush. For more information see the revegetation section contained in the plan.

3. Broadcast or seed drilling for grasses and forbs such as salt grass, alkali sacaton, sand dropseed, alkali muhley, and indian ricegrass, among many others depending on the local site conditions.

**Weed control following tamarisk and Russian olive control and during revegetation efforts is necessary to prevent the establishment of noxious weeds such as Russian knapweed, perennial pepperweed, cheatgrass, hoary cress (whitetop), Canada thistle, etc.** In general, weed control for all areas, when required, may utilize herbicide, mechanical and biological control, and preventive measures associated with successful revegetation approaches. Weed control will increase proportionately with the degree of infestation.

## Purgatoire River Watershed Strategies

### Purgatoire River, Trinidad Lake to San Francisco Creek confluence (including tributaries: Raton Creek, Powell Arroyo, Chicosa Arroyo, Frijole Creek, San Francisco Creek and San Isidro Creek)

Drawings P35 to P44, RC1 to RC2, PA1, CA1 to CA4, FC1 to FC5, SFC1 to SFC3, and SIC1 to SIC6
Photo Log No. 50, 53, 56, 58, 59, 61, 64, 74 – 78; 41 – 43; 51 – 52; 63, 66, 67, 68, 72, 80 – 82, 0, 83, 86, 87, 90 - 93
Estimated Acres Infested with Tamarisk – **2,748 acres**
Estimated Average Tamarisk Density – **30%**

This area is located north, south and east of Trinidad and consists mostly of prairie grasslands with blue grama, western wheatgrass, prairie sandreed, and fourwing saltbush as some of the dominant vegetation in this zone. Native vegetation in the riparian zone includes cottonwood and willow communities, with large cottonwood galleries present in the areas near the San Francisco Creek confluence. Additionally, heavy infestations of Russian olive exist in the riparian areas near Trinidad, in some cases they are the dominant plant species near the river mainstem. Some agricultural areas exist in this area; subsequently vehicle access to the mainstem and tributaries in this area is generally good.

The broad tamarisk infestations occupying the majority of this section of the Purgatoire's mainstem will be controlled with combinations of mechanical removal, herbicide application, and some hand cut-stump work. Light, broad infestations would best be removed with mechanical extractors and grab & cut-stump equipment. Biomass will then be stacked for wildlife habitat or mulched for revegetation purposes depending on the desires of the landowner. Additionally, biomass can be piled and burned when conditions permit. Moderate to heavy, broad infestations where biomass reduction is a high priority should be mechanically mulched. Due to the high costs of hand cut-stump control work, this method should only be used around valuable vegetation and in areas inaccessible to mechanical equipment. Only areas that are very heavily infested and broad should be considered for aerial spraying, such a section is represented in drawing P40-P41.

The areas necessitating biomass reduction will require revegetation. For mechanical methods, native planting requirements will increase proportionately with the density of infestation and extent of ground disturbance. In aerial spraying locations, revegetation is critical in all cases due to the inherent loss of surrounding vegetation. Weed control will be critical for much of this river section to prevent other noxious weeds from filling the void left by tamarisk and Russian olive removal.

Mostly hand work should be performed along the spottily infested tributaries in this section. Biomass should be stacked for wildlife and natural revegetation is expected to occur. Additionally, biomass can also be piled and burned when conditions permit. As with other sites, natural biomass decomposition, reduction, and revegetation should occur after biological control has caused a significant mortality in tamarisk.

Russian olive, although less abundant than tamarisk, has a significant presence throughout much of this river section. Control will correspond with tamarisk removal methods in most areas with the exception of mechanical extraction which is inappropriate for Russian olive removal. In such instances mechanical grab and cut-stump removal should be used instead. The primary approach for controlling those Russian olive stands that do not occur near tamarisk infestations will be either hand or mechanical cut-stump removal with herbicide application.

| **Control, Biomass Reduction, & Revegetation Approach** |
|---|
| **Light Infestations along the Mainstem**:<br>Control: Mechanical extraction or grab & cut-stump control for high priority areas. Hand cut-stump control work around valuable vegetation and in inaccessible areas. If proven effective in Southeastern Colorado for remaining tamarisk.<br>Biomass: Mulch for revegetation or stack for wildlife. Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow along channel edges & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |
| **Moderate to Heavy Infestations along the Mainstem:**<br>Control: Mechanical mulching for high priority areas. Hand cut-stump control work around valuable vegetation and in inaccessible areas. Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Mulching or stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow along channel edges & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |
| **Light, Spotty Infestations along the Tributaries**:<br>Control: Hand cut-stump removal where appropriate around valuable vegetation. Bio-control for remaining tamarisk (if proven effective in Southeastern Colorado).<br>Biomass: Stacking for wildlife.<br>Revegetation: Natural revegetation. |

**Purgatoire River northern tributaries, from San Francisco Creek to Nine-Mile Bottom (Hwy 109 intersection) – including tributaries: Luning Arroyo, Van Bremer Arroyo, Bent Canyon, and various washes/arroyos contained in Pinon Canyon Military Reservation and Comanche National Grasslands**

Drawings LA1 to LA6, VBA1 to VBA5, and BC1 to BC2
Photo Log No. N/A
Estimated Acres Infested with Tamarisk – **98 acres**
Estimated Average Tamarisk Density – **30%**

This area is partially contained within the Pinon Canyon Maneuver Site (PCMS) and the Comanche National Grasslands. Generally the upper reaches of washes and arroyos in this section are characterized by shallow, broad stream morphology. In particular, Luning and Van Bremer Arroyos display this character for the vast majority of their 20+ mile reaches. As these two waterways descend the last several miles of their courses, they become more incised and narrow, with steep canyon walls and very limited vehicle access. Lockwood Arroyo is contained within the boundaries of PCMS. The shallow washes in this area possess better vehicle access, except near their terminus as they enter the Purgatoire River canyon. Here they demonstrate a deeper incision and more difficult access.

These washes and arroyos typically have heavier tamarisk infestations at their juncture with the Purgatoire River and become sparse farther upstream. Tamarisk infestation within these washes is generally light, with pockets of infestation confined to either standing water or ephemeral streambanks. Cover from other riparian species in this area is typically light, with native grasses and forbs constituting the majority of upland cover. Small stands of cottonwood and willow do exist in isolated areas, and should be adjusted for accordingly.

Hand cut-stump control should be used in each of these areas starting at the upper extent of infestations and working down to the continuous, dense infestations near the tributaries' confluences with the Purgatoire River. Biological control, if proven effective in Southeastern Colorado, may be active along the mainstem of the Purgatoire River and could adequately control these heavy infestations. Some hand cut-stump work should be used in these areas around stands of valuable vegetation. Biomass for the upper portions of the washes where hand control is performed will be stacked for wildlife habitat. Biomass reduction may be necessary in the lower, denser infestations around valuable vegetation by the Purgatoire River following beetle defoliation. Natural revegetation with native grasses, 4-wing saltbush, and other shrubs and forbs will likely occur in most areas.

The areas necessitating biomass reduction will require revegetation. Native planting requirements will increase proportionately with the density of infestation and extent of ground disturbance. Weed control will be critical for much of this river section to prevent other noxious weeds from filling the void left by tamarisk and Russian olive removal.

| Control, Biomass Reduction, & Revegetation Approach |
|---|
| **Upper Extent of Light Infestations**:<br>Control: Hand cut-stump control work with Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Stack for wildlife where hand cut-stump control is used. Leave standing where Bio-control (If proven effective in Southeastern Colorado) is used. Stack and burn slash piles when conditions permit.<br>Revegetation: Natural revegetation. |
| **Lower, Heavy Infestations at Tributaries' Confluence with the Purgatoire River:**<br>Control: Mostly bio-control for tamarisk control with some hand cut-stump work around stands of valuable vegetation.<br>Biomass: Stack for wildlife where hand cut-stump work is performed. Leave standing following Bio-control (If proven effective in Southeastern Colorado). Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep plantings of native shrubs and grass seed mixes for upland areas. |

**Purgatoire River and southern tributaries, San Francisco Creek to Nine-Mile Bottom (Hwy 109 intersection) – including tributaries: Trinchera Creek, Chacuaco Creek, Plum Creek, Bachicha Creek**

Drawings P13 to P35, TrC1 to TrC2, and ChCr1 to ChCr4
Photo Log No. 11, 12, 13, 14, 15, 98, 100, 25, 28
Estimated Acres Infested with Tamarisk – **3,157 acres**
Estimated Average Tamarisk Density – **30%**

This area contains the mainstem canyon of the Purgatoire River (P35 to P16). Large ranches constitute the majority of landownership in this section. This narrow canyon section greatly restricts access to the river until it broadens slightly as it moves east toward Nine-Mile Bottom (P15 to P13). If proven effective in Southeastern Colorado, biological control should be considered the main control approach for this section. In the narrow canyon of the mainstem, hand cut-stump control methods should be used to protect areas of valuable vegetation. In these locations biomass should be stacked for wildlife habitat and some low maintenance revegetation (i.e. pole plantings of willow and/or cottonwood) may be appropriate. Light, broad infestations in the wider section approaching the floodplain would best be removed with mechanical extractors and grab & cut-stump equipment. Biomass will then be stacked for wildlife habitat or mulched for revegetation purposes depending on the desires of the landowner. Moderate to heavy, broad infestations where biomass reduction is a high priority should be mechanically mulched.

The areas necessitating biomass reduction will require revegetation. Native planting requirements will increase proportionately with the density of infestation and extent of ground disturbance. Weed control will be critical for much of this river section to prevent other noxious weeds from filling the void left by tamarisk and Russian olive removal.

Most of the southern, tributary canyons are characterized by deeply incised, narrow waterways, have little or no vehicle access, and fall within several very large ranches on the southeast side of the Purgatoire River. The canyons are very remote and are home to several rare plant, animal and fish species including leafy goldenweed (*Oonopsis foliosa var. foliosa*), swift fox, mountain plover, and Arkansas darter.

Hand cut-stump control should be used in each of these tributaries starting at the upper extent of infestations and working down to the continuous, dense infestations near the tributaries' confluences with the Purgatoire River. Biological control, if proven effective in Southeastern Colorado, may be active along the mainstem of the Purgatoire River and could adequately control these heavy infestations. Some hand cut-stump work should be used in these areas around stands of valuable vegetation. Biomass for the upper portions of the washes where hand control is performed will be stacked for wildlife habitat. Biomass reduction may be necessary in the lower, denser infestations around valuable vegetation by the Purgatoire River following beetle defoliation. Natural revegetation with native grasses, 4-wing saltbush, and other shrubs and forbs will likely occur in most areas; however, some revegetation and some weed control will be required.

| **Control, Biomass Reduction, & Revegetation Approach** |
| --- |
| **Mainstem – Narrow Canyon:**<br>Control: Hand cut-stump control work around areas of valuable vegetation with Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Stack for wildlife where hand cut-stump control is used. Leave standing where Bio-control (If proven effective in Southeastern Colorado) is used. Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas in areas where hand control is used. Natural revegetation following Bio-control (If proven effective in Southeastern Colorado). |
| **Mainstem – Light Infestations, Broader Floodplain:**<br>Control: Mechanical extraction or grab & cut-stump control for high priority areas. Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Mulch for revegetation or stack for wildlife.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |

| |
|---|
| **Mainstem – Moderate Infestations, Broader Floodplain:**<br>Control: Mechanical mulching for high priority areas. Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Mulching. Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |
| **Tributaries - Upper Extent of Light Infestations**:<br>Control: Hand cut-stump control work with Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Stack for wildlife where hand cut-stump control is used. Leave standing where Bio-control (If proven effective in Southeastern Colorado) is used.<br>Revegetation: Natural revegetation. |
| **Tributaries - Lower, Heavy Infestations at Tributaries' Confluence with the Purgatoire River:**<br>Control: Mostly Bio-control (If proven effective in Southeastern Colorado) for tamarisk control with some hand cut-stump work around stands of valuable vegetation.<br>Biomass: Stack for wildlife where hand cut-stump work is performed. Leave standing following Bio-control (If proven effective in Southeastern Colorado). Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |

## Purgatoire River and Smith Canyon, Nine-Mile Bottom to Arkansas Confluence

Drawings P1 to P13 and AW150 to AW154
Photo Log No. 2187, 2188, 2, 3, 5, 6, 7, 9, 10
Estimated Acres Infested with Tamarisk – **4,254 acres**
Estimated Average Tamarisk Density – **25%**

This area constitutes the opening of the Purgatoire River canyon and its return to meandering, wide floodplain morphology. The level of agricultural use on the lands along and surrounding this reach of the Purgatoire River increases significantly as they approach the Arkansas River. Significant irrigation and infrastructure are characteristic of this area. Consequently, vehicle access to the river and tributaries in this area is generally good. Land ownership in this region consists of smaller private parcels than those of the large ranches upstream.

This area consists of more dense, wide and monotypic stands of tamarisk than any other on the Purgatoire River system. The primary management method for these areas should be biological control (if proven effective in Southeastern Colorado) and/or aerial foliar herbicide spraying. Root plowing and raking would be appropriate for lands needed for agricultural use. No herbicide should be needed for resprouts if biological control is active in the area. Mechanical or hand cut-stump removal should be used in some areas to protect valuable vegetation and to form fire breaks and reduce wildfire damage. Along Hwy 109 and 101, mechanical removal with cut-stump herbicide application or extraction should be used to assure highway safety.

Russian olive, although less abundant than tamarisk, has a significant presence throughout much of this river section. Control will require either hand or mechanical cut-stump approaches with herbicide application as the primary approach in all areas.

Biomass reduction should not be needed for light infestations and some moderate infestations, but should be performed for all other situations to reduce the fuel load in riparian areas. This is especially important to protect the valuable cottonwood galleries in many of these areas as well as native shrubs such as sand sagebrush, fourwing saltbush, and western sandcherry. Mechanical methods are recommended with some hand work required in difficult to access areas. As with other sites, natural biomass decomposition and reduction should occur after biological control has caused a significant mortality in tamarisk.

Areas necessitating biomass reduction will require revegetation. Native planting requirements will increase proportionately with the density of infestation and extent of ground disturbance. Weed control will be critical for much of this river section to prevent other noxious weeds from filling the void left by tamarisk and Russian olive removal.

| Control, Biomass Reduction, & Revegetation Approach |
|---|
| **Heavy Infestations in the Floodplain:**<br>Control: Aerial herbicide, Bio-control (If proven effective in Southeastern Colorado), and root plow and rake.<br>Biomass: Mulch, controlled burn, or stack for wildlife (if land is to be used for agriculture). Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |
| **Light to Moderate Infestations in the Floodplain:**<br>Control: Hand cut-stump control, mechanical extraction, or grab & cut-stump control for high priority areas. Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Mulch for revegetation or stack for wildlife. Stack and burn slash piles when conditions permit.<br>Revegetation: Pole plantings of cottonwood & willow & tall-pot, deep planting of native shrubs and grass seed mixes for upland areas. |
| **Along Highways 109 & 101:**<br>Control: Mechanical removal with grab & cut-stump or extraction. Bio-control (If proven effective in Southeastern Colorado) for remaining tamarisk.<br>Biomass: Mulching for revegetation. Stack and burn slash piles when conditions permit.<br>Revegetation: Native shrubs and grass seed mixes. |

# Section 2 – Implementation

The TTP plan up to this point (Section 1 – Background) has outlined the background of the TTP planning process, the general nature of the problem, important governmental actions, the site-specific problem in the study area, the natural resource impacts to water and wildlife habitat, recommended restoration approaches, and costs associated with those control and revegetation actions. **Section 2 – Implementation** now lays out a specific "path forward" for implementing the plan including a specific set of "actions" to facilitate success. These discussions include:

1. Working with landowners
2. Education, outreach, and volunteerism
3. Research needs
4. Active restoration initiatives
5. Long-term sustainability

## Working with Landowners

TTP's main objective is to restore riparian lands within the Purgatoire River's watershed that have been degraded by woody invasive plants, principally tamarisk and Russian olive. To successfully implement these restoration actions, each landowner's property rights must be respected to ensure that 1) the landowner is included in restoration decision-making and that 2) efforts coordinate with the landowner's specific objectives for the land. Property interest stakeholders include public entities (federal, state, county, and local communities), legal subdivisions of the state (e.g., sanitation districts, drainage districts), private landowners, non-profits (e.g., Colorado Cattleman's Agricultural Land Trust), commercial and industrial interests (e.g., Colorado Interstate Gas Co.).

Because noxious weed control and riparian restoration are not normal components of most of these landowner activities, assistance is often needed to identify funding opportunities, apply for grants, and to administer grants. There is no precedence for who should be the lead for each situation; however, the following provides some general guidance for the partners in TTP:

- ✓ For private agricultural producers, the conservation districts are the most appropriate organizations to manage many of these grants, especially those grants from the USDA. The Colorado Association of Conservation Districts, located in Grand Junction, is a good resource to assist the local conservation districts in becoming significant partners with landowners and restoration activities.

- ✓ Counties and non-profits (e.g., The Nature Conservancy) can assist in acquiring grants for all entities, even for work on federal lands through some grant programs (e.g., National Fish and Wildlife Foundation).
- ✓ Each entity can pursue its own grant opportunities for the land that it manages.

A concern of the partners in TTP is that without coordination between all these entities, there will be undue competition for the same funds; entities will not be aware of all of the funding resources available; and/or there will be inefficiency in using funds that are acquired. To resolve this concern, the following action is recommended.

**Action #1**
County weed managers along with local conservation organizations such as conservation districts, RC&D's, and the CO Association of Conservation Districts; major federal natural resource management agencies such as the NRCS, USFS, and USBOR; major state natural resource management agencies such as the CO State Forest Service, CO Division of Wildlife, and CO State Parks; and NGO's such as The Nature Conservancy, and the Tamarisk Coalition should develop the following:

a) Develop or locate a GIS dataset of land ownership for the riparian corridor impacted by the target invasive species.

b) Establish a simple clearinghouse system to inform all parties of grant opportunities. A list of grant opportunities was placed on the Tamarisk Coalition website ( www.tamariskcoalition.org ) in the summer of 2007.

c) Create a prioritization system that could be used to screen grants and appropriate locations for restoration work. An example is provided in Appendix F.

d) Develop a communication system that informs county weed managers of all projects being conducted.

## Education, Outreach, and Volunteerism

Gaining public support requires providing factual information that describes the problem and the solutions being initiated. Important information for public understanding includes all aspects of the tamarisk and Russian olive problem; control approaches that will be used with significant emphasis on the biological control component; how things will look differently over the next 10 years; as well as revegetation, biomass removal, monitoring, and long-term maintenance.

**The overarching theme is RESTORATION not just tamarisk or Russian olive control.**

**Action #2**
Outreach expertise from counties, USFS Comanche National Grassland, CO State Parks, CO State Land Board, CO State Forest Service, National Park Service, The Nature Conservancy and the Tamarisk Coalition could be used to develop materials appropriate for the community and visitors to the area. Some of the key elements of the program may include:

- ✓ A "frequently asked questions" brochure that will help local communities and visitors understand the following: 1) What tamarisk is, where it came from, why it is a problem, and tamarisk control methods; 2) How biological control works, what to expect, monitoring of changes, etc.; 3) What will replace the tamarisk, how the process will affect wildlife; 4) Who will implement these projects and how will they be funded?

- ✓ Brochures for distribution through the NPS and USFS visitor centers, Colorado state parks, CDOW State Wildlife Areas, etc.

- ✓ Fact sheets on tamarisk ecology, biological control, herbicide usage and safety, etc.

- ✓ Display boards with historical photos can be utilized to compare past and present conditions to give a perspective on the problem.

- ✓ Information booths at local events, festivals, etc.

- ✓ Presentations to service groups such as Lions, Rotary, and Chamber of Commerce.

- ✓ Demonstration sites that can be used for tours.

[Note: the Tamarisk Coalition is currently developing many of these components with support from others.]

**Volunteer Program –** An important aspect of education is gaining public support for tamarisk and Russian olive control and revegetation to improve the ecosystem of the TTP study area. One way of achieving this is through volunteer programs. A number of groups in Colorado have done some excellent work using volunteers for riparian restoration. These include: Trinidad State Park, Boggsville National Historic Site, Roaring Fork Outdoor Volunteers at the I-70 Rifle Rest Stop, Audubon Society at Connected Lakes State Park, Eagle County tamarisk removal program, Volunteers for Outdoor Colorado, North Fork River Improvement Association, The Nature Conservancy, and the BLM/Tamarisk Coalition partnership in the McInnis Canyons National Conservation Area (see

Figure 8). By participating in these programs, people gain first-hand experience and an appreciation of ecosystem restoration. The volunteer education effort would include information concerning how and where to get involved as an individual or an organization.

**Action #3**
The volunteer groups identified above and TTP partners should work together to 1) develop a volunteer "lessons learned" pamphlet that can be used by others to develop their own volunteer program (a starter "cookbook"), 2) identify good volunteer projects, and 3) pool resources for volunteer projects.

Figure 3: Trinidad State Park has been working for the past five years at the top of the Purgatoire River watershed to control tamarisk. They have employed the use of volunteers and have received grant funding to employ the services of the Colorado Youth Corps as well. As of 2008, the majority of tamarisk at Trinidad State Park is under control. Trinidad State Park is a very active TTP coalition partner.

## Long-term Sustainability

Long-term sustainability of the restored riparian lands is a function of a good monitoring and maintenance program. To reiterate from previous discussions, "monitoring" is the act of observing changes that are occurring with, or without, remediation actions. The purpose of monitoring is to provide information for making informed decisions to ensure "maintenance" will maintain, remediate, and improve the ecological processes of the watershed. For tamarisk and Russian olive restoration these measures are important for effective control on a long-term basis and to ensure that the desired outcomes of revegetation and prevention of other noxious weed infestations are successful.

The questions that must be addressed for the entire Purgatoire River watershed are – ***Who should perform monitoring and maintenance? Do they have the legal responsibility for these actions? Do they have the necessary funding to carry out these responsibilities?*** These are complicated questions because there are multiple jurisdictions (i.e., federal, state, county, and local) and there are multiple land ownerships (i.e., private, industry, non-profit organizations, community, county, state, and federal). To be successful, an organized, collaborative approach must be found.

**Action Item #4**

It is clear that if resources are spent only on control and revegetation with no cohesive approach to long-term monitoring and maintenance, the potential for successful riparian restoration is limited. Therefore, the following recommendation is made to establish a workable long-term monitoring and maintenance program:

1. A working group must be initiated to formulate a set of solutions and policies for long-term monitoring and maintenance for the entire Purgatoire River system. It is recommended that the working group be co-chaired by the Colorado Department of Agriculture and the Colorado Department of Natural Resources. These two agencies are appropriate to lead this effort because their main responsibilities are to protect our natural resources and they work closely with the agricultural community.

2. The working group may include, but not be limited to, representatives from:
   - ✓ Colorado Association of Conservation Districts
   - ✓ Colorado Department of Local Affairs
   - ✓ Colorado Division of Wildlife
   - ✓ Colorado State Forest Service
   - ✓ Colorado State University
   - ✓ County weed management departments (the areas within the watershed with most of the infestations)
   - ✓ CSU Cooperative Extension
   - ✓ Local Conservation Districts
   - ✓ National Park Service
   - ✓ Purgatoire River Water Conservancy District
   - ✓ State representatives to the House and Senate
   - ✓ Tamarisk Coalition
   - ✓ The Nature Conservancy
   - ✓ USDA Natural Resource Conservation Service
   - ✓ US Forest Service

3. Within a few years of implementing the strategic plan a consensus plan should be produced to implement a long-term monitoring and maintenance program describing the technical, political, and financial steps for tamarisk control implementation and responsible entities.

This will be no easy task, but it is the critical element for successful riparian restoration and should be dealt with seriously. If a workable long-term monitoring and maintenance program for the Purgatoire River is successfully formulated, this would be truly landmark work. It would lay the groundwork for tackling this prickly issue and would be an excellent example for other watersheds to use.

## Research Needs

There are a number of research activities that can improve the success, effectiveness, and efficiency of restoration for the TTP study area. The Purgatoire River watershed also offers special opportunities to better understand tamarisk and Russian olive impacts to water resources and wildlife habitat as well as restoration responses. By intertwining restoration with research there is greater appeal to some funding sources to provide grants (e.g., new federal legislation under P.L. 109-320 in Appendix B). The following are current research interests at the university and federal research levels:

- ✓ Releasing and monitoring a new biological control agent ecotype that is adapted to the lower latitudes of the eastern release could offer crucial insight into the widespread success of bio-control.
- ✓ The University of Denver (DU) has developed a "Best Management Practices" handbook for tamarisk control will complete a similar handbook for revegetation in the summer of 2008.
- ✓ DU has an active riparian restoration program that includes field work to develop practical solutions for undergraduate and graduate students.
- ✓ CSU is devoting approximately $1,000,000 over the next five years for tamarisk research efforts.
- ✓ Bureau of Reclamation scientists in Denver are developing more effective measures to improve revegetation success.

**Action #5**
A working group should be established to collaborate with these institutes to identify specific research needs for the area, to utilize their research skills, and to ensure information sharing in the watershed and with other planning efforts.

## Active Restoration Activities

**Action #6**
The partners of TTP will work together to continue to support and leverage existing projects to gain additional funding resources. An example will be funding derived from federal legislation PL 109-320. An active Grants and Projects Committee will be established in the watershed to focus on grant opportunities and to communicate progress for active projects. The key to successful implementation on any of the proposed restoration strategies,

education, research, outreach, etc. is funding to sustain the activity. A list of grant opportunities that are available for tamarisk related issues is available from the Tamarisk Coalition. For further information the reader is encouraged to visit the funding source's website and contact the funding source directly.

Table 6 provides a summary of all the action items that have been developed, responsibilities for carrying out the action or organizing a working group to complete the action, and a schedule for accomplishing the action.

Table 2: Actions, Lead Responsibility, and Time Line.

| Action | Lead Responsibility | Time Line |
|---|---|---|
| **#1: Working with landowners:** GIS database, clearinghouse, prioritization, and communications. | TTP Co-leaders: TNC, CSFS. As well as TC. | On-going—Project dependent |
| **#2 and #3: Education, Outreach, & Volunteerism** | TTP Education and Outreach Team | Most educational materials will hopefully be completed and distribution will begin by 2010 |
| **#4: Long-term Sustainability** | All TTP Partners | On-going for the life of the project. |
| **#5: Research Needs** | TTP Science and Technology Team | On-going—Research needs will be determined on a site by site basis. Different projects will lend themselves to different research needs. |
| **#6: Restoration Activities** | TTP Science and Tech. Team | On-going—project dependent. Different projects will lend themselves to specific restoration needs and activities. |

# Definitions

**Adaptive management** is a natural resources management process under which planning, implementation, monitoring, research, evaluation, and incorporation of new knowledge are combined into a management approach that 1) is based on scientific findings and the needs of society, 2) treats management actions as experiments, 3) acknowledges the complexity of these systems and scientific uncertainty, and 4) uses the resulting new knowledge to modify future management methods and policy.

**Basal bark herbicide application** refers to the application of herbicide to the smooth bark at the base of a plant.

**Biodiversity** refers to biological diversity in an environment as indicated by numbers of different species of plants and animals.

**Biological control** is the use of specific organisms to control an undesirable organism.

**Collaboration** means involving all affected stakeholders in a set of decisions that guide the action, support, and evaluation of ecological rehabilitation and maintenance.

**Coordination** means making sure that those involved are aware of what other related activity is taking place. Coordination helps to maximize the efficient use of resources, promote consistency in process and standards where appropriate, and sequence efforts to achieve the greatest impact.

**Disturbance regimes** are the range of events, natural to an ecosystem, that temporarily change the structure and function of the systems, such as wildfire, drought, floods and insect or disease outbreak, to which the system is adapted.

**Ecological processes** refer to the natural cycles, disturbances and interactions of all parts of an ecosystem, such as nutrient and mineral cycles, fire or flood incidence, and species interactions.

**Ecological restoration** refers to a broad framework of activities for returning ecosystems to healthy functioning conditions. Ecological restoration activities are based on specific landscapes and objectives, and should incorporate past experience as a guide to sustainable futures. These activities include, but are not limited to: reducing overly-dense woody vegetation, re-establishing native vegetation, repairing erosion and soil condition, restoring hydrological function, and monitoring all these activities for effective long-term maintenance.

**Ecosystem** is a community of organisms interacting with one another and with the chemical and physical factors of their environment. In Colorado, the pinyon-juniper forest is an example of an ecosystem.

**Economies** in Colorado take many forms, and include those that are amenity-based, such as tourism, recreation, real estate and others; product-based, which refer to forest products, mining and other extractive industries; as well as those that are agriculturally based such as farming and ranching.

**Ephemeral streams** are streams that flow only during or immediately after periods of precipitation.

**Evapotranspiration** is the combined diffusion of water vapor into the atmosphere from transpiration from plants and evaporation from soil and water surfaces.

**Floodplain terraces** are the lands outside the riparian zone but within the floodplain that support~~s~~ native phreatophytes. Terraces are generally supportive of xeric and mesic types of vegetation.

**Foliar herbicide application** refers to the application of herbicide to the leaves of a plant usually through a spray.

**Forb** is a small, herbaceous (non-woody), broad-leaved vascular plant (excluding grasses, rushes, sedges, etc.). For example, wild flowers are a type of forb.

**Health** refers to a condition where the system's parts and functions are sustained over time and where the capacity for ecological self-repair is maintained within a natural range of variability, allowing goals for sustainable uses, values and services to be met.

**Hydrologic cycle** describes the continuum of the transfer of water from precipitation to surface water and ground water, to storage and runoff, and to the eventual return to the atmosphere by transpiration and evaporation.

**Hydrologic processes** refer to that part of the hydrologic cycle that includes the amount and timing of stream flow, which in turn influences ecological functions in the stream corridor.

**Implementation** refers to the development of teams and specific action items to address the recommendations of this Plan as well as efforts to initiate "on-the-ground efforts."

**Integration** means considering the other initiatives taking place as well as the impacts of these on the larger ecosystem over the long term, and having this consideration inform the effort.

**Landscape** means a spatial mosaic of several ecosystems, landforms, watersheds and plant communities that are repeated in similar form across a defined area irrespective of ownership or other artificial boundaries.

**Mesic** vegetation consists of plants that utilize soil moisture that is more readily available than would be present in upland drier soils.
**Partners** are considered to be all State, federal, local, non-governmental, individuals, industry, or private entities that cooperate in TTP.

**Phreatophyte** refers to a deep-rooted plant that obtains its water from the water table or the layer of soil just above it.

**Restoration** is the reestablishment of the structure and function of ecosystems. It involves the recovery of ecosystem functions and processes in a degraded habitat. The restoration process reestablishes the general structure, function, and dynamic but self-sustaining behavior of a system as closely as possible to pre-disturbance conditions and functions while respecting private property rights, state water law, existing infrastructure, and endangered species considerations.

**Riparian Zone** is the geographically delineated area with distinct resource values that occur adjacent to rivers, streams, lakes, ponds, wetlands, and other water bodies. Typical vegetation in the TTP study area includes grasses, cottonwoods, willows, and forbes.

**State** refers to Colorado state government and its agencies.

**Stream Morphology** refers to the study of the channel pattern and the channel geometry at several points along a river channel, including the network of tributaries within the drainage basin.

**Sustainable** refers to a level of human use of a natural resource that can continue through time without diminishing the resource's productivity or resilience.

**Watershed** refers to a region or land area that is drained by a single stream, river or drainage network, and includes all of the land within the entire drainage area. The Colorado River is an example of a large watershed. An example of a smaller watersheds within the larger watershed is the San Francisco Creek drainage.

**Xeric** vegetation represents plants that are adapted to a dry environment.

# References

Baum, B. R. 1978. The Genus Tamarix. Israel Academy of Sciences and Humanities, Jerusalem. 209 pp.

Bawazir, A.S., New Mexico State University, Personal communication, April 2003.

Bean, D. Director Palisade Insectary, Personal communication, March, 2007

Belcher, E. W. and R. P. Karrrfalt. 1979. Improved methods for testing the viability of Russian olive seed. Journal of Seed Technology 4:57-64.

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream
and riparian ecosystems in the Western United States. Journal of Soil and Water Conservation.

Borell, A. E. 1962. Russian-olive for wildlife and other conservation uses. U.S. Department of Agriculture, Washington, DC, USA. Leafet No. 517.

Brown, C.R. 1990. Avian use of native and exotic riparian habitats on the Snake River, Idaho. M.S. Thesis. Colorado State Univ., Fort Collins, CO. pp. 60.

Busch, D. E., and S. D. Smith. 1993. Effects of fire on water and salinity relations of riparian woody taxa. *Oecologia* 94:186-194.

Busch, D. E., and S. D. Smith. 1995. Mechanisms associated with decline of woody species in riparian ecosystems of the Southwestern US. *Ecological Monographs* 65: 347-370.

Busch, D. E., N. L. Ingraham, and S. D. Smith. 1992. Water-uptake in woody riparian phreatophytes of the southwestern United States: a stable isotope study. *Ecological Applications* 2: 450-459.

Caplan, T. 2002. Controlling Russian olives within cottonwood gallery forests along the Middle Rio Grande floodplain (New Mexico). Ecological Restoration 20(2): 138-139.

Carman, J.G., and J.D. Brotherson. 1982. Comparison of sites infested and not infested with saltceder (*Tamarix pentandra*) and Russian-olive (*Elaeagnus angustifolia*). Weed Sci. 10:360-364.

Carpenter, A. 1998. Element Stewardship Abstract for *Tamarix ramosissima* Lebedour, *Tamarix pentandra* Pallas, *Tamarix chinensis* Loureiro, and *Tamarix parviflora* De Candolle. The Nature Conservancy, Arlington, Virginia.

Chaney, E., W. Elmore, and W.S. Platts. 1990. Livestock grazing on western riparian
areas. Northwest Resources Information Center, Inc. Eagle Idaho.

Cleverly, J. R., S. D. Smith, A. Sala, and D. A. Devitt. 1997. Invasive capacity of *Tamarix-ramosissima* in a Mojave desert floodplain : the role of drought. *Oecologia* 111: 12-18.

Décamps, H., A.M. Planty-Tabacchi, and E. Tabacchi. 1995. Changes in the hydrological regime and invasions by plant species along riparian systems of the Adour river, France. Regulated Rivers: Research & Management, 11:23-33.

DeLoach, J. 1997. Effects of Biological Control of Saltcedar (Tamarix ramosissima) on Endangered Species: Biological Assessment. U.S. Department of Agriculture, Temple, Texas.

DeLoach, J., R Carruthers, J. Lovich, T. Dudley, and S. Smith, 2000. "Ecological Interactions in the Biological Control of Saltcedar (*Tamarix spp.*) in the United States: Toward a New Understanding." Proceedings of the X International Symposium on Biological Control of Weeds, 4-14 July 1999, Montana State University, Bozeman, Montana.

DeLoach, J., R Carruthers, J. Lovich, T. Dudley, and S. Smith, 2002. "Ecological Interactions in the Biological Control of Saltcedar (*Tamarix spp.*) in the United States: Toward a New Understanding" – Revised.

Ebinger, J. and L. Lehnen. 1981. Naturalized autumn olive in Illinois. Transactions of the Illinois State Academy of Science 74: 83-85.

Ellis, L. M. 1995. Bird use of salt cedar and cottonwood vegetation in the middle Rio Grande valley of New Mexico, USA. Journal of Arid Environments 30:339-349.

Gaskin, John F. 2002. Hybrid *Tamarix* widespread in U.S. invasion and undetected in native Asian range. Proceedings of the National Academy of Sciences of the United States of America 99. no. 17: 11256-11259.

Gaskin, J.F. and B. A. Schaal. 2002. Hybrid Tamarix widespread in US invasion and undetected in native Asian range.

Graf, W.L. 1978. Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region. Geological Society of America Bulletin 89 :1491-1501.

Haber, E. 1999. Invasive Exotic Plants of Canada Fact Sheet No.14: Russian-olive. National Botanical Services, Ottawa, ON, Canada.

Hansen, N. E. 1901. Ornamentals for South Dakota. U.S. Experiment Station, Brookings, SD, USA. Bulletin 72.

Hayes, B. 1976. Planting the *Elaeagnus* Russian and autumn olive for nectar. American Bee Journal 116:74,82.

Horton, J. S., F. C. Mounts, and J. M. Kraft. 1960. Seed germination and seedling establishment of phreatophyte species. U.S. Department of Agriculture, Rocky mountain Forest and Range Experiment Station, Fort Collins, Colorado. Paper No. 48. 26 pp.

Hogue, E. J. and L. J. LaCroix. 1970. Seed dormancy of Russian olive (*Elaeagnus angustifolia* L.). Journal of the American Society of Horticultural Science 95:449-452.

Howe, W.H. and F.L. Knopf. 1991. On the imminent decline of Rio Grande cottonwoods in central New Mexico. The Southwestern Naturalist 36:218-224.

Katz, G. L. 2001. Fluvial Disturbance, flood control, and biological invasion in Great Plains riparian forests. Ph.D. Dissertation. University of Colorado, Boulder, CO, USA.

Katz, G.L., and P.B. Shafroth. 2003. Biology, ecology and management of Elaeagnus angustifolia L. (Russian olive) in western North America. Wetlands 23(4): 763-777.

King, J.P. and Bawazir, S.A. 2000. Riparian Evaporation Studies of the Middle Rio Grande. Technical Completion report, U.S. Bureau of Reclamation.

Kolb, Thomas E. 2001 "Water Use of Tamarisk and Native Riparian Trees." Proceedings of the Tamarisk Symposium, September 26 – 27, 2001, Grand Junction, Colorado.

Knopf, F.L., and T.E. Olson. 1984. Naturalization of Russian-olive; implications to Rocky Mountain wildlife. Wildl. Soc. Bul. 12: 289-298.

Lesica, P. and S. Miles 1999. Russian olive invasion into cottonwood forests along a regulated river in north-central Montana. Canadian Journal of Botany 77: 1077-1083.

Little, E. L. 1961. Sixty trees from foreign lands. U. S. Department of Agriculture, Washington, DC, USA. Agricultural Handbook No. 212.

Lonsdale, W. M. 1993. Rates of spread of an invading species *Mimosa pigra* in northern Australia. J. of Ecology 81:513-521.

McDaniel, K.C., DiTomaso, J.M., Duncan, C.A. 2004. *Tamarisk or Saltcedar (Tamarix spp.)* Galley proof for Allen Press.

Muzika, R.-M. and J.M. Swearingen. 1998. Russian-olive (*Elaeagnus angustifolia L.*). PCA Alien Plant Working Group. (http://www.nps.gov/plants/alien/fact/elan1.htm).

National Invasive Species Council, Tamarisk Economics Impact Study, in progress – January 2006.

Ohmart, R.D. 1996. Historical and present impacts of livestock grazing on fish and
wildlife resources in western riparian habitats. Pages 245-279 In: Krausman, P.R. (ed.).
1996. Range wildlife. Society for Range Management, Denver, CO.

Olson, T.E. and F.L. Knopf. 1986. Agency subsidization of a rapidly spreading exotic. Wildlife Society Bulletin: 492-493.

Robinson, T. W. 1965. Introduction, spread, and aerial extent of salt cedar (*Tamarix*) in the western states. Geological survey professional paper 491-A. United States Government Printing Office, Washington.

Shafroth, P.B, J.M. Friedman, and L.S. Ischinger. 1995. Effects of salinity on establishment of *Populus fremontii* (cottonwood) and *Tamarix ramosissima* (salt cedar) in southwestern United States. Great Basin Naturalist 55:58-65.

Shafroth, P.B., G.T. Auble, J.C. Stromberg, and D.T. Patten. 1998. Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona. Wetlands 18:577-590.

Shafroth, P. B., G. T. Auble, and M. L. Scott. 1995. Germination and establishment of native plains cottonwood (*Populus deltoids* Marshall subsp. *Monilifera*) and the exotic Russian-olive (*Elaeagns angustifolia*). Conservation Biology 9:169-175.

Sher, A. A. and D. L. Marshall. 2003. Competition between native *Populus deltoides* and invasive *Tamarix ramosissima* and the implications of reestablishing flooding disturbance. Conservation Biology 14:1744-1754.

Sher, A. A., D. L. Marshall, and S. A. Gilbert. 2000. Competition between native Populus deltoides and invasive Tamarix ramosissima and the implications for reestablishing flooding disturbance. *Conservation Biology* 14:1744.

Sher, A.A., Marshall, D.L., and Taylor, J.P. 2002. Establishment patterns of native *Populus* and *Salix* in the presence of invasive, non-native *Tamarix*. *Ecological Applications* 12: 760-772.

Shishkin, B. K. (ed.). 1949. Flora of the U.S.S.R. Institute of the Academy of Sciences of the U.S.S.R., Moscow, USSR.

Smith, S.D., D. A. Devitt, A. Sala, J. R. Cleverly, and D. E. Busch. 1998. Water relations of riparian plants from warm desert regions. *Wetlands* 18: 687-696.

Springuel, I.; M Sheded, and K.J. Murphy. 1997. The plant biodiversity of the Wadi Allaqi Biosphere Reserve (Egypt): Impact of Lake Nasser on a desert Wadi ecosystem. Biodiversity and Conservation 6:1259-1275.

Sternberg, G. 1996. *Elaeagnus umbellata*. P. 54. *in* J. M. Randall and J. Marinelli (eds.) Invasive Plants: Weeds of the Global Garden. Brooklyn Botanic Garden, Brooklyn, NY, USA.

Stromberg, J. 1998. Dynamics of Fremont cottonwood (*Populus fremontii*) and salt cedar (*Tamarix chinensis*) populations along the San Pedro River, Arizona. *Journal of Arid Environments* 40: 133-155.

Stromberg, J. C., R. Tiller, and B. Richter. 1996. Effects of groundwater decline on riparian vegetation of semiarid regions: The San Pedro, Arizona. *Ecological Applications* 6:113-131.

Taylor, J. P, D. B. Wester, and L.M. Smith. 1999. Soil disturbance, flood management, and riparian woody plant establishment in the Rio Grande floodplain. *Wetlands* 19:372-382.

Tesky, J.L. 1992. *Elaeagnus angustifolia*. *In*: USDA, Forest Service, Rocky Mountain Res. Sta., Fire Sci Lab. (2001, July). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/.

Tu, M. 2003. Element Stewardship Abstract for *Elaeagnus angustifolia* L., Russian olive, oleaster. The Nature Conservancy. (http://tncweeds.ucdavis.edu/esadocs/documnts/elaeang.html).

US Department of Energy, 2005. “Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah, Final Environmental Impact Statement.” July 2005.

USDI-BOR 1995. “Vegetation Management Study: Lower Colorado River, Phase II.” U.S. Department of Interior, Bureau of Reclamation, Lower Colorado River, Draft Report, Boulder City, Nevada.

USDA. 1974. Seeds of wood plants in the United States. USDA Agr. Handbook No. 450.

USDA. 2002. Technical Notes: Plant Materials No. 47. History, Biology, Ecology, Suppression and Revegetation of Russian-Olive Sites (*Elaeagnus angustifolia* L.). Available: http://www.usgs.nau.edu/SWEPIC/factsheets/ELAN.APRS.pdf.

US Fish and Wildlife Service, 2005. "Designation of Critical Habitat for the Southwestern Willow Flycatcher (*Empidonax trailli extimus*); Final Rule", Federal Register (50 CFR Part 17), October 19, 2005.

Weeks, E., H. Weaver, G. Campbell and B. Tanner, 1987. Water use by saltcedar and by replacement vegetation in the Pecos River floodplain between Acme and Artesia, New Mexico. U.S. Geological Survey, Reston, Virginia.

Zimmerman, J. 1997. Ecology and Distribution of *Tamarix chinensis* Lour and *T. parviflora* D.C., *Tamariccea*. Southwest Exotic Plant Mapping Program, U.S. Geological Survey.

# Appendix A

## Executive Order D 002 03
## Directing State Agencies to Coordinate Efforts for the Eradication of Tamarisk on State Lands

Pursuant to the authority vested in the Office of the Governor of the State of Colorado, I, Bill Owens, Governor of the State of Colorado, hereby issue this Executive Order directing the Colorado Department of Natural Resources, in consultation and cooperation with other appropriate state and federal agencies, to coordinate efforts to eradicate the tamarisk plant on public lands.

1. Background and Purpose:

The State of Colorado, like the rest of the Western United States, faces the immense challenge of dealing with noxious weeds that cause harm to the ecosystem. The most destructive non-native invasive species in Colorado is the tamarisk plant, also known as saltcedar.

Tamarisk is rapidly spreading throughout Colorado and the surrounding region. Efforts to control this aggressive plant species have been unsuccessful. It is now estimated that the plant has overcome native species on 1.5 million acres throughout the region and it is has become apparent that the plant is causing serious ecological and environmental problems within the State of Colorado.

The tamarisk plant consumes an enormous amount of water. A single tamarisk tree can transpire up to 300 gallons of water per day. As a comparison, an average acre of native cottonwood trees uses 845,000 gallons of water per year, while an acre of tamarisk uses 1.3 million gallons of water per year. An accumulation of tamarisk plants close to a watershed can effectively limit or dry up an entire water source. The disproportionate consumption of water by a non-native invasive species is cause for serious concern for Colorado as it continues to endure one of the worst droughts in state history.

In addition, tamarisk species are inedible to most animals. As a result, wildlife over browse the surviving native plant species, further speeding the tamarisk invasion process. Finally, tamarisk trees produce extremely flammable leaf litter which promotes the incidence of wildfire.

Given the devastating effect of this non-native species, I am directing state agencies to take appropriate measures to eradicate tamarisk on public lands.

2. Mission

I hereby direct the Department of Natural Resources, the Department of Agriculture and any other state agency that may prove helpful with this project, to take measures necessary to eradicate tamarisk on public lands within ten years of this Executive Order.

State agencies participating in this project shall designate a point of contact to coordinate tamarisk assessment and removal efforts, and to identify necessary funding sources.

The Department of Natural Resources shall coordinate these efforts and, within one year of the effective date of this order, shall submit a report to the Governor's Office outlining a viable plan to achieve the eradication of tamarisk in Colorado within ten years.

3. Duration

This Executive Order shall remain in effect until modified or rescinded by Executive Order.

GIVEN under my hand and the
Executive Seal of the State of
Colorado, this 8th day of
January, 2003.
Bill Owens
Governor

# Appendix B

H. R. 2720 (Public Law 109-320)

# One Hundred Ninth Congress of the United States of America

**AT THE SECOND SESSION**

***Begun and held at the City of Washington on Tuesday, the third day of January, two thousand and six***

*An Act*

To further the purposes of the Reclamation Projects Authorization and Adjustment Act of 1992 by directing the Secretary of the Interior, acting through the Commissioner of Reclamation, to carry out an assessment and demonstration program to control salt cedar and Russian olive, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

**SECTION 1. SHORT TITLE.**

This Act may be cited as the ‘‘Salt Cedar and Russian Olive Control Demonstration Act’’.

**SEC. 2. SALT CEDAR AND RUSSIAN OLIVE CONTROL DEMONSTRATION PROGRAM.**

(a) ESTABLISHMENT.—The Secretary of the Interior (referred to in this Act as the ‘‘Secretary’’), acting through the Commissioner of Reclamation and the Director of the United States Geological Survey and in cooperation with the Secretary of Agriculture and the Secretary of Defense, shall carry out a salt cedar (Tamarix spp) and Russian olive (Elaeagnus angustifolia) assessment and demonstration program—

(1) to assess the extent of the infestation by salt cedar and Russian olive trees in the western United States;

(2) to demonstrate strategic solutions for—

(A) the long-term management of salt cedar and Russian olive trees; and

(B) the reestablishment of native vegetation; and

(3) to assess economic means to dispose of biomass created as a result of removal of salt cedar and Russian olive trees.

(b) MEMORANDUM OF UNDERSTANDING.—As soon as practicable after the date of enactment of this Act, the Secretary and the Secretary of Agriculture shall enter into a memorandum of understanding providing for the administration of the program established under subsection (a).

(c) ASSESSMENT.—

(1) IN GENERAL.—Not later than 1 year after the date on which funds are made available to carry out this Act, the Secretary shall complete an assessment of the extent of salt cedar and Russian olive infestation on public and private land in the western United States.

(2) REQUIREMENTS.—In addition to describing the acreage of and severity of infestation by salt cedar and Russian olive trees in the western United States, the assessment shall—

(A) consider existing research on methods to control salt cedar and Russian olive trees;

(B) consider the feasibility of reducing water consumption by salt cedar and Russian olive trees;

(C) consider methods of and challenges associated with the revegetation or restoration of infested land; and

(D) estimate the costs of destruction of salt cedar and Russian olive trees, related biomass removal, and revegetation or restoration and maintenance of the infested land.

(3) REPORT.—

(A) IN GENERAL.—The Secretary shall submit to the Committee on Energy and Natural Resources and the Committee on Agriculture, Nutrition, and Forestry of the Senate and the Committee on Resources and the Committee on Agriculture of the House of Representatives a report that includes the results of the assessment conducted under paragraph (1).

(B) CONTENTS.—The report submitted under subparagraph (A) shall identify—

(i) long-term management and funding strategies identified under subsection (d) that could be implemented by Federal, State, tribal, and private land managers and owners to address the infestation by salt cedar and Russian olive;

(ii) any deficiencies in the assessment or areas for additional study; and

(iii) any field demonstrations that would be useful in the effort to control salt cedar and Russian olive.

(d) LONG-TERM MANAGEMENT STRATEGIES.—

(1) IN GENERAL.—The Secretary shall identify and document long-term management and funding strategies that—

(A) could be implemented by Federal, State, tribal, and private land managers in addressing infestation by salt cedar and Russian olive trees; and

(B) should be tested as components of demonstration projects under subsection (e).

(2) GRANTS.—

(A) IN GENERAL.—The Secretary may provide grants to eligible entities to provide technical experience, support, and recommendations relating to

the identification and documentation of long-term management and funding strategies under paragraph (1).
(B) ELIGIBLE ENTITIES.—Institutions of higher education and nonprofit organizations with an established background and expertise in the public policy issues associated with the control of salt cedar and Russian olive trees shall be eligible for a grant under subparagraph (A).
(C) MINIMUM AMOUNT.—The amount of a grant provided under subparagraph (A) shall be not less than $250,000.

(e) DEMONSTRATION PROJECTS.—
(1) IN GENERAL.—Not later than 180 days after the date on which funds are made available to carry out this Act, the Secretary shall establish a program that selects and funds not less than 5 projects proposed by and implemented in collaboration with Federal agencies, units of State and local government, national laboratories, Indian tribes, institutions of higher education, individuals, organizations, or soil and water conservation districts to demonstrate and evaluate the most effective methods of controlling salt cedar and Russian olive trees.
(2) PROJECT REQUIREMENTS.—The demonstration projects under paragraph (1) shall—
(A) be carried out over a time period and to a scale designed to fully assess long-term management strategies;
(B) implement salt cedar or Russian olive tree control using 1 or more methods for each project in order to assess the full range of control methods, including—
(i) airborne application of herbicides;
(ii) mechanical removal; and
(iii) biocontrol methods, such as the use of goats or insects;
(C) individually or in conjunction with other demonstration projects, assess the effects of and obstacles to combining multiple control methods and determine optimal combinations of control methods;
(D) assess soil conditions resulting from salt cedar and Russian olive tree infestation and means to revitalize soils;
(E) define and implement appropriate final vegetative states and optimal revegetation methods, with preference for self-maintaining vegetative states and native vegetation, and taking into consideration downstream impacts, wildfire potential, and water savings;
(F) identify methods for preventing the regrowth and reintroduction of salt cedar and Russian olive trees;
(G) monitor and document any water savings from the control of salt cedar and Russian olive trees, including impacts to both groundwater and surface water;
(H) assess wildfire activity and management strategies;
(I) assess changes in wildlife habitat;
(J) determine conditions under which removal of biomass is appropriate (including optimal methods for the disposal or use of biomass); and

(K) assess economic and other impacts associated with control methods and the restoration and maintenance of land.

(f) DISPOSITION OF BIOMASS.—

(1) IN GENERAL.—Not later than 1 year after the date on which funds are made available to carry out this Act, the Secretary, in cooperation with the Secretary of Agriculture, shall complete an analysis of economic means to use or dispose of biomass created as a result of removal of salt cedar and Russian olive trees.

(2) REQUIREMENTS.—The analysis shall—

(A) determine conditions under which removal of biomass is economically viable;

(B) consider and build upon existing research by the Department of Agriculture and other agencies on beneficial uses of salt cedar and Russian olive tree fiber; and

(C) consider economic development opportunities, including manufacture of wood products using biomass resulting from demonstration projects under subsection (e) as a means of defraying costs of control.

(g) COSTS.—

(1) IN GENERAL.—With respect to projects and activities carried out under this Act—

(A) the assessment under subsection (c) shall be carried out at a cost of not more than $4,000,000;

(B) the identification and documentation of long-term management strategies under subsection (d)(1) and the provision of grants under subsection (d)(2) shall be carried out at a cost of not more than $2,000,000;

(C) each demonstration project under subsection (e) shall be carried out at a Federal cost of not more than $7,000,000 (including costs of planning, design, implementation, maintenance, and monitoring); and

(D) the analysis under subsection (f) shall be carried out at a cost of not more than $3,000,000.

(2) COST-SHARING.—

(A) IN GENERAL.—The assessment under subsection (c), the identification and documentation of long-term management strategies under subsection (d), a demonstration project or portion of a demonstration project under subsection (e) that is carried out on Federal land, and the analysis under subsection (f) shall be carried out at full Federal expense.

(B) DEMONSTRATION PROJECTS CARRIED OUT ON NONFEDERAL LAND.—

(i) IN GENERAL.—The Federal share of the costs of any demonstration project funded under subsection (e) that is not carried out on Federal land shall not exceed 75 percent.

(ii) FORM OF NON-FEDERAL SHARE.—The non-Federal share of the costs of a demonstration project that is not carried out on Federal land may be provided in the form of in-kind contributions, including services provided by a State agency or any other public or private partner.

(h) COOPERATION.—In carrying out the assessment under subsection (c), the demonstration projects under subsection (e), and the analysis under subsection (f), the Secretary shall cooperate with and use the expertise of Federal agencies and the other entities specified in subsection (e)(1) that are actively conducting research on or implementing salt cedar and Russian olive tree control activities.

(i) INDEPENDENT REVIEW.—The Secretary shall subject to independent review—

(1) the assessment under subsection (c);
(2) the identification and documentation of long-term management strategies under subsection (d);
(3) the demonstration projects under subsection (e); and
(4) the analysis under subsection (f).

(j) REPORTING.—

(1) IN GENERAL.—The Secretary shall submit to Congress an annual report that describes the results of carrying out this Act, including a synopsis of any independent review under subsection (I) and details of the manner and purposes for which funds are expended.
(2) PUBLIC ACCESS.—The Secretary shall facilitate public access to all information that results from carrying out this Act.

(k) AUTHORIZATION OF APPROPRIATIONS.—

(1) IN GENERAL.—There are authorized to be appropriated to carry out this Act—

(A) $20,000,000 for fiscal year 2006; and
(B) $15,000,000 for each of fiscal years 2007 through 2010.

(2) ADMINISTRATIVE COSTS.—Not more than 15 percent of amounts made available under paragraph (1) shall be used to pay the administrative costs of carrying out the program established under subsection (a).

(l) TERMINATION OF AUTHORITY.—This Act and the authority provided by this Act terminate on the date that is 5 years after the date of the enactment of this Act.

*Speaker of the House of Representatives.*

*Vice President of the United States and*
*President of the Senate.*

# Appendix C

## Purgatoire Tamarisk Mapping & Inventory Project Objectives, Protocols, and Guidelines

**Purpose:** The purpose of this study was to establish and implement an inventory protocol that provides a clear understanding of the extent of the tamarisk problem but is also economical to perform. Quantifying and characterizing the tamarisk infestations on each major river system provides a wealth of information for many diverse users. The data produced provides planning level information that can support policy; and state, federal, and local decision-making concerning tamarisk control and riparian restoration efforts. Land managers, however, must take into consideration the site specific conditions of each land parcel and the desires/preferences of the landowner to select the appropriate tamarisk control and revegetation approach to implement.

**Goal:** The goal of these mapping and inventory protocols was to identify 85 to 90 percent of the tamarisk infestations in Colorado. This goal is achieved through the efficient inventory approach described below. The remaining 10 to 15 percent of infestations are scattered among minor tributaries and headwaters which can cost more to find than to control. These small scattered infestations are best identified as a component of larger-scale control projects.

**Inventory Approach:** To provide a thorough understanding of tamarisk infestations, a comprehensive data set was collected. This data provides essential information for developing effective cost estimates for control and revegetation, and to better understand impacts such as water losses and wildlife habitat effects. Tamarisk infestations were mapped by the Tamarisk Coalition on the Arkansas, Colorado, Purgatoire, White, Gunnison, Uncompahgre, Dolores, San Juan, Republican, and South Platte watersheds including major tributaries of each. The Yampa River watershed was mapped under an agreement with the National Park Service at Dinosaur National Monument. The North Platte and Rio Grande watersheds have minimum infestations that were assessed based on local weed managers' input but were not directly surveyed. The mapping and inventory process had five basic components.

1) High resolution aerial and satellite photos that are ortho-rectified (usually at 1-meter resolution or better) were acquired from available sources at no cost. These include photography from Mesa County GIS, U.S. Department of Agriculture – Farm Service Agency, and TerraServer. Utilization of National Agricultural Imagery Program (NAIP-2005) aerial photographs were, in most cases, the most current, consistent source of imagery for mapping purposes (available at http://datagateway.nrcs.usda.gov/NextPage.asp).

2) A basic understanding of infestation locations was gleaned from county weed managers, the state weed coordinator, state agriculture specialists, the water conservancy district staff, federal weed managers, university researchers, private land owners, and/or others. Photo interpretation of high-resolution aerial

photography proved to be valuable in determining the potential infestation extent where prior knowledge was not available.

3) A consultation with the US Geological Survey (USGS) and National Institute of Invasive Species Science was performed for technical assistance and data standardization to ensure database compatibility with the national database system ( www.niss.org )

4) On-the-ground surveys were then performed by a two-person crew to verify the following attributes of the tamarisk infestation:

   - ✓ GPS coordinates of tamarisk stand (Universal Transverse Mercator-UTM)
   - ✓ Percent cover (canopy)
   - ✓ Average height (added at the request of USGS partway through the field work on the Arkansas River)
   - ✓ Percent riparian area: defined as the portion of area currently occupied by tamarisk found in the floodplain corridor where native phreatophytes such as cottonwoods and willows could exist in the future.
   - ✓ Percent upland or terrace area: defined as the remaining land within the floodplain where dryland plant species would be more prevalent after tamarisk control is achieved is classified as upland or floodplain terrace.
   - ✓ Maturity (mature or immature)
   - ✓ Accessibility (good or poor for mechanized removal)
   - ✓ Presence other significant species (Russian olive, willow, cottonwood). Note that for some rivers such as the White, South Platte, Republican, and Purgatoire that Russian olive was the dominant invasive species and additional mapping was performed to inventory these infestations.

These attributes were initially recorded on a Personal Data Assistant (PDA) system with standardized data collection software (EcoNab) integrated with a GPS unit. As the mapping work progressed, a rugged quality field laptop computer with ArcView 9 and preloaded NAIP imagery was used to allow for on-site data entry. Digital photos representing each data point were also taken to visually display the infestations. Additionally, a field notebook documenting other significant observations (i.e. access issues, land use, etc.) was recorded at every data point.

5) The field imagery data was transferred into shapefiles using ArcGIS software and attached to the tabular data listed above. These shapefiles were subsequently utilized to calculate the total areas of infestation in any specific region.

**Deliverables:**

1) Shape files characterizing each infestation with an attribute table including the following fields: acreage, percent cover, average height, percent riparian, maturity, accessibility, and other significant species presence. These shapefiles

have added value in that they can be overlaid with other GIS referenced information; e.g., county property boundaries and ownership maps.

2) Digital photo album of the infested areas corresponding to each data point.

3) Auxiliary notebook describing significant observations.

4) PDFs of river segments showing shapefiles overlaid onto aerial photos and Excel spreadsheet tables are provided as user-friendly formats to present usable information for people without GIS expertise.

5) Excel spreadsheets provide individual details for each shapefile as well as watershed summaries. The summaries contain infestation acreage, percent cover, estimates of existing and future water losses, and estimates of total restoration costs including planning, control, revegetation, monitoring, and maintenance. These cost estimates are based on algorithms developed in *Options for Non-Native Phreatophyte Control* (See Appendix H). The cost equations incorporate best management practices coupled with an Integrated Pest Management approach based on three variables – percent tamarisk cover, accessibility, and average width of infestation.

**System Requirements:**

System requirements to use the inventory and mapping data require the following computer and software capability.

1) The minimum requirement for viewing the shapefiles is a free program called ArcExplorer, available at **http://www.esri.com/software/arcexplorer/**.

2) Computer specs: Access the ESRI site at www.esri.com for specific system requirements.

3) Microsoft Word and Excel software are used for viewing reports and spreadsheets. Adobe Reader is required for PDFs of river segments showing shapefiles overlaid onto aerial photos.

4) Digital photos: Any software capable of viewing JPEGs is sufficient.

# Appendix D

## Tamarisk Infestation presented on Aerial Photos

Tamarisk infestation maps have been developed for the Colorado Water Conservation Board as Adobe PDF files that overlain onto 1-meter high-resolution aerial photos flown by the USDA Farm Service Agency in 2005. Because of their very large number (88) and large size (11" x 17"), these photos are included on the supplementary
Data-DVD located in the back of the CHIP Plan. The following is a listing of the Table of Contents for these aerial photos in the watershed.



**Instructions –** To view the tamarisk density maps use the Data-DVD attached to this study. The PDF files provided there are quite large (>500 mb) and may bog down many computer systems. To minimize computer storage use, choose a specific section of river section desired based on the descriptive folder titles listed above. If you are unsure where your area of interest lies within these river sections, locate it the "Cover & Scales" folder to find specific sites on large scale maps. Note that the large scale maps require the most time and memory to download.

# Appendix E

## Templates and Protocols – General

For the purposes of this Plan the term *template* defines what actions should be taken, and the term *protocol* defines how the actions could be performed. The templates and protocols are intended as suggested guidance and criteria for decision making while carrying out the activities associated with various aspects of tamarisk and Russian olive control and biomass reduction, revegetation, monitoring, and long-term management. Thus, the intent is to ensure that selected approaches are effective and efficient, and decisions are well documented. They do not include technical details required for carrying out each specific action. As this watershed program matures, these templates and protocols should be continuously updated to improve the efficiency and effectiveness of actions. ***The intent of these templates and protocols is to raise the awareness of issues that might be important to be considered and not to be overly burdensome to develop an appropriate approach.*** In many cases, most of this data can be developed extremely quickly and some topics will not be applicable depending on the specifics of the project. It is suggested in both the control and revegetation sections that several alternative methods be analyzed. The reason for this approach is to ensure that a full range of options are assessed.

## Control and Biomass Reduction Templates and Protocols

The control of invasive species such as tamarisk and Russian olive requires an overall approach that looks at the long-term objective as the central component for selecting an appropriate control strategy. For the Purgatoire River watershed, this objective is the *return of riparian areas to healthy productive states and maintainence of uninfested areas to prevent further spread of non-native phreatophytes*.
This objective may include the reduction in wildfire potential, increased habitat diversity, and controlling the spread of non-native plant species. To reach this objective requires that each site-specific project define the full range of actions that are necessary to accomplish this objective, including their costs and their impacts. This includes the control technology, restoration efforts, and maintenance requirements. Thus, the templates and protocols developed for control have an interactive relationship with the revegetation, and long-term maintenance sections. Specific technologies for control are presented in some detail in the supporting document *Options for Non-native Phreatophyte Management* (see Appendix H).

**Table 1: Control and Biomass Reduction Templates and Protocols**

| Templates | Protocols |
|---|---|
| **1. Identify the historic and existing setting –** This baseline and historic information is | Gather the following information:<br>o Does the project adhere to the State and watershed plans and their priorities? |

| Templates | Protocols |
|---|---|
| essential in order to identify the reasonable approach(s) for control and will provide a point from which to compare and measure future changes. | o Terrain type<br>o Land ownership<br>o Adjacent land use<br>o Size and shape of parcel identified for control<br>o Type of existing and historic vegetative stand including density and diversity<br>o Susceptibility to erosion<br>o Hydrologic integrity, floodplain connectivity, water table depth, and availability of irrigation water or periodic flood waters<br>o Soil characteristics especially texture, depth, and salinity<br>o Threatened or endangered species habitat and other species of concern<br>o Local landowner attitudes and desires<br>o State, local, and community attitudes and desires<br>o Other legal and physical considerations/constraints |
| **2. Identify the objective for each site –** This information is critical so that all parties understand and accept the desired end condition. | Determine the objective that is acceptable by each landowner and the respective control technique(s) to use in series with revegetation efforts. Landowners may have different land use objectives for the restoration of infested lands. These land uses typically could include rangeland, pasture land, crop land, wildlife habitat, recreational, cultural, and/or aesthetic uses. |
| **3. Identify control alternatives –** At least three alternatives should be considered as well as the "No Action" alternative. | Select appropriate alternatives based on the existing setting and objectives for each site.<br>o Hand labor using chainsaws with herbicide applied to the cut stump<br>o Hand applied herbicide to basal bark<br>o Foliar herbicide application:<br>    ➢ Spraying from the ground<br>    ➢ Spraying with helicopters or fixed wing aircraft.<br>o Mechanic removal:<br>    ➢ Root plow<br>    ➢ Extraction<br>    ➢ Mulching followed by cut stump herbicide application<br>    ➢ Roller chopping followed by cut stump herbicide application<br>o Biological control<br>    ➢ Goats<br>    ➢ Chinese leaf beetle |
| **4. Identify alternatives for dead vegetation management –** Each control alternative must be | Select alternatives for the dead vegetation management:<br>o Stack and burn<br>o Burn in place |

| Templates | Protocols |
|---|---|
| linked to at least one alternative for handling the dead vegetative mass. | ○ Mulch in place<br>○ Mulch in discrete areas<br>○ Remove from site for disposal<br>○ Utilize as a resource such as fuel, commercial commodity, or to support sustainable local businesses that generate a value-added product<br>○ Leave in place; i.e., no further action required |
| **5. Identify alternatives for revegetation –** The success of revegetation efforts may be aided or hampered by the alternative selected for control; thus it is critical that revegetation be considered when selecting the control option. | Select specific revegetation alternatives as described in detail in the “Revegetation Templates and Protocols” section. |
| **6. Identify necessary maintenance –** Depending on the control and revegetation alternatives selected, maintenance costs and efforts can be significantly different. | Identify a preliminary understanding of the maintenance that may be required over a period of several years:<br>○ Monitoring the success of control and revegetation measures<br>○ Performing resprout treatment<br>○ Reestablishing desired vegetation<br>○ Irrigating, only if necessary, to maintain vegetation until self supporting |
| **7. Develop cost estimates and schedule for each alternative –** This will include the complete set of anticipated costs and their associated schedules to meet the objective of returning a riparian area to a healthy productive state. | Develop estimates of costs, schedules, and impacts for the following activities:<br>○ Control<br>○ Dead vegetation management<br>○ Revegetation<br>○ Landowner monitoring and maintenance<br>○ Administration |
| **8. Develop impacts associated with each alternative** | Quantify the potential impacts associated with each fully developed alternative for the following:<br>○ Community and landowner support<br>○ Re-infestation from adjacent un-controlled sources<br>○ Other noxious weeds or other undesirable plant infestations<br>○ Increase in water availability and water quality based on the establishment of the desired vegetative state<br>○ Wildlife habitat<br>○ Biodiversity<br>○ Herbicide use, both short-term and long-term impacts<br>○ Increase in sediment loads to rivers and streams and other erosion impacts<br>○ Local employment and business potential |

| Templates | Protocols |
|---|---|
| | ○ Fire and its consequential impacts<br>○ Long-term value for the watershed and the State |
| **9. Develop mitigation plans for negative impacts –** Where negative impacts will result because of some action, it is important to know what action can be taken to mitigate these impacts. | Include mitigations measures and their costs in the development of control alternatives. Examples might include:<br>○ Erosion protection<br>○ Smaller demonstration plots to establish refined approaches for new technologies<br>○ Tours of restored sites to increase public understanding |
| **10. Compare each combined alternative and select the preferred control approach** | Determine the preferred approach based on costs and impacts associated with the full range of activities related to each control alternative. |
| **11. Negotiate contracts with landowners** | Obtain contracts with landowners that provide written confirmation on the specific control approach(s) selected, land area that is to be controlled, anticipated outcome of control, dead vegetation management, revegetation approach, and monitoring and maintenance requirements. State any specific mitigation measures required, identify cost share and responsibility, provide an anticipated schedule, and identify method for resolving complaints. Coordinate Request for Proposal process with the landowner and establish responsibilities for contract supervision, training, monitoring, etc. |
| **12. Provide education and public outreach** | Provide education and public outreach efforts. These may include:<br>○ Public notification on the specifics of the control project; such as method, dates, participation, etc.<br>○ Development and dissemination of valuable insights derived from project experiences to the public.<br>○ Signage explaining the stage of control/revegetation.<br>○ Tours of sites in various stages of control and revegetation.<br>○ Annual landowner training through CSU Cooperative Extension and/or NRCS<br>○ Historic photo record of existing setting before, during, and after control and revegetation. |

# Revegetation
# Templates and Protocols

For the purposes of this document, *revegetation* refers to the restoration of vegetation to a site. This is not confined to native vegetation and may occur naturally through regeneration or through induced means. Costs for non-native phreatophyte control, revegetation, and long-term maintenance can often be quite high, and specific treatment areas should be evaluated and prioritized based on revegetation potential.

Please note that templates 1, 2, 6, and 7 and their associated protocols are very similar to those identified for control actions.

**Table 2: Revegetation Templates and Protocols**

| Templates | Protocols |
|---|---|
| **1. Identify the historic and existing setting –** This baseline and historic information is essential in order to identify the reasonable approach(s) for revegetation and rehabilitation and will provide a point from which to compare and measure future changes. | Gather the following information:<br>o Terrain type<br>o Land ownership<br>o Adjacent land use<br>o Size and shape of parcel to be revegetated<br>o Type of existing and historic vegetative stand including density and diversity<br>o Susceptibility to erosion<br>o Hydrologic integrity, floodplain connectivity, water table depth, and availability of irrigation water or periodic flood waters<br>o Soil characteristics especially texture, depth, and salinity<br>o Threatened or endangered species habitat and other species of concern<br>o Local landowner attitudes and desires<br>o State, local, and Tribal community attitudes and desires |
| **2. Identify the objective for each site –** This information is critical so that all parties understand and accept the desired end condition. | Determine the objective that is acceptable by each landowner and the respective revegetation technique(s) to use in series with control efforts. Landowners may have different objectives for the use of rehabilitated lands. These typically could include rangeland, pasture land, crop land, wildlife habitat, recreational, cultural, and/or aesthetic values. |
| **3. Identify revegetation alternatives and impacts –** At least two alternatives should be considered as well as the "No Action" alternative. Criteria for review would include costs, environmental impacts, | Select appropriate alternatives based on the existing setting and objectives for each site.<br>o Natural revegetation<br>o Irrigation and seeding<br>o Flooding with native seed dispersal<br>o Pole plantings of cottonwood and willows<br>o Nursery stock plantings |

| Templates | Protocols |
| --- | --- |
| acceptability, effectiveness, as well as others that may be appropriate. | o Use of livestock to facilitate seeding establishment |
| **4. Develop a preliminary revegetation plan** | Produce a preliminary revegetation plan using information developed in the baseline survey and the landowner's desires consistent with express State limitations on expenditures of rehabilitation funds. This would include costs, timing, and long-term maintenance requirements. The plan would also define responsibilities for cost share, work efforts, and expected outcomes. |
| **5. Identify the post-control plant inventory and adjust revegetation plan accordingly** | After a suitable rest period following control efforts, perform an inventory of available plant resources that are acting as seed sources adjacent to and within the control area. Refine the revegetation and rehabilitation plan based on this knowledge. Seek advice, as appropriate, from CSU Cooperative Extension, NRCS, and other specialists. |
| **6. Negotiate contracts with landowners** | Obtain contracts with landowners that describe the proposed revegetation and rehabilitation measures that are anticipated and any monitoring and maintenance requirements. This includes schedules, any mitigation measures required (e.g., erosion control), cost share responsibility, and method for resolving complaints if they arise. |
| **7. Provide education and public outreach** | Provide education and public outreach efforts which may include:<br>o Development and dissemination of valuable insights derived from project experiences to the public.<br>o Signage explaining the revegetation/reclamation efforts.<br>o Tours of sites in various stages of revegetation.<br>o Annual landowner training through CSU Cooperative Extension and/or NRCS<br>Historic photo records of existing setting before, during, and after control and revegetation. |
| **8. Use adaptive management techniques** | Demonstrate flexibility in revising revegetation practices to improve efficiency and effectiveness based on valuable insights derived from project experiences. |

# Monitoring
# Templates and Protocols

For watershed and remediation activities, "monitoring" is the act of observing changes that are occurring with, or without, remediation actions. The purpose of monitoring is to provide information for making informed decisions on the initiation, continuation, modification, or termination of specific remediation activities or programs; and most importantly to assess whether or not objectives are met. Two monitoring regimes are important to the understanding of changes within an ecosystem – large-scale monitoring and small-scale monitoring.

Large-scale monitoring is essential for policy makers and the public to evaluate the potential impacts of remediation on the watershed's water resources, vegetation, wildlife habitat, biodiversity, economic health, society, and culture – these are essential considerations for determining what level of funding should be committed to the control efforts by the state and/or federal agencies. "However, most impacts (e.g., increased fire frequency, declines in water availability or native plant and animal populations, and soil erosion) are caused by a complex array of factors, only one of which is non-native phreatophytes. Accurately determining the relative contribution of these infestations to a particular impact parameter may be difficult. In addition, these invasive species may have impacts that have not been identified yet and/or may become quantifiable only after long periods." [1]

Small-scale monitoring provides useful information on the effectiveness of control and remediation activities to allow modifications, if necessary, to achieve the remediation goals. This is the essence of adaptive management.

**Large-scale Monitoring –** The approach for monitoring large-scale changes to the environment includes a number of well-developed methods. These include:

- Using appropriate techniques that best achieve the objectives of monitoring to ensure that monitoring approaches are efficient, economical, and relatively easy to implement and maintain. For TTP, monitoring efforts will be completed using The Nature Conservancy's WIMS database to track removal projects, regrowth, and revegetation.

- Adopting monitoring protocols agreed to by State, federal, and local governments so that monitoring data from disparate projects is compatible and easily stored in a single database.

[1] National Invasive Species Council, *Draft Guidelines for Ranking Invasive Species Projects in Natural Areas*, August 2004.

- Providing information that can eventually be incorporated into a centralized database for storing compatible monitoring data from remediation projects across the State.

**Small-scale Monitoring –** Monitoring at the landowner level is needed primarily for adaptive management purposes to assure compliance with funding agreements, to identify maintenance needs, and to document ecological response to controls and remediation actions. In general, small-scale monitoring criteria should include simple and inexpensive monitoring techniques based on the needs of the landowner's management objectives.

The monitoring protocols identified are for future projects and cannot necessarily be applied retroactively to past projects. They are intended to be simple and straightforward. Basically, they are intended to provide an understanding of the baseline condition, the success of controls, the success of revegetation, and any necessary modifications to improve success. Much of this can be accomplished through fixed photo points and paced transects. CSU Cooperative Extension, and/or NRCS are good sources for providing training and assistance in any of these areas that are beyond the capabilities of individual landowners.

The determination of what parameters to measure and how they will be measured is critical so that the attainment of objectives can be properly evaluated. "Both quantitative (e.g., percent reduction in water lost to evapotranspiration), and qualitative (e.g., visitor satisfaction at a riparian area) assessments may be used. Data concerning the impacts of various actions (e.g., control operations) should also be collected, evaluated, and used to guide the adaptive management of invasive species." [2] As such, templates and protocols are presented in the following tables for large-scale and small-scale monitoring levels.

**These large-scale and small-scale monitoring protocols are only guidelines** to help identify information that is typically important to collect and should not be considered as absolutes. Additionally, there may be additional parameters that a project manager must evaluate, and these protocols should not be viewed as a hindrance to do so. It is also clear that many of these protocols overlap and will support different monitoring objectives.

It is important to note that monitoring in all places for all components would be extremely expensive and that much of the large-scale efforts are really research actions. Thus, scientific knowledge must be used to define monitoring requirements that match best with the monitoring objective and that the researchers at Colorado's universities and through federal agencies are in the best position to perform this type of monitoring activity.

[2] National Invasive Species Council, *Draft Guidelines for Ranking Invasive Species Projects in Natural Areas*, August 2004.

**Table 3: Large-scale level monitoring templates and protocols**

| Templates | Protocols |
|---|---|
| **1. Water Quantity --** What is the baseline situation and the changes in water quantity that the watershed is experiencing from non-native phreatophytes and what changes to the water inventory are occurring due to control and remediation actions? | Note: For the purposes of this protocol the identification of long-term potential changes to water quantity resulting from replacing non-native phreatophytes with desired vegetation requires an understanding of the extent and type of infestation, and the water usage of both the non-native phreatophytes and the desired vegetation that would replace it. Actual changes in water quantity are determined from stream flow and groundwater measurements over time. These later changes may take years or even decades to determine. Thus, the importance of monitoring to determine both potential as well as actual water quantity changes. |
| **2. Water Quality –** What is the baseline situation and the impacts to water quality in the watershed from non-native phreatophytes and what changes are occurring due to control and remediation actions? | Measure appropriate surface and groundwater parameters that will allow direct comparison with published results |
| **3. Wildlife Habitat and Biodiversity –** What is the baseline situation and the impacts to wildlife habitat and biodiversity in the watershed from non-native phreatophytes and what changes are occurring due to control and remediation actions? | Measure appropriate aquatic and terrestrial habitat parameters that are consistent with published data from the Colorado Division of Wildlife and the U.S. Fish and Wildlife Service. |
| **4. Soils –** What is the baseline situation and the impacts to soils from non-native phreatophytes and what changes are occurring due to control and remediation actions? | A. Salinity<br>B. Soil moisture<br>C. Erodability<br>D. pH |
| **5. Economic --** What is the baseline situation and the impacts to the watershed's economy from non-native phreatophytes and what changes are occurring due to control and remediation actions? | Measure the economic impact of the cost of control and rehabilitation versus economic impacts to agriculture, water, wildlife habitat, endangered species, etc. |

**Table 4: Small-scale monitoring templates and protocols**

| Templates | Protocols |
|---|---|
| 1. How effective are the control measures? | Provide a photo history of pre-control and the post-control situation. |
| 2. To what extent have treated areas revegetated without human intervention? | A. Visually identify natural revegetation and document with photos.<br><br>B. Over a period of 3 to 5 years, photograph, identify, and document regrowth of invasive plants and the success of any additional control actions as a component of long-term maintenance. |
| 3. How successful has active remediation to the desired vegetative state been? | A. Visually assess the effectiveness of active revegetation and document with photos.<br><br>B. Note areas for additional active revegetation and develop adaptive management plan and future monitoring needs.<br><br>C. Identify and document success of any additional control and revegetation actions as a component of long-term maintenance. |

## Long-term Maintenance Templates and Protocols

Long-term maintenance is the dynamic process, carried out over time (years to decades), to achieve social, economic, and ecological goals associated with a watershed. The process of management involves the strategic implementation of actions to identify, maintain, remediate, improve, and monitor the ecological processes of the watershed. Actions, and the tools required to accomplish them, are chosen because they are consistent with and likely to achieve the watershed goals, and because they address the results of monitoring. Watershed management is necessarily adaptive because actions or tools may need to be changed or replaced to adapt to any unexpected results of monitoring.

**Table 5: Templates and Protocols for Long-term Maintenance**

| Templates | Protocols |
|---|---|
| **1. Provide funding to carry out the preferred long-term maintenance plan** | Determine funding sources for long-term maintenance that is consistent from year to year and can be provided over a long time period. Sources that may be available include state, local, federal, foundations, and/or private landowner funds derived form taxes, user fees, bonds, incentives, grants, etc. |
| **2. Implement the long-term maintenance plan** | Select actions could include efforts such as:<br>o Non-native phreatophyte control<br>o Conservation easements<br>o Wildlife habitat improvement<br>o Endangered/sensitive species habitat management<br>o Economic development |
| **4. Monitor actions and adjust as needed** | Measure appropriate parameters for each major action to determine if the goals and objectives are being met. This information will allow informed decisions on the continuation, modification, or termination of the specific action or program; i.e., adaptive management. |

# Appendix F

## Example Project Prioritization System

The following criteria for prioritizing future projects for tamarisk and Russian olive control and revegetation are preliminary in nature and intended to be an example of how the TTP plan can approach prioritization of projects they support. They are listed in no particular order of priority. Any of several criteria may be more important depending on the funding source, landowner desires, location, etc.

**Funding Type & Opportunity –** Funding opportunities often have specific goals, timing, landownership status, matching requirements, etc. that enhance a projects probability of gaining funding. Also considered is whether identified funding source(s) will provide the necessary resources for performing all activities; i.e., control, revegetation, monitoring, and maintenance.

**Educational Opportunities –** The location of a project can sometimes provide good educational opportunities. An example is Trinidad State Park gets that gets significant public exposure.

**Willing Landowner –** Landowner support of a project is essential for funding.

**Weed Management Approach –** This criterion addresses the specifics of the proposed control and revegetation approach to assess how best management practices (e.g., wildfire model), and Integrated Pest Management approaches are being incorporated into the project.

**Cost Effectiveness & Efficiency –** Are the costs associated with a control and revegetation project being used efficiently and will the results be effective at meeting the goals of the project?

**Achievement of Goals –** What is the specific goal of the project (e.g., wildlife habitat enhancement, water resources, endangered species, wildfire protection, etc.), are there multiple goals, and what is the probability of them being achieved?

**Overall Potential for Success –** Overall, will the project's setting, approach, landowner commitments, etc. lend it to being successful in meeting the goals of the project and be sustainable? Examples of questions that might be considered are: *Will native vegetation be able to be established without much help, and if not, does the project accommodate this condition? Is the budget realistic, and are matching funds and in-kind contributions available? Is there a commitment by the landowner to prevent other weed infestations?*