Southeast Utah Tamarisk Partnership

Woody Invasive Species Management Plan

July 2007

Colorado River near Moab, Utah – mixed tamarisk, willow, and cottonwood. Photo credit: John Dohrenwend 2006

Prepared by the
Southeast Utah Tamarisk Partnership

Endorsement

The Southeast Utah Tamarisk Partnership – *Woody Invasive Species Management Plan* was prepared with the input of many partners from Grand and San Juan counties in eastern Utah representing state and federal agencies, local communities, private landowners, industry, and non-governmental organizations (NGOs). This partnership was funded through grants from the Grand Canyon Trust, The Nature Conservancy, and Utah Department of Transportation with the Tamarisk Coalition providing staff to assemble the plan based on inputs from partner organizations. This plan only makes suggestions on management strategies for tamarisk and other invasive woody species. Each landowner will make their own determination on the strategy for their property. Endorsement of this plan by the parties named in the accompanying Memorandum of Understanding (Appendix A) in no way limits any government's, agency's, industry's, landowner's, or organization's existing legal authority or responsibilities. Parties to this plan agree to collaborate to provide information and expertise on woody invasive management. It does not obligate the parties to transfer funds, labor, or equipment.

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Executive Summary

In March 2006 a partnership was formed to plan collaborative riparian restoration efforts in Southeastern Utah's Colorado River Watershed. Much of this area is heavily infested by non-native, invasive vegetation, principally tamarisk (*Tamarix* spp., aka salt cedar) and Russian olive (*Elaeagnus augustifolia*). The partnership, known as Southeast Utah Tamarisk Partnership (SEUTP), is composed of agencies, organizations, businesses, non-profits, and individuals who live and work near or on the Colorado River in southeastern Utah. SEUTP is based in Utah's Grand and San Juan Counties with focus on restoration activities for lands managed by state and federal agencies, local communities, private landowners, industry, and non-governmental organizations. SEUTP's mission is:

The Partnership is committed to restoring, protecting, and maintaining a healthy riparian ecosystem in our Colorado River watershed.

The SEUTP's major **Goals** are to: 1) control and/or remove tamarisk and Russian olive and restore riparian lands; 2) deal with the effects of tamarisk biological control; 3) educate the public; 4) obtain funding; 5) organize volunteer programs; 6) ensure the long-term maintenance and sustainability of SEUTP, its strategic plan, and restoration projects; 7) effectively apply monitoring, research, and adaptive management to projects; and 8) successfully revegetate, improve, diversify, and restore project sites.

The SEUTP 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 threatened and endangered and sensitive species; 3) education to gain public support; 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.

The boundaries of the planning area include: 1) the Colorado River watershed from the confluence of the Green River to the UT/CO state line, 2) tributaries north of the San Juan River watershed and east of the Colorado River from the Green River to Lake Powell, and 3) the section of the Dolores River watershed located in Utah. Tamarisk and Russian olive are not the only non-native, invasive species present in the watershed and invasive species are not the only problem impacting this river system. However, due to their extensive growth patterns and high profile images, these species serve as the main emphasis for riparian restoration.

Tamarisk infestations within the SEUTP study area occur primarily below 6,500 feet in elevation. Russian olive occupies a similar range although both species occur in isolated pockets at higher elevations. Tamarisk infestations dominate most riparian habitats along the Colorado River and its tributaries except in the lower elevations of Mill Creek in Moab where Russian olive is pervasive.

These infestations degrade wildlife habitat, agricultural lands, recreational activities, and water resources. If no action is taken, the potential intensification and expansion of ecosystem degradation in the future is prohibitively high.

The control of tamarisk and Russian olive in the watershed may utilize a full suite of techniques including hand control, herbicide treatment, biological control, and mechanical treatment. No one technique is right for all situations. Additionally, all of these techniques must be matched with an effective restoration plan for the riparian corridor. **Restoration is the ultimate goal**. Even with coordinated, sustained control of non-native woody invasives over the next several decades, eradication within the basin is not achievable.

Biological control is a promising method that employs the leaf beetle *Diorhabda elongate* from the tamarisk's native Asia. These insects, which have been tested extensively, have been released within the SEUTP study area during the past three years and current results indicate that tamarisk biological control may be successful on a large-scale. While biological control can reduce costs and herbicide use, a disadvantage is significant short-term impact of browning of tamarisk vegetation that visitors to the area may consider unsightly. Education, for this reason, is an important component of the Plan's strategy.

SEUTP partners have proposed strategies for: 1) tamarisk and Russian olive control, biomass reduction, revegetation, monitoring, and long-term maintenance; 2) education, outreach, and volunteerism; 3) project prioritization criteria; and 4) research needs.

Expected results of tamarisk and Russian olive control projects in the Colorado River watershed include restored aquatic, riparian, and floodplain ecosystems. The quantity and quality of these habitats for fish and wildlife, including endangered status fish species, would be improved. Project areas would also provide opportunities for environmental education, improved aesthetics, recreation, and improved management of flood flows.

Beneficial impacts of restoration also include increased resilience to future stresses such as fire, drought, or other invasive plants. Riparian restoration creates a more self-sustaining ecosystem, provides the benefits of improved water resources, and reduces future riparian management costs.

The SEUTP plan is a collaborative document to plan the development and implementation of future, objective-driven designs for each area within the watershed impacted by tamarisk and Russian olive. **The SEUTP plan is not a site-specific design for restoration.** Rather, the plan functions as the backbone of future riparian restoration work. It is also designed to complement adjacent planning efforts on the Colorado River watershed in Colorado and the San Juan River watershed in the four-corner area.

SEUTP Background

Southeast Utah Tamarisk Partnership (SEUTP) – The Partnership was formed in March 2006 to initiate a collaborative planning effort for riparian restoration projects in Southeastern Utah's Colorado River watershed impacted by non-native invasive vegetation, principally tamarisk (*Tamarix* spp., aka salt cedar) and Russian olive (*Elaeagnus augustifolia*). This partnership is a collaboration of agencies, organizations, businesses, non-profits, and individuals who live and work near or on the Colorado River in southeastern Utah as shown in Figure 1.

The boundaries of the planning area include: 1) the Colorado River watershed from the confluence of the Green River to the UT/CO state line, 2) tributaries north of the San Juan River watershed and east of the Colorado River from the Green River to Lake Powell, and 3) the section of the Dolores River watershed located in Utah. This area spans two counties in southeastern Utah and includes lands managed by state and federal agencies, local communities, private landowners, industry, and non-governmental organizations. The logic behind this boundary determination is both ecological and political.

The Planning Process – Over the past year, the Partnership met on a monthly basis to develop this plan with facilitation by Canyon Springs Consulting and the assistance of the Tamarisk Coalition to collect input and assemble the plan. The SEUTP plan provides a collaborative document to organize the development and implementation of future objective-driven designs for the watershed impacted by tamarisk and Russian olive. **The SEUTP plan is not a site-specific design for restoration.** These designs require restoration site assessment, site prioritization, site planning, and pre- and post- management monitoring. Rather, the SEUTP plan functions as the context that connects existing and future riparian restoration work.

Within the SEUTP plan the term "restoration" is defined as 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 as closely as possible to pre-disturbance conditions and functions while respecting private property rights, state water law, existing infrastructure, and endangered species considerations.

The SEUTP plan should be considered as guidance that is constantly being updated to reflect new information. To update the plan requires that a long-term leadership structure be identified that conforms to the values articulated within the plan and provides sustainability to restoration efforts. This leadership issue is addressed more fully in the "Long-term Maintenance" section.

SEUTP Subcommittees – SEUTP formed the following subcommittees that have or will address the specific concerns listed below:

1) The Control, Revegetation, Monitoring, and Maintenance Subcommittee:

a) Recommend the best possible strategies for control and revegetation;
b) Recommend techniques for monitoring control and revegetation work; and
c) Develop mapping categories to describe site specific infestation attributes.

2) The Grants and Funding Subcommittee:
   a) Examine upcoming funding opportunities;
   b) Build a timeline of opportunities; and
   c) Identify organizations to serve as potential leads for particular funding opportunities.

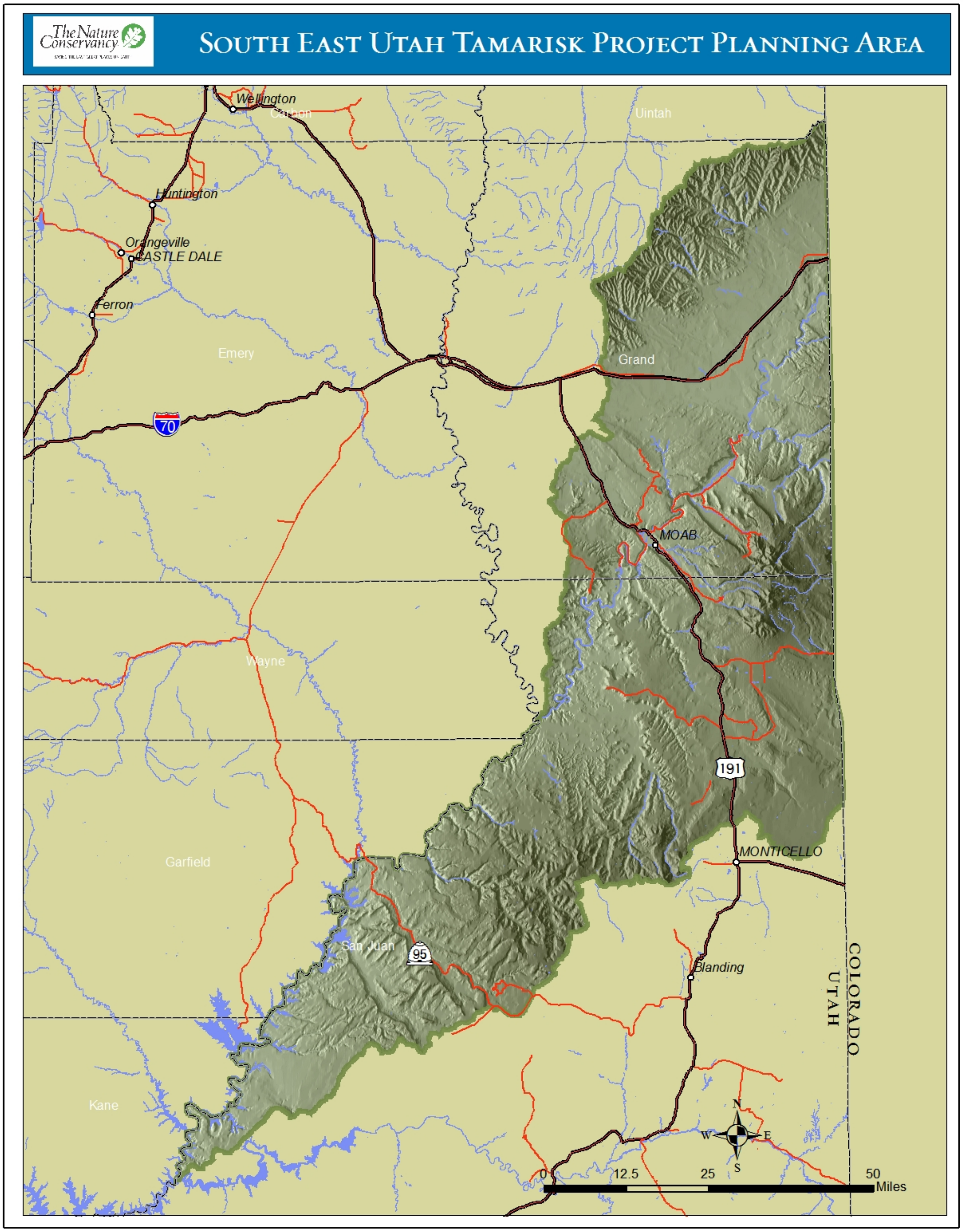
3) The Projects Subcommittee:
   a) Inventory past and current tamarisk and Russian olive weed projects in the area;
   b) Compile ideas for future projects; and
   c) Develop prioritization criteria for grants and projects.

4) The Education and Outreach Subcommittee:
   a) Educate the public about biological control and riparian restoration;
   b) Diffuse the potential crisis mentality concerning "brown-outs" and the potential of fire danger due to the work of the tamarisk beetle;
   c) Inform public discussions about tamarisk and Russian olive issues;
   d) Develop a common set of talking points;
   e) Gather resources for distribution;
   f) Correct misinformation or incomplete information already distributed to the public; and
   g) Communicate with potential educators (river guides, Utah Guides and Outfitters, etc.) by developing curriculum and writing articles.

SEUTP Partners

- Bureau of Land Management
- Bureau of Reclamation
- Canyon Voyages
- Castleland Resource Conservation and Development Council
- City of Moab
- Grand Canyon Trust
- Grand County
- Living Rivers
- National Park Service
- Natural Resources Conservation Service
- Plateau Restoration
- Private landowners and citizens
- Red River Canoe Company
- Red Rock Forests
- Rim to Rim Restoration
- San Juan County
- Southern Utah Wilderness Alliance
- Southwest Satellite Imaging
- Tamarisk Coalition
- The Nature Conservancy
- Town of Castle Valley
- US Fish & Wildlife Service
- US Forest Service
- Utah Department of Transportation
- Utah Division of Forestry Fire and State Lands
- Utah Division of Parks and Recreation
- Utah Division of Wildlife Resources
- Utah School and Institutional Trust Lands
- Utah State University Extension

Figure 1: Southeast Utah Tamarisk Partnership planning area of the Colorado River Watershed



Mission Statement

The Southeast Utah Tamarisk Partnership is committed to restoring, protecting, and maintaining a healthy riparian ecosystem in our Colorado River watershed.

This planning effort's intent is to strategically improve and maintain the riparian areas of the Colorado River and its tributaries. Demonstrating measurable progress over time on the highly visible tamarisk and Russian olive infestations provides an effective mechanism for developing the public and political support needed to meet the Partnership's goals.

SEUTP's Long-Term Visions

1) Provide a mechanism for communication and coordination among diverse parties and land managers throughout the watershed;
2) Develop a strategy pairing timely and cost-effective riparian restoration with well designed monitoring and maintenance processes;
3) Control tamarisk and Russian olive infestations while reestablishing sustainable native plant and animal communities;
4) Maintain information databases such as partnerships, funding and intellectual resources, infestations, volunteers, on-the-ground project areas, and areas requiring monitoring and maintenance; and
5) Support strong localized leadership and initiatives to successfully realize our visions.

Goals and Objectives

The major **Goal** areas of SEUTP are:

1) Control and/or remove tamarisk and Russian olive;
2) Deal with the effects of tamarisk biological control;
3) Educate the public;
4) Obtain funding;
5) Organize volunteer programs;
6) Ensure the long-term maintenance and sustainability of SEUTP, its strategic plan, and restoration projects;
7) Effectively apply monitoring, research, and adaptive management to projects; and
8) Successfully revegetate, improve, diversify, and restore project sites such that natural processes favor native recruitment over non-natives.

The following ***preliminary*** **Objectives** are based on the above list of goals:

1) Control and/or Removal of Tamarisk and Russian olive:
   a) Prevent recurrence of tamarisk and other invasive vegetation growth in treated areas;
   b) Sustain native species over time; and
   c) Classify and prioritize sites, including coordination of control and revegetation projects.

2) Effects of Biological Control:
   a) Educate the public about the timeline of biological control, and the possible need for tamarisk removal once the tamarisk is dead;
   b) Coordinate removal of dead biomass in areas where this is important; and
   c) Coordinate with researchers to monitor and study the impacts of the beetle.

3) Public Education:
   a) Create a Frequently Asked Questions sheet in print and on the web;
   b) Prepare presentations for speaking venues and on the radio; and
   c) Prepare press releases identifying problems and control methods.

4) Obtain, Sustain, and Maintain Funding:
   a) Research and catalog funding opportunities, including criteria for funding, timing of funding, and identification of organization/agency as lead applicant for each funding opportunity; and
   b) Work with the Projects Subcommittee to identify possible projects that best match specific funding opportunities.

5) Volunteer Programs:
   a) Identify groups with volunteer potential, such as boy scouts, river guides in training, inmates, etc.; and
   b) Use local media to put out a call for volunteers.

6) Sustainability of SEUTP:
   a) Reach agreement within the partnership to continue meeting and working together;
   b) Identify individuals to lead the group; and
   c) Set up a rotation of leadership.

7) Long-Term Monitoring/Adaptive Management/Research Projects:
   a) Identify the purposes and needs of control efforts for every project;
   b) Identify responsible parties for long-term maintenance of each control project;
   c) Assist responsible parties in identifying specific action items for maintenance of projects;
   d) Determine the length of each control project;
   e) Re-evaluate at the end of each control project cycle to determine the need for continued maintenance; and

f) Design a monitoring plan with a baseline of factors to be measured.

8) Revegetation, Diversification, and Restoration of Habitat:
   a) Identify propagation sources for native species;
   b) Assist in the identification and understanding of restoration potentials of ecological sites and develop criteria for ;
   c) Identify potential methods, costs, limitations and consequences of invasive control and ecological restoration, including potentials for noxious weed infestations; and
   d) Maintain areas where removal has occurred and manage for natural processes that favor native recruitment over non-natives.

SEUTP Guiding Principles

Guiding principles provide the common ground, "the foundation," which can direct ecological restoration efforts into the future. These guiding principles reflect a broad agreement between SEUTP partner organizations, agencies, communities, and individuals that are cooperating to develop this riparian management plan. These principles also reflect the priorities of many stakeholders in adjoining watersheds in Utah, Colorado, Arizona, and New Mexico. These principles will be adjusted and changed as needed. ***This community driven effort recognizes that tamarisk and associated non-native invasive plants cause economic and environmental damage, negatively affect public health and welfare, and require active long-term management programs with sustainable funding. Thus, the SEUTP partners subscribe to the following guiding principles:***

Ecological: Promoting ecological integrity, natural processes, and long-term sustainability is important for success.

a) Recent releases of the biological control agent tamarisk leaf beetle (*Diorhabda elongata*) within the Colorado River basin requires aggressive monitoring, evaluation of impacts (fire regime, scenic, etc), and development and prioritization of immediate and long-term management strategies.

b) Where appropriate, non-native invasive vegetation will be replaced with native plant species that can be self sustaining.

c) Restoration will take into account the overall condition of the system, including presence of native species, species diversity, hydrologic regime, water quality, and wildlife habitat.

d) Best management practices utilizing Integrated Pest Management techniques will be used and, as improved science develops, practices will be updated through adaptive management.

e) Changes to hydrologic conditions can support native plant restoration efforts and will be considered where possible within the constraints of state and federal water law and the Colorado River Compact.

f) Efforts will be made to understand the historical, present, and future role of fire in riparian areas.

g) The removal of tamarisk and Russian olive canopy may promote the growth of other invasive plants. Management strategies will be developed to avoid additional noxious plant infestations.

h) Restoration and maintenance efforts will be monitored and evaluated on an ongoing basis to ensure effectiveness.

i) In some circumstances the protection of threatened and endangered species as well as sensitive 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.

j) If no action is taken, tamarisk and associated non-native invasive plants will continue to spread and increase the environmental damage to SE Utah's river systems.

k) Using a coordinated, sustained management strategy for non-native woody invasives over the next several decades will not achieve eradication, but can achieve control to a level that allows native vegetation to be competitive.

l) It is generally agreed by the SEUTP Control and Revegetation committee that the least intensive/disruptive revegetation treatments are preferred (which also carries over to removal techniques) This means avoiding long-term costs associated with irrigated projects – and relying on the natural regenerative capabilities of most areas. It is also important to remember that removing other weed species may be the most important revegetation treatment performed.

Social – Cultural: The values of SE Utah's diverse human communities will be supported and sustained by ecological restoration.

a) A comprehensive strategic approach throughout the watershed is important for success. However, southeastern Utah is a mix of publicly managed lands, Tribal lands, industry owned lands, and private property. Federal land management policy will be adhered to and private property rights, Tribal rights, local customs, and cultures will be respected.

b) The rivers of Utah are highly controlled by man to improve their capability to store and supply water (e.g., dams, irrigation systems) for beneficial use. Tamarisk and Russian olive control and restoration can respect these conditions.

Economic: Economic productivity is dependent on healthy ecosystems and will be leveraged to its full advantage in support of long-term ecological health.

a) Existing frameworks of funding, technical assistance, and expertise will be identified, used, and publicized to optimize resources and maximize local effectiveness.

b) Partnerships will be developed to leverage existing and future funding.

c) Tourism is a vital economic component of southeastern Utah. Visitors come from all over the world to run the rivers and view the exceptional scenery and ecosystem. Enhancing the visitor's experience and promoting a safe recreational experience is important.

d) Private sector involvement in restoration efforts will lead to quality employment and economic benefits to the local communities of SE Utah.

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

a) Educational materials will be developed on all aspects of the restoration process. This is especially important and critical for the recent release of biological control agents.

b) Community outreach and volunteer efforts will be used to aide the public and land owners in gaining first-hand knowledge of the problem and establishing ownership of the solution.

c) Appropriate outreach will be used to communicate our successes and failures to other regions and the scientific community.

Research: Research can provide mechanisms to improve the effectiveness and efficiency of restoration actions.

a) Universities, federal, and state agencies will be encouraged to use the riparian restoration efforts in SE Utah as a "living laboratory" to monitor changes and provide scientific support to enhance success.

b) To improve management decisions, data from inventories, monitoring, and control actions will be comparable (standardized and consistent) and shared at all levels.

c) 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.

SEUTP Interface with other Planning Efforts

Effective watershed planning and invasive species control efforts rely on a coordinated approach that transcends artificial boundaries such as political jurisdictions. However, implementation often requires planning efforts within the confines of political jurisdictions or at least reasonable land masses. Thus, the SEUTP *Woody Invasive Species Management Plan* was developed geographically to focus on three areas within Grand and San Juan Counties: 1) the Colorado River watershed from the confluence of the Green River to the UT/CO state line, 2) tributaries north of the San Juan River watershed and east of the Colorado River from the Green River to Lake Powell, and 3) the section of the Dolores River watershed located in Utah. These boundaries were formed with the knowledge that land managers in Colorado were working on their own comprehensive plans for the Colorado River, Gunnison River, and Dolores River watersheds. Additionally, a four state four tribe effort is underway downstream on the San Juan River. Thus, SEUTP's boundaries are both ecological and politically based. All of these plans rely in some respect on the success of adjacent planning activities. The common thread between all of these invasive species/watershed efforts is the coordinating support being provided by the Tamarisk Coalition.

Relevant Legislation and Government Actions

Grand County and San Juan County Actions – In April 2006 both counties passed a "Noxious Weed" designation for tamarisk and Russian olive. This listing will stop sales of nursery stocks of both plants (see Appendix B). Authority for control of noxious weeds and enforcement are governed by the *Utah Noxious Weed Act* (see http://www.co.tooele.ut.us/PDF/UT%20Noxious%20Weed%20Law.pdf)

Utah Strategic Tamarisk Management Plan – In 2005, federal, state, and local weed management agencies developed a strategic framework for addressing the tamarisk problem (see Appendix C). The Purpose of the plan is to provide common goals and objectives, criteria for prioritizing projects and funding, measures of success, and an overview of current tamarisk management tactics. SEUTP's *Woody Invasive Species Management Plan* compliments this effort by focusing on the specific understandings and circumstances of the southeastern region of Utah.

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 HR2720 or Public Law 109-320 (the Library of Congress site http://thomas.loc.gov). Utah's congressional representative for the

SEUTP study area, Congressman Jim Matheson, was very supportive of its passage. The principle 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.

The next Congressional step is to provide funding at the local level with the inclusion of appropriations to fully fund the Act in 2007. Several organizations and states are currently working with Congress on this measure.

The SEUTP could be an ideal large-scale demonstration project as it encompasses a critical watershed area, has diverse landscape characteristics of national importance, is a significant cooperative conservation effort, and provides unique opportunities for field research. As a significant tourist destination the area receives substantial national media coverage. It is also a research destination for local institutions such as the University of Utah. These provide additional reasons for locating a large-scale restoration demonstration in the SEUTP area.

California Legislation – On September 29, 2006, California Governor Schwarzenegger signed Assembly Bill 984 into law (see www.leginfo.ca.gov) which directs California state agencies to work with other Colorado River basin states to develop a comprehensive plan for tamarisk control and revegetation for the entire Colorado River system. Once the plan is completed, California will implement it upon the appropriation of funds. This provides a major step towards cooperative conservation – states and federal agencies working together to approach the problem on a watershed scale. The importance of this legislation for SEUTP is that it sets precedence for all seven states within the Colorado River watershed to work together to strengthen the potential for long-term funding and success of tamarisk control and management.

Environmental Background

Environmental Setting

The SEUTP project area is located entirely within Grand and San Juan counties including: 1) the Colorado River watershed from the confluence of the Green River to the UT/CO state line, 2) tributaries north of the San Juan River watershed and east of the Colorado River from the Green River to Lake Powell, and 3) the section of the Dolores River watershed located in Utah – an area of approximately 5,500 square miles. According to the U.S. Census Bureau's 2005 report, the population of Grand and San Juan Counties combined was just under 23,000 individuals. This is a relatively small population for an area visited by over two million tourists every year. If visitations to the Lake Powell National Recreation Area are included, visitation days to the area are increased substantially.

Terrain within this area ranges from saline Mancos shale north of the Colorado River in the Cisco Desert to deeply incised sandstone canyons of the Colorado Plateau with occasional broad open valleys and tributaries. The Colorado River passes near two incorporated towns; the city of Moab and the town of Castle Valley. The other community in the area is Monticello which lies on the southern fringe of the watershed. Numerous tributaries (perennial, intermittent, and ephemeral) originate in the La Sal and Abajo mountains, Bookcliffs, and the canyon country of Arches and Canyonlands National Parks. The primary flow of the Colorado River originates in the state of Colorado along the continental divide. The major tributaries in the SEUTP study area are the Dolores River just west of the UT/CO state line, the Green River and several other local, large tributaries.

Landownership is mixed and includes two national parks, Bureau of Land Management (BLM), US Forest Service, School and Institutional Trust Lands Administration (SITLA), Sovereign Lands managed by the State of Utah, Utah Division of Forestry, Fire and State Lands, conservation lands, county owned lands, city owned lands, and private property. All segments of the Colorado River are boat-friendly, with sections being extremely popular with rafters and kayakers including the "daily" reach from Hittle Bottom to Moab in addition to Westwater and Cataract Canyons; both of which are world renowned for their scenic grandeur and whitewater.

Vegetation within this portion of the Colorado River watershed ranges from alpine spruce/fir conifer forests and aspen communities; to mountain shrub and pinon/juniper uplands; to saltbush/bunch grasses/sage/oak-leaf sumac sumac/greasewood/rabbitbrush terraces adjacent to the riparian zone traditionally inhabited by cottonwood, willow, reeds and other shrubs.

Since the early 1900's following its introduction from Eurasia tamarisk infestations have dominated and altered many watersheds in the west including the Colorado River Basin. Tamarisk infestations are generally located below 6,500 feet in elevation primarily in the riparian zones along waterways within the basin. There are isolated pockets at higher elevations, but tamarisk is less competitive with native species at these altitudes due to higher precipitation rates.

The majority of tamarisk infestations can be found within river corridors including riparian and floodplain terraces, often stretching to the full extent of the floodplain. Side canyons, ephemeral streams, and tributaries typically have denser stands near their confluence with the Colorado River gradually thinning upstream within the drainage to support isolated stands of tamarisk. Upland tamarisk infestations do occur outside of the floodplain where shallow groundwater or surface water accumulates, but are typically not as common or as dense.

Introduced in the late 1800's, Russian olive is found below 8,000 feet and ranges more widely than does tamarisk from the riparian corridor. Russian olive infestations are predominantly located near population centers where they have spread from ornamental plantings – e.g., Mill Creek in Moab and Castle Valley. It is particularly important to address these infestations where they are contained in side canyons before they spread further into the river corridor. There are also some other invasive trees such as Siberian elm (*Ulmus pumila*), black locust (*Robina pseudoacacia*), tree of heaven (*Ailanthus altissima*), etc. that could spread. Fortunately these invasive woody species do not exist in large numbers; thus, it will be important to target these species in any restoration strategy.

Special Status Wildlife Habitat

Invasive woody species such as tamarisk and Russian olive are concentrated along rivers and waterways which contain important wildlife species and habitats. According to The Nature Conservancy, more than 22 percent of the freshwater fish species and subspecies in the Upper Colorado River are of global conservation concern. The Colorado River within the planning area is formally designated Critical Habitat for four endangered fish; the bonytail (*Gila elegans*), the Colorado pikeminnow (*Ptychochelius lucius*), the humpback chub (*Gila cypha*), and the razorback sucker (*Xyrauchen texanus*). The Nature Conservancy has also indicated that the Upper Colorado River's amphibians have the highest percentage (75 percent) of imperiled species and subspecies. In addition, Federally-listed or candidate threatened and endangered (T&E) bird species known to use the project area include the yellow-billed cuckoo (*Coccyzus americanus*), Mexican spotted owl (*Strix occidentalis*), and the bald eagle (*Haliaeetus leucocephalus*). Several T&E plant species also occur in the area. Locations of observed sites for these species within the study area are maintained by the Utah Division of Wildlife Resources and the U.S. Fish and Wildlife Service.

The Colorado River and its tributaries riparian woodlands are prime examples of a plant community or type of ecosystem that is scarce at lower elevations of this arid region. Although riparian areas comprise only 0.5-1.0% of the overall western landscape, a disproportionately large percentage (approximately 70 to 80 percent) of all desert, shrub, and grasslands animals depend on them (Belsky et al. 1999). An estimated 60 to 70 percent of western birds species (Ohmart 1996) and as many as 80 percent of wildlife species in Arizona and New Mexico (Chaney et al. 1990) are dependent on riparian habitats. Consequently, riparian ecosystems are considered to be important repositories for biodiversity throughout the West.

In the past, there has been concern about the endangered southwestern willow flycatcher (*Empidonax trailii extimus*) nesting in the SEUTP study area; however, recent determination by the U.S. Fish and Wildlife Service is that this area is no longer considered critical habitat for this avian species (USFWS 2005)

Tamarisk and Russian Olive Species

The Colorado River and its associated riparian corridor are renowned for their ecological, recreational, aesthetic, cultural, and vital economical value for water supply, livestock production, and, to a smaller degree in Southeastern Utah, agriculture (USDI/USDA 1998). 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.

- Leaf litter from tamarisk 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 livestock by reducing forage and preventing access to surface water.

- 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).

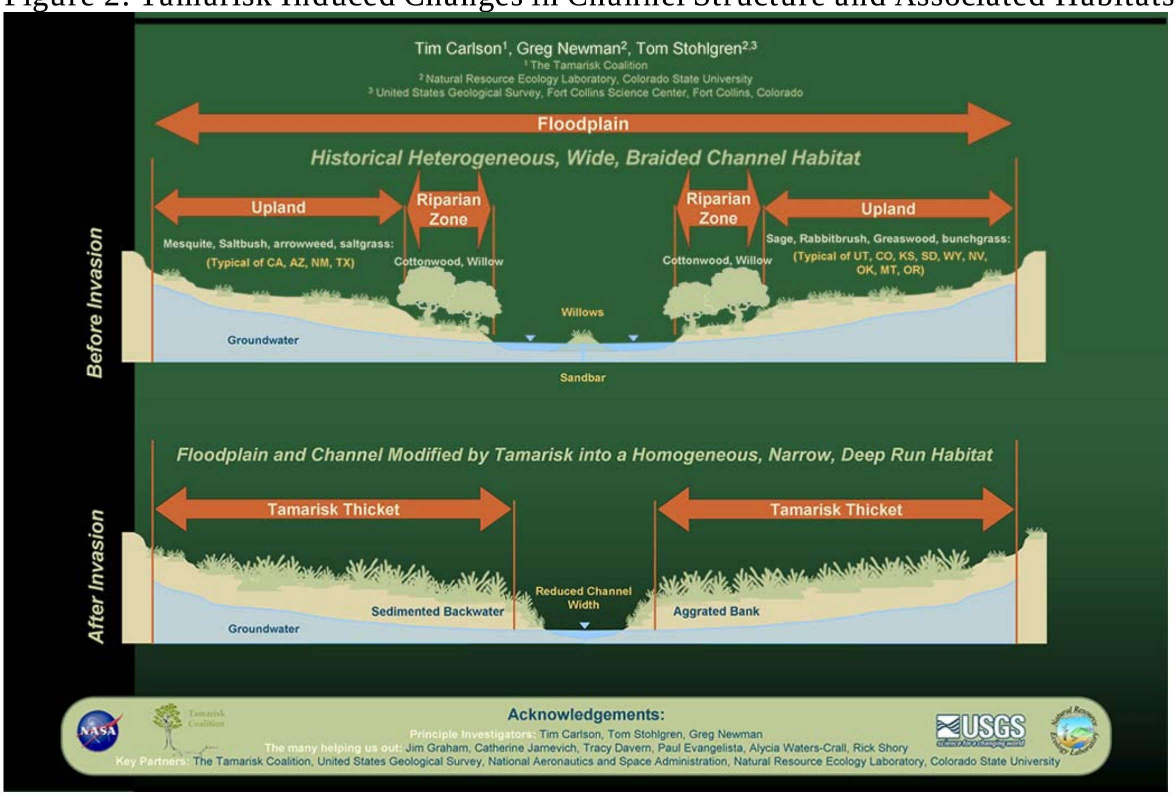
What are the Local Impacts? – The most critical impacts for the SEUTP study area are aesthetics, wildlife habitat loss, fire, and water usage. Aesthetics is critically important to the area because tourism is the major economic driver for the area. Wildlife habitat loss is important from the ecological standpoint while fire is a safety concern to the communities. Water loss, while less of an important issue locally is probably more critical from a state perspective. 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 oak-leaf sumac) 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 greatly with changing locations, plant maturity, and density of infestation, water quality and depth to groundwater. 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.

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 Associated Habitats



When tamarisk occurs amid 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 principally a function of the precipitation received for the area. 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. In the West this ranges typically from 0.5 to 1.5 feet per year.

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 (Elemental Stewardship, 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 mature and 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 tolerate 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
- Wide spreading throughout woodlands connects 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 2002 and Tu 2003.

It should be noted that various other tree species, such as Siberian elm, ailanthus, and black locust; grasses such as pampas and ravenna grass; forbs and flowers including Russian knapweed, spotted knapweed, purple loosestrife; and other invasive plants are of concern and will be considered throughout the planning and implementation of SEUTP's 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
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

CHARACTERISTICS		DESCRIPTION
	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 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

Extent of the Problem

Inventory Background & Objectives – In January 2007, SEUTP initiated efforts to inventory and map tamarisk and Russian olive infestations in the Colorado River watershed and its main tributaries within the study area. The purpose of this work is to provide a relatively accurate understanding (80 to 90 percent) of the extent of the tamarisk and Russian olive problem. The remaining percentage represents small pockets of infestations that are scattered throughout the region and would be proportionately very expensive to map. This work will be completed during the spring 2007 and will be contained in a document that compliments the SEUTP plan. This information will include aerial photos, highlighted infestations, GIS shapefiles, photo points, attribute tables, restoration cost estimates, and impacts to water resources and wildlife habitat. A CD format will be used to distribute this large volume of information. It should be noted that other invasive non-native woody species also exist within the SEUTP study but are not being inventoried because of their low density and distribution.

Inventory Approach – The inventory and mapping work is being coordinated with the U.S. Geological Survey's (USGS) efforts to establish a national on-line database conforming to the North American Weed Management Association's mapping standards. The basic approach (see Appendix D for mapping protocols) utilizes existing aerial photography completed by the Farm Service Agency at one-meter resolution (flown on July 13-15 and August 23, 28, and 29, 2006) and local knowledge available from counties, federal agencies, and local experts. BLM aerial photos and Google Earth images are used to crosscheck the Farm Service Agency images to improve the accuracy and quality of the photography. These images will be analyzed for tamarisk density, accessibility, presence of native species, and several other site characteristics. Impacts to wildlife habitat and water resources will be assessed as well as restoration cost impacts. Over 500 miles on the Colorado River and major tributaries are being surveyed using this approach. This information, in the form of shapefiles and attribute data, will be transformed into a digital GIS database which will be available on the USGS invasive species website, www.niiss.org .

Preliminary Findings – The preliminary inventory for the Colorado River and its major tributaries indicates that there are approximately 30,000 to 35,000 acres of the riparian floodplain that supports tamarisk infestation within the SEUTP study area (see Figure 1). Of these infested areas, overall tamarisk canopy cover is estimated to be between 30 and 40 percent. Soil and groundwater conditions necessary to support native phreatophyte communities, such as willows and cottonwoods, occur on only 5 to 15 percent of the floodplain. The remainder of the floodplain supports mesic and xeric vegetation such as oak-leaf sumac, 4-wing saltbush, rabbitbrush, bunch grasses, salt grass, and other shrubs and forbs. Russian olive infestations are most prominent in the Moab area along Mill Creek and in Castle Valley. There are only limited infestations outside of these areas.

Expected Ecosystem Changes to Riparian Areas – Expected results of tamarisk and Russian olive control projects in the Colorado River watershed include restored aquatic, riparian, and floodplain ecosystems. The quantity and quality of these habitats for fish and wildlife including endangered status fish species would be improved.

Opportunities for environmental education, improved aesthetics, recreation, and improved management of flood flows would exist in project areas. In some areas there may be conservation of water resource and the reestablishment of wildlife habitat resulting from tamarisk and Russian olive control in the Colorado River watershed.

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 principle non-native phreatophyte in the Colorado River watershed. In general, the following discussion also applies to Russian olive and other invasive tree species 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 at www.tamariskcoalition.org . It describes 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.

The discussions below represent brief descriptions of most of the techniques available and the findings of the "Control and Revegetation Committee" as to their suitability for the SEUTP study area. It is important to note that the approaches recommended conform to Guiding Principles discussed earlier in the plan and that each land manager and/or land owner is responsible for selecting the most appropriate techniques for their land.

Control

Tamarisk can be controlled using a variety of weed management techniques, including manual, chemical, mechanical, and biological methods. All of the following tamarisk control techniques are appropriate, but each must be selected based on local conditions; i.e., “Integrated Pest Management.” Integrated Pest Management or IPM is the “toolbox” from which land managers select techniques for a project in a specific setting. Land managers may deem any of the techniques described below as appropriate control methods for their specific lands.

The IPM toolbox includes community values, prevention, cultural management, land stewardship, mechanical or physical removal, biological control, herbicide treatments, and revegetation techniques (see www.tamariskcoalition.org for more detail). It should be noted that combinations of these methods are often used for effective tamarisk control. Actual costs and applicability may vary for each site. The basic approaches include:

- **Hand cutting with herbicide application** – This method is referred to as the “cut stump” approach in which the tree is cut or scored with chainsaws, handsaws, or axes, and the stump is treated with an herbicide within a few minutes of cutting. This approach is considered to be very appropriate in the SEUTP study area for difficult to access areas; areas of special concern; areas in close proximity to valuable native vegetation, historic and archeological sites; campgrounds; and efforts involving volunteer support.

- **Hand removal by extraction –** This method uses simple hand tools such as the Weed Wrench, tripod/hand winch, and shovels and saws to dig out the root system and cut below the root crown. These techniques have been perfected at the Dinosaur National Monument and utilize volunteer groups because of their high labor requirements. No herbicides are used with these approaches. These approaches are most appropriate for the SEUTP study area in sensitive areas where volunteer labor can be used to effectively remove tamarisk. This approach may not work on larger trees.

- **Mechanical removal –** This approach uses heavy equipment to physically remove tamarisk. This is accomplished in one of two ways – root crown removal or mulching.

    - **Root crown removal** is the extraction of the root crown by either root plowing accompanied by root raking to remove the root crown from the soil or by extraction of the entire plant. These approaches do not use herbicide.

- **Root plowing and raking** is extremely disruptive to the soil, native plants are destroyed, and the intense soil disturbance would support weed viability. It essentially removes all vegetation in a manner that would be similar to preparing land for intense agricultural production. For this reason and because much of the area is not accessible for large equipment (Cat D-7 or larger), it is unlikely that root plowing and raking would be used in the SEUTP area.

- **Extraction** approaches using a large tracked excavator (Cat 325 or larger) is appropriate for some areas, especially those areas that have steep banks such as ditches and river banks and along roadway embankments. Figure 3 provides an example of this technique. This approach results in high levels of soil disturbance and thus may require significant revegetation efforts. The removed biomass may also require disposal or additional treatment such as mulching.

Figure 3: Extraction of tamarisk near Socorro, New Mexico

- o **Mulching** uses newly developed specialized equipment followed by herbicide application to the cut stumps. The most commonly used pieces of equipment are the Timber Ax, the Hydro Ax, and the Bull Hog (see Figure 4). The resulting mulched materials can reduce soil disturbance, and provide a good seed bed for native plant recruitment if the mulched materials are not too thick while discouraging establishment of noxious weeds. Tracked mulching equipment provides a lighter footprint pressure than those with wheels and thus causes less soil disturbance. SEUTP areas suitable for this approach are limited to wide or somewhat level floodplains or terraces in scattered locations along the Colorado River. A few larger tributaries could also be treated by mulching, including discontinuous bottomlands along the Dolores River, lower reaches of Kane Creek, wetland areas within the Matheson Wetlands Preserve and in 7-mile Wash, the middle reach of Indian Creek, and possibly areas along Cisco Wash.

Figure 4: Medium-sized mulching equipment using a rotary drum cutting head, Moab, Utah.

- **Aerial herbicide application –** In larger infestation areas such as in Texas and New Mexico, helicopter and fixed wing aircraft are being used to apply foliar herbicide where monotypic stands of tamarisk exist. This approach will likely be limited in the SEUTP study area because: 1) monotypic infestations in this region are typically not broad enough to make this approach economically feasible, 2) significant native vegetation is present within the tamarisk infestations and aerial spraying would cause mortality among these species, and 3) preliminary biological control results for southeastern Utah look promising.

- **Ground application of foliar and basal bark herbicides –** Herbicides can be effectively applied by hand, on horseback (see Figure 5), or by motorized equipment in some cases where other methods are impractical or expensive. It is recommended that this approach be used in isolated areas where other methods would unlikely be used such as scattered infestations in sparse or remote locations, upland areas, isolated stock tanks, etc.

Figure 5: Horseback herbicide spray application, Wyoming 2004

- **Biological control –** This method for invasive plant control uses specific organisms to control an undesirable organism. For tamarisk, two biological control agents have been identified – goats and a tamarisk leaf-eating beetle. Both organisms work to control tamarisk by repeated defoliation of the plant over several years.

    - **Goats** will feed on tamarisk shrubs if fencing is provided to limit other food sources. Typically, a guard dog, herding dog, and goat herder or electric fencing pens are required. Several private goat herds are available throughout the region. For some areas this approach may be favored, especially if other noxious weeds such as knapweed are in abundance and herbicide use is restricted.

- ***Diorhabda elongata*, tamarisk leaf-eating beetle,** has been tested extensively in quarantine and field releases to ensure safety with respect to non-target impacts. These insects, native to Kazakhstan, are currently being openly released in Utah. Russian olive will not be controlled through this biological control agent. The use of these insects is seen as an important issue and a promising approach for tamarisk control for the main river corridor. Because of the significance of this technique to the SEUTP study area, a more complete discussion on this approach is provided in the next section.

Figure 6: *Diorhabda elongata* adult beetle, actual size ~ 3/16 inch.

Biological Control of Tamarisk with the Tamarisk Leaf Beetle and Its Implications for Southeast Utah

Over the past three years, there have been concentrated releases of large numbers of the biological control tamarisk leaf beetle (*Diorhabda elongata*) in the Moab, Utah area. Records of biological control releases will be maintained by Grand and San Juan Counties and research and/or future releases should be coordinated through each county. Landowner approval is required for releases to occur whether private, public, or conservation lands (e.g., The Nature Conservancy). Past release sites are located along the Colorado River at Dewey Bridge on Highway 128 and at the Potash mine site approximately 15 miles west of Moab, in Williams Bottom, and Canyonlands by Night. These releases resulted in a few tamarisk trees being defoliated in Year-1 and approximately 2 acres in Year-2. In Year-3, the insect populations were fully established and tamarisk was totally defoliated (though not killed), on over 10 miles of the Colorado River including spread to non-release sites on the opposite side of the river and along tributaries (see Figures 7, 8, and 9).

The extent of the beetles' impact in Utah is unique and provides an excellent opportunity to gather information about the implications of the biological control for the native plant mosaic. State universities are responding quickly (May 2007) to this opportunity by setting up monitoring stations to track various impacts before and after beetle presence.

Controlled test sites show that three to five years of sequential defoliation are required to achieve tamarisk mortality of 70 percent (Delta , Utah); however, it is unknown how many seasons of defoliation will be required to kill tamarisk in Southeastern Utah's natural setting (Bean, 2007). The most promising characteristic of the tamarisk beetle is that it inflicts no damage to native plant populations. Preliminary evidence of effectiveness shows great potential and if biological control continues to progress it could be used as one of the main mechanisms for tamarisk control and maintenance. If this is the case, the advantages over other approaches will be significant; i.e., limited use of herbicides and a cost effective long-term solution.

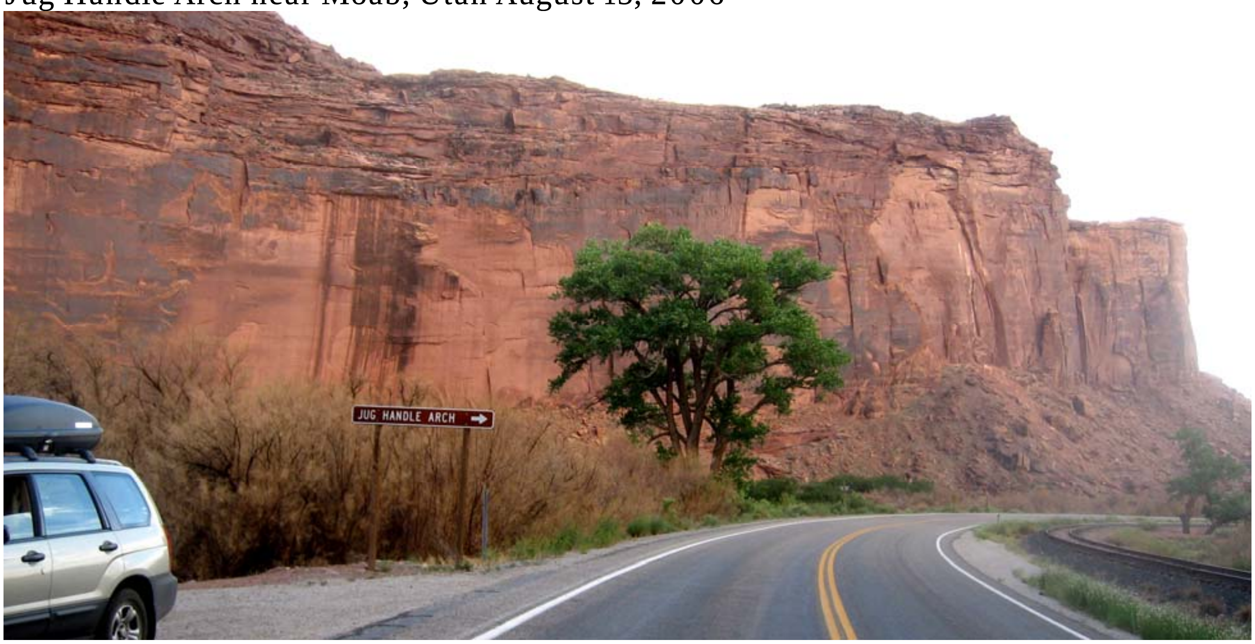
Figure 7: Colorado River at Potash mine boat launch area near Moab, Utah showing defoliated tamarisk, August 15, 2006

Figure 8: Defoliated tamarisk and undamaged native vegetation along the Colorado River west of Moab, Utah; August 15, 2006.

Another point of interest is that lightly infested areas some distance from the main tamarisk infestations along the Colorado River in southeastern Utah support beetle activity and experience defoliation. However, overtime, these small stands may simply provide an insufficient food source to sustain a growing population of insects. Thus, alternative methods should be considered for these areas. Monitoring will be instrumental in determining the rate of beetle spread, rate of defoliation, rate of tamarisk mortality, native plant recruitment, other weed infestations to be addressed, biomass accumulation, and biomass removal approaches. The expertise of regionally available entomologists and other experts at Utah State University, University of Utah, and the Palisade Insectary will be critically important for identifying the most appropriate protocols for disbursement, monitoring, and maintenance actions.

Although biological agents are being investigated for Russian olive, these invasive trees will still require traditional methods of control.

Figure 9: Defoliated tamarisk and undamaged cottonwood along the Colorado River at Jug Handle Arch near Moab, Utah August 15, 2006



Biomass Reduction

Removal of dead tamarisk tree skeletons may be important after mechanical root crown removal, biological control, or foliar herbicide control if densities are moderate to heavy. Biomass reduction under these conditions assists planned revegetation efforts, restores aesthetic values, and reduces the wildfire potential of decomposing litter in moderately to highly infested areas. Standing dead biomass in lightly infested areas probably does not significantly impede natural or planned revegetation, affect aesthetics, or support high wildfire potential. Therefore, such stands could be allowed to naturally decompose. The removal of green biomass in sensitive areas is important because wildfires may actually be a greater problem then dead skeleton trees.

The removal of dead trees can be accomplished using mechanical mulching equipment or fire (see Figures 10 and 11). Mechanical mulching, by its nature manages woody plant material by transforming it into mulch. However, if a large amount of biomass is mechanically mulched and piled the thickness of the layer produced may actually impede or prevent revegetation. Reducing biomass with fire may require the construction of adequate fire breaks in sensitive riparian areas to safely burn the invasive plants. At the same time, properly mulched areas can support native growth while limiting weeds. In addition, air quality may be a concern for large-scale burns as carbon sequestered in the tamarisk will be released instantly. In contrast, mulched or standing dead plants release carbon at a rate that is partially offset by the carbon sequestering growth of other plants.

Fire is an option that must be carefully coordinated with local land managers and county air quality personnel. As shown in Figure 11, fire breaks and professional fire fighting personnel are critical because of the intensity of tamarisk fires.

Figure 10: Fire break in Scott M. Matheson Wetlands Preserve, mechanical removal and cut stump approach, June 2004. See Figure 4 for equipment used.

Figure 11: Controlled fire used for dead tamarisk at the Bosque del Apache NWR, NM 2004

Revegetation

Successful revegetation is an enormously complex undertaking with few straightforward guidelines and no universal solutions. As a result, implementing revegetation projects following the removal of invasive species is an inherently site-specific task that does not easily translate into a large scale plan. SEUTP recommends consulting with revegetation specialists such as the Utah Partnerships in Cooperation and Development (UPCD), comprehensive revegetation and restoration texts, and local experts to develop a course of action for individual projects. The University of Denver is currently preparing a "Best Management Practices" handbook for revegetation that will be available in 2007. There are many excellent sources presently available to inform SEUTP's revegetation actions with some of them reviewed below:

- **Society for Ecological Restoration**
  Summary: This site provides a reading list for ecological restoration practices, links for many example projects and other resources and support.
  http://www.ser.org/reading_resources.asp

- **Riparian Restoration in the Southwest – Species Selection, Propagation, Planting Methods, and Case Studies**
  Summary: This document identifies the natural processes and managed activities that cause the degradation of riparian lands and provides general guidelines to restore the natural system. It details methods of selecting appropriate species for revegetation, producing riparian plants, planting techniques, and provides case studies of past projects.

http://www.nm.nrcs.usda.gov/programs/pmc/symposium/nmpmcsy03852.pdf

- **Stream Corridor Restoration: Principles, Processes, and Practices**
  Summary: This large and detailed document has a three-tiered design. The first section provides background information describing the basics of stream corridor systems. The second section describes the steps to produce an effective restoration plan. The final section provides guidelines to implement restoration projects.
  http://www.nrcs.usda.gov/technical/stream_restoration/

- **Guidelines for Planning Riparian Restoration in the Southwest**
  Summary: This restoration guide is intended to address concerns that must be considered when developing riparian restoration projects as well as a number of responses or solutions to these potential problems.
  http://www.nm.nrcs.usda.gov/news/publications/riparian.pdf

- **Guidelines for Planting Longstem Transplants for Riparian Restoration in the Southwest: Deep Planting**
  Summary: Good possible technique if you are revegetating a riparian site that lacks overbank flooding and has a deep water table.
  http://www.nm.nrcs.usda.gov/news/publications/deep-planting.pdf

- **The Pole Cutting Solution**
  Summary: Guidelines for planting dormant pole cuttings in riparian areas of the Southwest. Planting dormant pole cuttings has proven to be a successful technique for establishing many riparian tree and shrub species.
  http://www.nm.nrcs.usda.gov/news/publications/polecutting.pdf

- **Plant Technology Fact Sheet: Tall-Pots**
  Summary: This fact sheet describes the use of tall-pots to establish plants in areas lacking sufficient soil moisture or irrigation availability to revegetate using more traditional means. A discussion of the structure, usefulness, benefits, and limitations of the tall-pot revegetation method is included.
  http://www.nm.nrcs.usda.gov/programs/pmc/factsheets/tall-pot.pdf

While the specifics of revegetation are difficult to comprehensively determine, some general information corresponding to the SEUTP landscape is provided here.

One of the most interesting aspects of Utah's experience with tamarisk control is the abundance of native plants present in the tamarisk understory. Non-native weeds such as Russian knapweed and whitetop were also found and could become a problem if left unattended. It is important to remember that removing other weed species may be the most important revegetation treatment performed.

Weed species potentially targeted for control include (but are not limited to): invasive non-native trees such as Siberian elm, ailanthus, Russian olive, black locust; grasses such as pampas and ravenna grass; forbs and flowers including Russian knapweed, spotted knapweed, purple loosestrife, and others. Annual weeds, while a short term concern, generally find a balance that does not preclude native plant establishment (with some exceptions). A plant list is included in Appendix F as a starting point for revegetation planning, keeping in mind the importance of knowing specific site characteristics before choosing plants for revegetation purposes.

Revegetation is critical to successful long-term tamarisk and Russian olive control. Revegetation cost components include site preparation, labor, seed, plant materials, fertilizer, equipment rental, weed control, and water. Requirements for revegetation have a direct relationship to density of tamarisk infestation, disturbance, width of infestation, and ecological potentials for each site.

For narrow widths (less than 50 feet) natural revegetation is assumed to occur but may require minor to moderate costs because of soil disturbance and weed control. For broader widths (greater than 50 feet) costs will increase because less native plant/seed will be available for reintroduction.

The SEUTP Control and Revegetation committee recommends that the least intensive/disruptive revegetation treatments are preferred (which also carries over to removal techniques) in most areas. This means avoiding extensive costs associated with irrigated projects – and relying on the natural regenerative capabilities of most areas

Revegetation considerations put a constraint on removal options. In order to minimize costs and water resources associated with revegetation, removal needs to account for ecological potentials of sites. Revegetation may not be needed along the river corridor and in side canyons where native trees, shrubs, grasses and forbs can revegetate within 50 to 100 feet of removal areas centers, nor would it be needed in areas that were historically sand bars or islands that were frequently inundated.

When there are many natives interspersed within the tamarisk stand (which is often difficult to determine until removal begins) removal of invasives must be executed in a manner that protects native seed sources for natural revegetation on-site and within the basin. Manual control, root extraction and Timber Ax mowing/mulching are methods capable of sparing interspersed natives, even 1-inch caliper saplings.

In broader areas of infestation, such as the Scott M. Matheson Wetlands Preserve, it is important to plan a removal pace that allows and encourages natural native plant regeneration rather than seeding and planting. However, in such large dense stands of tamarisk it may be advisable to create vegetative islands and paths within the tamarisk to help speed the native regeneration process, and provide fire breaks such as shown in Figure 10.

In some higher value areas such as wildlife habitats or high profile/high human use areas pole plantings, shrub and tubing plantings, and seeding may be desirable to aid in the regeneration process. However, these kinds of revegetation projects are extremely expensive and require long-term maintenance commitments. These costs may be unreasonable to expect in any but the highest value areas.

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 (i.e., are objectives being met), 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 SEUTP 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 usually located on 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 on public lands 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.

Small-scale monitoring on private lands 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.

Monitoring the spread and impact of the tamarisk leaf beetle is considered critical for the SEUTP study area. In view of the unique nature of the Canyonlands landscape and the initially rapid spread of the biological control agent in this region, careful and comprehensive monitoring of its spread and effectiveness should be a high priority in this comprehensive regional plan. Such monitoring should be planned and conducted in as rigorous and quantitative manner as possible.

Coordination between private land owners and public land managers is essential to gain access to private lands, create a standard monitoring protocol, effectively measure control methods and scientific variables, and to develop and execute training in monitoring methods.

The Control and Revegetation Committee believes it is important to identify some locations with biological control releases that **WOULD NOT** have active restoration and/or dead biomass removal as part of a long-term monitoring and assessment program. This may help provide insight into the "do nothing" alternative for impacts by the tamarisk beetle among other things. It also would help to determine if active removal of dead biomass and/or revegetation is truly a necessary practice.

Appendix G provides some additional information on monitoring specifics that the committee suggested could be useful to structure a monitoring program.

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.

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.

The question that must be addressed for the SEUTP Colorado River riparian lands is – ***who should perform monitoring and maintenance, do they have the legal responsibility for these actions, and do they have the necessary funding to carry out these responsibilities?*** This is a complicated question 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, agreed upon approach must be found. The future leadership of SEUTP will be instrumental in organizing with the diverse organizations and agencies of SEUTP a practical approach.

It is clear from past experiences, 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.

SEUTP Future Leadership

In May 2007, the SEUTP partners met to discuss the future leadership for the group after this planning document is complete. County representatives gave an overview of the pros and cons of the counties being the lead agencies, one big impediment is the lack of time, people, and resources in county agencies that already are very committed.

The consensus of the group was that Castleland RC&D would be the best option to serve as the "umbrella" for SEUTP, assisting grant-writing resources, and providing administrative and fiscal agent responsibilities for grants going through the RC&D. The SEUTP partners will develop roles for Castleland RC&D for these activities with the ultimate goal of establishing a paid woody invasives coordinator. The decision-making role for prioritizing projects and what organization would be best for submitting and receiving grants would remain with the SEUTP group.

Proposed Strategies for Control, Biomass Reduction and Revegetation

The following discussion presents proposed approaches for control, biomass reduction, and revegetation for specific geographic settings in the SEUTP area. These methods are based on discussions with land managers and recommendations provided by the Control and Revegetation subcommittee. These are "Planning-level" approaches that can be used to structure site-specific strategies and funding initiatives. The discussion is divided into the three unique watersheds within the SEUTP study area: 1) the Colorado River watershed from the confluence of the Green River to the UT/CO state line, 2) tributaries north of the San Juan River watershed and east of the Colorado River from the Green River to Lake Powell, and 3) the section of the Dolores River watershed located in Utah.

Each fluvial system discussed below has unique characteristics requiring unique combinations of tamarisk control, biomass reduction, and revegetation methods. However, the following general statements regarding biomass reduction and revegetation apply to all areas.

Biomass reduction is an important consideration for control projects. The dead biomass from light to moderate densities of tamarisk infestation can normally be left standing. Over the next ten years these skeletons will be significantly reduced in size due to root decay and biomass decomposition. Sites supporting heavy tamarisk infestations may require active biomass removal using mechanical equipment, hand removal, or regulated controlled burns. Due to the high cost of biomass reduction sites, requiring active biomass removal should be prioritized according to safety and aesthetics. High biomass levels on sites supporting increased fire hazards in and around towns, homes, and campgrounds; and sites with high visual impacts such as along Highway 128 and in the South M. Matheson Wetlands Preserve should be candidates for early removal.

The intensity of revegetation and weed control efforts following control efforts will increase proportionately with the degree of tamarisk infestation. Revegetation will likely occur naturally in lightly infested sites when aided by some minor weed controls. Moderate infestations will require some reseeding, while heavy infestations may require substantial revegetation efforts. Monitoring is a vital component to restoration and adaptive management.

Colorado River watershed from UT/CO state line to Green River confluence

Westwater Canyon - UT/CO state line to Cisco boat ramp – This area extends from the CO/UT border to river mile 110.5 and is relatively remote, accessible only by boat except for the Westwater BLM ranger station, the area across the river from the ranger station via Glade Park, Colorado, the last 1.5 miles of private land on the west bank which are owned by a SEUTP partner, and the Cisco boat ramp. Infestations are fairly light in this section as the schist forming the canyon wall extents to the river along the majority of the stretch. These lands are principally managed by the BLM though there are some private lands including the Denver Rio Grande Railroad east of Westwater Wash. Vegetation in this area primarily consists of tamarisk, willow, cottonwood and native riparian shrubs and grasses.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work will be necessary around camp sites and high priority cottonwood galleries to reduce the potential for wildfire. Applying herbicide to resprouts may not be necessary if biological control is active in the area. Some areas, such as the mouth of Westwater Creek and the area adjacent to the railroad right-of-way may be accessed by mechanical equipment for extraction, mulching, and/or biomass reduction. These options must be carefully coordinated and directed by BLM, the railroad company, and Grand County.

Cisco boat ramp to Dewey Bridge – This section of the Colorado River between river miles 110.5 and 94.5 is contained in a broad canyon wider than Westwater Canyon. There is some irrigable acreage at the Dolores River confluence. This braided river section is primarily managed by the BLM and has some private land inholdings. Throughout this section there are numerous large cottonwood galleries on floodplain benches, willows occupying islands and river edges, and tamarisk infestations ranging from light to heavy.

There were successful releases of the biological control agent, *Diorhabda elongata*, in 2004 within this segment. The results have been impressive. Insect populations became fully established in 2006 and tamarisk has been totally defoliated on several miles of the Colorado River adjacent to the release sites.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary around camp sites and high priority cottonwood galleries to reduce the potential for wildfire. In some areas where the floodplain is larger, such as the confluences of Cisco Wash and the Dolores River, it may be possible to use mechanical extraction and/or mulching followed by herbicide application. Applying herbicide to resprouts may not be necessary if biological control is active in the area. These options must be carefully coordinated and directed by the BLM and private land owners.

Dewey Bridge to Hittle Bottom – The Colorado River section between river miles 94.5 and 86 lies in a relatively narrow canyon with Highway 128 on the south bank and steep canyon walls on the north. Vegetation is dominated by tamarisk though willows, cottonwoods, 4-wing saltbush, rabbitbrush, oak-leaf sumac, and other shrubs and forbs are present. The land is managed by the BLM and the Utah Department of Transportation.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary around camp sites and high priority cottonwood galleries to reduce the potential for wildfire. Along Highway 128, hand removal with cut stump herbicide application and/or mechanical plant extraction may be a priority to ensure safety. Applying herbicide to resprouts may not be necessary if biological control is active in the area. These options must be carefully coordinated and directed by the BLM and the Utah Department of Transportation.

Hittle Bottom to Whites Rapid – Between Hittle Bottom (river mile 86) and Whites Rapid at the Castle Creek confluence (river mile 78) the Colorado River transitions from a narrow canyon to a broad valley back to a narrow canyon. The north side of the river is a continuous, sheer canyon wall in contrast to the south side of the river which is interrupted by a number of tributary valleys formed by Onion, Professor, and Castle Creeks. The land is owned by the BLM and private parties including two guest ranches. The vegetation is dominated by tamarisk with some Russian olive growth. There are also areas of prime native willow, cottonwood, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs and forbs. Working within these areas requires consideration for the health and preservation of these native plants.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary around camp sites and high priority cottonwood galleries to reduce the potential for wildfire. Applying herbicide to resprouts may not be necessary if biological control is active in the area. Russian olive control will require hand cutting or mechanical control with herbicide. These options must be carefully coordinated and directed by the BLM and private land owners.

Whites Rapid to Highway 191 bridge at Moab – The Colorado River between river miles 78 and 64 is contained in a narrow, sheer walled canyon bordered by Arches National Park on the north and BLM lands on the south. There are no private lands within this river section. Vegetation is dominated by tamarisk though willow, oak brush, cottonwood, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs and forbs are present.

This area has the highest concentration of BLM campgrounds in the area and tamarisk is the major vegetative species in many of them (see Figure 12). These popular campgrounds are considered high priority areas for tamarisk control to reduce the risk of wildfire to campers and native vegetation (e.g., the oak grove campground). Therefore tamarisk control for these campground areas should utilize hand cut stump and mechanical removal techniques and potentially an aggressive revegetation strategy. Working within these areas requires consideration for the health and preservation of these native plants. These areas also offer excellent opportunities to provide educational materials to visitors on all aspects of the riparian restoration activities.

Tamarisk control in areas away from the campgrounds will rely primarily on biological control using the tamarisk leaf beetle. Along Highway 128, hand removal with cut stump herbicide application and/or mechanical plant extraction may be a priority to ensure safety and ecological restoration. Applying herbicide to resprouts may not be necessary if biological control is active in the area. These options must be carefully coordinated and directed by the BLM and Arches National Park.

Figure 12: BLM campgrounds adjacent to Colorado River, September 2002.

Scott Matheson Wetlands Preserve – This 3 mile stretch of river (river miles 64 to 61) boarders a 900 acre wetland ecosystem containing the most diverse wildlife habitat between the UT/CO state line and Lake Powell. The Preserve comprises the largest wetland on the Colorado north of Lake Powell, is located on the east side of the Colorado River, and is jointly owned and managed by The Nature Conservancy and the Utah Division of Wildlife Resources. The west side of the river is owned by the U.S. Department of Energy (DOE) and contains the largest uranium mill tailings pile in the

U.S. (12,000,000 tons) that has not been fully remediated. DOE's long-term plans indicate that the tailings will be removed to a permanent repository north of Crescent Junction (DOE, 2005).

During the 100-year flood event of 1984 both sides of the main stem of the Colorado River experienced flooding conditions that were ideal for tamarisk and cottonwood recruitment. Prior to this event, the northern, upstream end of the Preserve was composed almost entirely of wetland meadows; though the southern, downstream area already supported a substantial cottonwood and black willow community. There are also numerous dense patches of Russian olive within the Preserve especially along Mill Creek.

There have been a number of tamarisk and Russian olive control projects that have occurred within this area to develop fire breaks, mosquito control access, gas pipeline and power line right-of-way clearing, and to improve wildlife habitat. The techniques used have been hand clearing and mechanical mulching both followed by herbicide treatment. It is recommended that both of these techniques should continue to be used for high value areas such as in/near cottonwood groves and for fire breaks.

Biological control using the tamarisk leaf beetle could be used for the remainder of the area; however, The Nature Conservancy would require permission from its lead scientist prior to any beetle releases. For the DOE site, it will be important for the biomass to be surveyed for radiation contamination to determine the most ecological restoration practice to be used.

Most of the tamarisk infestations within this area are heavy density stands. These areas will require a well coordinated biomass reduction and revegetation approach which may be extensive. Many of the areas within the cottonwood groves may need only low to moderate revegetation efforts because natural revegetation is more likely to occur here.

Scott Matheson Wetlands Preserve to Potash – Between river miles 61 and 47, the Colorado River enters into the canyon country that the area is known world-wide. Highway 279 borders on river right to the Potash boat launch. On river left, Kane Creek Road borders the Colorado River to the Kane Creek confluence. The land is owned by the BLM and the Utah Department of Transportation. Vegetation is a mix of tamarisk (the most abundant species), willows, some scattered cottonwoods and cottonwood galleries, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs and forbs.

There were two releases of the biological control agent, *Diorhabda elongata,* in 2004 at the Potash boat launch and Williams Bottom. The results have been impressive. Insect populations became fully established in 2006 and tamarisk have been totally defoliated on over 10 miles of the Colorado River including non-release sites on the opposite side of the river and along tributaries (refer back to Figures 3, 4, and 5).

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary at high priority cottonwood galleries, such as Williams Bottom picnic area and

Jug Handle Arch, to reduce the potential for wildfire. Along Highway 128 and Kane Creek Road hand removal with cut stump herbicide application and/or mechanical mulching and whole plant extraction may be necessary to assure highway safety. Applying herbicide to resprouts may not be necessary if biological control is active in the area. These options must be carefully coordinated and directed by the BLM, Grand County, and the Utah Department of Transportation.

Potash to Green River Confluence – This section of the Colorado River, between river miles 47 to mile 0, enters the heart of Canyonlands National Park here as a deep, sheer walled canyon with an extremely narrow floodplain no more than 100 feet on either side of the river's edge. The entire length of this riparian habitat is dominated by tamarisk with significant willow stands along the river's edge. This area is accessible only by boat.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary around camp sites, high priority cottonwood galleries, popular boat rest areas, etc. Applying herbicide to resprouts may not be necessary if biological control is active in the area. Due to the remote nature of this section, biomass removal may not be practical following biological control of sites within this segment.

This remote section in 2006 supported an established biological control presence. As a result, it will be important for the National Park Service and the BLM to monitor natural revegetation and to develop action plans for handling weed infestations and biomass reduction. Adaptive management will be a major component for restoration in this area.

Bitter Creek, Westwater Creek, Cottonwood Creek, Nash Wash, Pinto Wash, and Sagers Wash – These major intermittent to perennial drainages originate in the Book Cliffs and pass through the Cisco Desert on their way to the Colorado River. The land they occupy is predominately managed by the BLM though they occasionally pass through private ranchland. The drainages cut through soils derived from the Mancos shale of the Book Cliffs; therefore, their soils are highly alkaline silts with limited areas or segments of willow, cottonwoods and riparian grasses. The drainages have various levels of tamarisk infestations that extend many miles upstream of their confluence with the Colorado River. A few of the tributaries have relatively minor infestations, for example Cottonwood Creek. Others, such as Nash Wash, have heavy infestations.

In general, tamarisk infestations are lightly scattered in the upper elevations as they exit the Book Cliffs. Here it is recommended that hand control be utilized with herbicide, possibly by horseback. Where infestations are contiguous, it is recommended that biological control using the tamarisk leaf beetle be the main approach. Applying herbicide to resprouts may not be necessary if biological control is active in the area. Most of these areas should not require biomass reduction or revegetation efforts; however, weed control will be necessary. For Bitter Creek, coordination with BLM weed management in Colorado will be necessary as this tributary originates within that state.

Jones Canyon, Little Dolores River, and Coates Creek – These perennial streams originate in the upper canyons of the McInnis Canyons National Conservation Area in Colorado. They have heavy tamarisk infestations at their junctures with the Colorado River which thin upstream. Their soils are sandstone derived and support cottonwood, willow, and riparian grasses.

Hand cut stump control should be used in these areas beginning with the upper extent of infestation and working downstream towards the Colorado River. Biological control on the main stem of the Colorado River should provide the treatment for heavier infestations near the confluence. Some areas in the headwaters of Coates Creek (see Figure 13) and Little Delores River could be mechanically removed. Coordination with BLM weed management in Colorado will be necessary as these tributaries originate within that state.

Biomass reduction should not be necessary for the upper portions of the canyons where hand control is performed. Natural revegetation will likely occur in most areas; however, some weed control will be required.

Figure 13: Coates Creek, November 2005 with cottonwoods and scattered tamarisk.

Onion Creek, Professor Creek, and Castle Creek – These perennial streams originate on the slopes of the La Sal mountains and flow through sandstone canyons that support a wide variety of plant communities including areas of willows, cottonwoods, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs, forbs, and grasses. Tamarisk is most abundant at their confluences with the Colorado River but appear in isolated pockets of light infestation along these creeks. Additionally, there are significant infestations of Russian olive in the Castle Valley area that have escaped from ornamental plantings.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary around camp sites, high priority cottonwood galleries. In the Castle Valley community the recommended approach is the whole plant extraction technique to avoid the use of herbicide since the watershed serves as a domestic water source. Additionally, herbicide for resprouts may not be needed if biological control is active in the area. Russian olive control will require hand cutting or mechanical control with herbicide.

Salt Wash and Courthouse Wash – Salt Wash originates in the Book Cliffs and Courthouse Wash forms northwest of Arches National Park. Both are administered by the BLM and Arches National Park though they do pass through some private land. For much of their lengths the soils are derived from the marine deposited Mancos shale; therefore, their soil characteristics are highly alkaline silts that support limited growth of cottonwood, willow, and riparian grasses. When the washes pass through Arches National Park the soils are derived from sandstone and support more cottonwood and willows. This is particularly true for Courthouse Wash. Tamarisk infestations along both drainages range from light to heavy such as in Wolfe Ranch/Cache Valley area (see Figure 14).

Since biological control using the tamarisk leaf beetle is literally on the doorstep of the park, the NPS should plan for tamarisk control incorporating this technique into its invasive species strategy. For several years the NPS Lake Mead Exotic Plant Management Team has been successfully removing tamarisk in the park using the hand cut stump approach. This approach should be continued around cottonwood groves to reduce potential of wildfire, and any high priority sites. In some areas such as Wolfe Ranch/Cache Valley area it may be possible to use mechanical extraction and/or mulching with herbicide application.

Due to the national significance of this park, it will be important for the National Park Service to monitor how natural revegetation is proceeding and develop action plans for handling weed infestations and biomass reduction. Adaptive management will be a major component for restoration in this area.

Figure 14: Arches National Park, tamarisk infestations in Salt Wash at Wolfe Ranch with restoration efforts in foreground, August 15, 2006.

Negro Bill Canyon – This popular hiking area is moderately infested with tamarisk and would be an excellent location for hand control volunteer projects. No revegetation efforts will likely be needed on this perennial stream due to the high degree of native vegetation.

Moab Canyon – This canyon contains an ephemeral stream paralleling Highway 191 and support light to moderate infestations of tamarisk. The stream originates in the Island in the Sky district of Canyonlands National Park. It supports a wide variety of plant communities including willows, cottonwoods, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs and forbs. The lands are owned by the BLM, the state, and some private owners at the Highway 191 and 313 interchange.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work may be necessary around camp sites, and high priority cottonwood galleries. Along some areas of Highway 191 it may be important to remove tamarisk by hand or mechanical methods for safety. Herbicide may not be needed for resprouts if biological control is active in the area.

Mill Creek, North Fork Mill Creek, and Pack Creek – These perennial streams originate in the west flank of the La Sal Mountains and support light to moderate levels of tamarisk infestation in their upper reaches outside of the Moab/Spanish Valley area.

Russian olive densities increase tremendously within Moab to the point that Russian olive is the dominate invasive tree in Moab.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Russian olive control will require hand cutting or mechanical control with herbicide around camp sites, cottonwood galleries, and other high priority sites such as the Mill Creek trail to improve restoration and reduce fire risk associated with biomass concentrations.

Kane Creek, Hatch Wash, Indian Creek, North Cottonwood Wash, and Salt Creek – These perennial streams originate in the south and west flank of the La Sal National Forests and surrounding plateaus, and support light to moderate levels of tamarisk infestations.

Kane Creek headwaters are in USFS lands and Hatch Wash flows from the Monticello area. Both sandstone canyons flow mainly through BLM and support a wide variety of plant communities including areas of willows, cottonwoods and cottonwood galleries, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs, forbs, and grasses. There also are a number of large Russian olive trees in Kane Creek at its confluence with the Colorado River. The differences in infestation in Hatch Wash (light) and Kane Creek (moderate) is a good example of tamarisk's preference for siltly sand soils common to Kane Creek versus the coarser soils of Hatch Wash.

Indian Creek and North Cottonwood Wash begin on USFS managed lands in the Abajo Mountains. The streams drop in elevation into BLM lands and are mainly managed by the BLM though The Nature Conservancy owns Dugout Ranch. The confluence of Indian Creek and North Cottonwood is just below Dugout Ranch headquarters. The Conservancy controls the majority of the water rights (13.6 cfs) and thus the native riparian vegetation is in good to very good condition above the ranch's diversion with little to no non-natives present. Fremont and narrowleaf cottonwoods, box elders, and willows are the predominant native species. Below the ranch's diversions tamarisk dominance increases greatly and it forms many thick monostands. The lower reaches of Indian Creek are managed by the National Park Service. Access to the creek bottoms is mixed, ranging from excellent to poor. Indian Creek maintains very high visibility as a very popular camping and rock climbing destination area and as the gateway to the Needles section of Canyonlands National Park. The Nature Conservancy has done one small tamarisk removal project to date and plans to focus energy on riparian restoration efforts here in the future.

Salt Creek originates just west of the Seven Sisters Buttes on USFS lands. It crosses briefly through BLM land before entering its main stretch in Canyonlands National Park. The creek flows through remote canyons with moderate accessibility. Dense tamarisk stands at the Salt's confluence with the Colorado River are connected by light to moderate infestations to other stretches and pockets of extremely high infestation. Native species are limited and include oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs, forbs, and grasses, though a few scattered cottonwoods are present.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work and herbicides may be necessary around camp sites, cottonwood galleries, and other high priority sites to improve restoration and reduce fire risk associated with biomass concentrations. Where access and terrain allow, mechanical control may be possible.

Tributaries north of the San Juan River watershed and east of the Colorado River from the Green River Confluence to Lake Powell

Cataract Canyon - Green River confluence to Hwy 95 bridge at Lake Powell – This extremely remote river section extends between river miles 216.5 and 171 in a deep sandstone canyon and is only accessible by watercraft. The entire stretch is located in Canyonlands National Park and is managed by the National Park Service. The upper and lower ends of this section support moderate to heavy tamarisk infestations. The central portion of the canyon supports a few, scattered light to moderate infestations along the river due to its narrow nature and the bank scouring caused by high spring flows. Some willows and cottonwoods are present in the canyon.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work and herbicides may be necessary around camp sites, cottonwood galleries, and other high priority sites to improve restoration and reduce fire risk associated with biomass concentrations.

Hwy 95 Bridge at Hite to San Juan confluence – This section of the river is the point where the Colorado River transitions into the slake water of Lake Powell between river miles 171 and 77. The lakes surface elevation can fluctuate up to 50 feet in any one year as the lake is filled by spring runoff or drained for power production and to satisfy water demands required under the 1922 Colorado River Compact. In the late 1990's, inflow to Lake Powell was above average and the lake stayed full from 1995 through 1999. As late as September 1999, Lake Powell was still 95 percent full. Since year 2000 the lake has drained considerably because of the drought that has occurred in the West. The current lake elevation is 3,601 feet (May 8, 2007) which is nearly a hundred feet below the full pool elevation of 3,700 feet. (http://www.usbr.gov/uc/feature/drought.html)

The result of 40 years of operation is that silt accumulation has occurred at the upper end of Lake Powell and in some side canyons. These are ideal conditions for tamarisk recruitment which has resulted in monostands of tamarisk, as can be observed from the Hwy 95 Bridge at Hite. Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area or submersion if significant inflows can raise the lakes level above the tops of the tamarisk. No revegetation efforts are recommended for these areas since fluctuating lake conditions will not support a sustainable native plant community.

Butler Wash, Cross Canyon, Gypsum Canyon, Dark Canyon, White Canyon, Red Canyon, Cedar Canyon, Moki Canyon, and Lake Canyon – The headwaters of these perennial to intermittent streams are located in BLM lands southeast of the Colorado River with the exception of Dark Canyon, which begins in the Dark Canyon Wilderness on USFS lands. All of these streams drain the Elk Ridge highlands on the Manti-La Sal National Forests and the surrounding plateaus. They are highly inaccessible to motorized vehicles with the exception of a few scattered locations and some more prolonged stretches along Red, White, and Dark Canyons. Tamarisk infestations are light to moderate in the upper reaches of these desert riparian areas and increase as the streams approach the Colorado River.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Limited hand cut-stump and hand extraction work and herbicides may be necessary around camp sites, cottonwood galleries, and other high priority sites to improve restoration and reduce fire risk associated with biomass concentrations. Methods for control within the Dark Canyon Wilderness will be those that have the least impact on the wilderness values of the area.

Dolores River Watershed in Utah

Dolores River UT/CO state line to Colorado River confluence – This river section is relatively remote with moderately accessible areas along a few miles from both Utah and Colorado. BLM manages much of the riparian land though there is a significant amount of private property along the stretch. Tamarisk infestations are continuous in this section and range from light to heavy. The river supports a wide variety of native plant communities including areas of willows, cottonwoods, scrub oak, oak-leaf sumac, 4-wing saltbush, rabbitbrush, and other shrubs, forbs, and grasses.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for this area. Access, though remote, may allow a significant portion of the infestation to be mechanically removed. Limited hand cut-stump and hand extraction work and herbicides may be necessary around camp sites, cottonwood galleries, and other high priority sites to improve restoration and reduce fire risk associated with biomass concentrations.

Granite Creek, Fisher Creek, Beaver Creek, John Brown Creek, West Paradox Creek, Coyote Wash, and McIntyre Canyon – These perennial to intermittent streams originate in the north, east or south and west flank of the La Sal Mountains and surrounding plateaus along the Utah/Colorado border. The Dolores River and its tributaries support moderate to heavy densities of tamarisk infestations, with areas or segments of heavy native willows, scattered cottonwoods or galleries, and other riparian shrubs and grasses.

Biological control using the tamarisk leaf beetle will be the most practical tamarisk control strategy for these areas since access tends to be remote. Limited hand cut-stump and hand extraction work and herbicides may be necessary around cottonwood galleries, and other high priority sites to improve restoration and reduce fire risk associated with biomass concentrations. Where access and terrain allow, mechanical control may be possible.

Education, Outreach, and Volunteerism

The education committee is preparing a detailed approach for providing educational and outreach programs. Important information for the public to understand includes all aspects of the tamarisk and Russian olive problem, how serious it is, and why it is important to address it; control approaches that will be used with much emphasis on the biological control component; how things will look differently over the next couple of years (in 5 years and in 10 years); revegetation, biomass removal, monitoring, and long-term maintenance. The overarching theme is RESTORATION not just tamarisk or Russian olive control. The Tamarisk Coalition, BLM, and NPS outreach expertise is being offered to develop materials appropriate for the community and visitors. Key partners on educational and outreach efforts will be Canyonlands Field Institute, Four Corners School of Education, and Plateau Restoration. Some of the key elements of the program may include:

- ✓ A “frequently asked questions” brochure that will help locals 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 Moab Information Center, NPS and BLM visitor centers, campgrounds, etc.
- ✓ Fact sheets
- ✓ Display boards with historical photos can be utilized to compare present day conditions to the past to give a perspective on the problem.
- ✓ Press releases
- ✓ River guide training on the issue and provision of education cards similar to “Leave no trace” laminated waterproof cards.
- ✓ Information booths at local events, festivals, etc.
- ✓ Presentations to service groups such as the Rotary Club and Chamber of Commerce.
- ✓ Postcards for free distribution to visitors highlighting the issue.
- ✓ Demonstration sites that can be used for tours.

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 SEUTP study area. One way of achieving this is through volunteer programs. During July 2006 a survey of the Moab community was conducted by Tamarisk Coalition staff to better understand the needs and desires for a volunteer program in the SEUTP area. People from various

organizations including OARS, Colorado Plateau River Guides, Plateau Restoration, Sheri Griffith River Expeditions, Trail Mix, Local Government, The Nature Conservancy, Rim to Rim Restoration, and the Youth Garden Project were interviewed.

There was a general consensus that a Volunteer Coordinator Position would help address riparian restoration in the SEUTP study area. Making the program a true grassroots effort will help gain support in the community. It was also found that this must be a paid position in order for it to be realistically filled. Many believe that a volunteer program is possible; but that it will be hard work and people may lose interest over time. The SEUTP could be a solid focal point for volunteer programs if sustainable funding for this position is developed with help from the Grants Committee. A key issue to resolve by the SEUTP partners is – *whom would this person work for?*

Some potential volunteer activities that were identified include:

- ✓ Beach areas cleared for camping, staging, access
- ✓ Hiking trails
- ✓ Court House Wash was noted for a large Russian olive problem
- ✓ Westwater campgrounds, Cataract Canyon, Meander Canyon, Potash to the confluence with the Green, and Goose Island. The majority of guides run their trips through West Water and Cataract Canyon; therefore, the guides would be more likely to help out in these sections of the river.
- ✓ Places where a demonstration project could take place include Court House Wash, Mill Creek, Kane Creek, Hunter Canyon, Hatch Wash, Indian Creek, and Negro Bill Canyon.
- ✓ Areas or river segments with sparse scattered invasive infestations such as scattered Russian olive, elm, or emerging tamarisk.
- ✓ Areas with highly mixed native riparian vegetation requiring hand control.

Draft Criteria for Future Project Prioritization

The following criteria for prioritizing future projects for tamarisk and Russian olive control, revegetation, monitoring, and maintenance were developed by the Projects Committee and are listed in no particular order. The relative importance of each criterion for any given project will vary 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 Mill Creek 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, revegetation, monitoring, and maintenance 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?

Minor species control – There are relatively few other invasive trees such as Siberian elm, black locust, ailanthus, etc. in the area; therefore, these may constitute be high priority projects to keep future invaders to a minimum.

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?*

Ecological Factors- The presence and patterns of invasive woody species and the benefits of restoration within a specific site are dictated by ecological factors. Current ecological conditions and potentials for restoration of each site should be considered, including the presence of native riparian vegetation; the distance to surface water/groundwater; site terrain/accessibility, potential for native revegetation, and important wildlife habitat such as oak stands important for heron rookeries; cottonwood galleries or stands important for eagle nests, roosts or hunting; floodplain beaches or islands important for migrating waterfowl; maintaining understory thickets for avian diversity and prey bases; or tributary and backwaters critical as fishery spawning/rearing areas. These types of ecological factors dictate the control methods, costs, revegetation and monitoring of restoration areas. (See appendix F- Riparian Ecology for further discussion).

Research Needs

There are a number of research activities that can improve the success, effectiveness, and efficiency of restoration for the SEUTP study area. The unique nature of the Colorado River watershed in southeastern Utah offers special opportunities to better understand tamarisk and Russian olive impacts to water resources and wildlife habitat as well as restoration responses on the Colorado Plateau. 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). The following are current research interests at the university and federal research levels that the SEUTP partners believe are important to incorporate, when appropriate, into restoration efforts:

- ✓ Monitoring of the tamarisk leaf beetle (*Diorhabda elongata*) releases to determine rate of spread, plant mortality, beetle predation, suitability for remote areas, native revegetation characteristics, weed propagation, and effectiveness of control.
- ✓ Monitor to assess the achievement of restoration objectives and long-term sustainability.
- ✓ Assessment of biomass reduction techniques as to effectiveness, efficiency, plant propagation, timing, and necessity as a function of tamarisk density.
- ✓ Assessment of revegetation approaches under different control technologies and levels of infestations.
- ✓ Assessment of fire as a tool within a biological control program.
- ✓ Utilize the Matheson Wetlands Preserve, Dugout Ranch, and the Entrada Ranch as "living laboratories" for researchers from Utah's universities and state and federal agencies to have dedicated locations to perform monitoring and to do field research on the topics described above.

Grant Opportunities

The key to successful implementation on any of the proposed restoration strategies, education, research, outreach, etc. is funding to sustain the activity. The grants committee has prepared a preliminary list of grant opportunities that identifies the funding source, description of the grant, recipient requirements, type of award, and activities funded. This resource will be continuously updated by the grant subcommittee with the leadership team providing direction and assistance in securing funding for SEUTP partners.

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 herbicides to the smooth bark at the base of non-native phreatophytes usually through a spray.

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 how ecological rehabilitation and maintenance is undertaken, supported, and evaluated.

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.

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 and wildlife habitats, repairing erosion and soil condition, restoring hydrological function, and monitoring all these activities for effective long-term maintenance.

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

Economies in Utah take many forms, and include those that are amenity-based, such as tourism, recreation, real estate and others like industries; 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 terrace are the lands along the river corridor that supports native phreatophytes but still within the floodplain. Terraces are generally supportive of both 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.

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."

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 is plants that utilize soil moisture that is more readily available than would be present in upland drier soils.

Partners are considered to be any State, federal, local, non-governmental, individuals, industry, or private entities that cooperate in SEUTP.

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

State refers to Utah 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. Example of a smaller watershed within the larger watershed is the Salt Wash drainage.

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

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Appendix A

FS Agreement Number 06-MU-10041000-035 NPS #G1341060604

South East Utah Tamarisk Partnership

MEMORANDUM OF UNDERSTANDING
To
Support the Development of a Comprehensive Plan to Improve Riparian Lands Impacted by Non-Native Invasive Trees Colorado River Watershed – Grand and San Juan Counties, Utah

This Memorandum of Understanding (MOU) is made and entered into by and between the following parties:

Grand County, San Juan County, City of Moab, Town of Castle Valley, National Park Service, Bureau of Land Management, USDA Forest Service, U.S. Fish and Wildlife, Utah Department of Transportation, Utah Division of Parks and Recreation, Utah Division of Wildlife Resources, Utah Division of Forestry Fire and State Lands, Utah School and Institutional Trust Lands Administration, Grand Canyon Trust, The Nature Conservancy, Tamarisk Coalition, Rim to Rim, Southern Utah Wilderness Alliance, Southwest Satellite Imaging, Red Rock Forests, Castleland Resource Conservation and Development Council, Inc., Utah State University Extension, Plateau Restoration, Living Rivers, Canyon Voyages, Red River Canoe Company, Jennifer Speers.

Article I. Background and Objective

Tamarisk and Russian olive have significantly impacted the riparian areas along the Colorado River and its tributaries within Grand and San Juan counties, Utah. These infestations are causing harmful impacts to wildlife habitat, recreational use, and water resources. Local communities, state and federal agencies, non-profit and private companies, and private landowners desire to develop a comprehensive plan to address this problem.

Article II. Authority

The National Park Service may enter into this MOU through the general management authorities contained in 16 U.S.C. Sections 1 through 3.

The Bureau of Land Management may enter into this MOU under the Federal Land Policy and Management Act of l976, 43 U.S.C. 1737, Sec 307.

Article III. Statement of Work

It is the intent of the signing parties to work together to develop a comprehensive plan to:

1) control non-native invasive tamarisk and Russian olive;
2) re-vegetate impacted areas with appropriate vegetation;
3) monitor outcomes;
4) identify long-term maintenance strategies;
5) structure educational efforts;
6) identify important research components;
7) prioritize actions; and
8) identify potential funding opportunities.

Signing parties agree to collaborate to provide information and expertise, develop objectives and acceptable alternatives to meet the objectives, and share knowledge of best practices for this region. The goal of the plan is to provide a path forward that will improve the riparian habitat of the Colorado River and its tributaries in a manner that meets the needs and values of the communities, land managers, and private landowners; and places the area in the best position to garner future funding to address the problem.

The signing parties agree to provide assistance of technical experts, information, and/or input to help in the completion of the comprehensive plan.

Nothing in this MOU shall obligate the signatory or their agencies, communities, and organizations to obligate or transfer funds.

Article IV. Term of Agreement

This MOU shall take effect on the date of final signature and shall be in force and effect for a period of five (5) years from the last date signed. This MOU may be modified in writing by mutual agreement and signature of all parties.

Article V. Key Federal Officials

Kate Cannon
Superintendent
Southeast Utah Group
National Park Service
2282 S. West Resource Blvd.
Moab, UT 84532
Phone (435) 719-2103

Margaret Wyatt
Field Manager
Bureau of Land Management
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Sandra Meyers
Field Manager
Bureau of Land Management
Monticello Field Office
P. O. Box 7
Monticello, UT 84535
Phone (435) 587-1500

Lee Johnson
District Ranger
Moab/Monticello Ranger District,
Manti-LaSal National Forest
P. O. Box 386
Moab, UT 84532
Phone (435) 259-7155

Larry Crist
Acting Field Office Supervisor
U.S. Fish and Wildlife Service
2369 West Orton Circle, Suite 50
West Valley City, UT 84119
Phone (801) 975-3330

Article VI. Termination - Any of the parties, in writing, may terminate the instrument in whole, or in part, at any time before the date of expiration.

Article VII. Required Clauses

Civil Rights – During the performance of this MOU, the participants will not discriminate against any person because of race, color, religion, sex, or national origin. The participants will take affirmative action to ensure that applicants are employed without regard to their race, color, sexual orientation, national origin, disabilities, religion, age or sex.

Promotions – The participants will not publicize or otherwise circulate promotional materials which state or imply endorsement of a product, service, or position of this MOU by any participant.

Publications of Results of Studies - No party will unilaterally publish a joint publication without consulting the other parties. This restriction does not apply to popular publication of previously published technical matter. Publications pursuant to this MOU may be produced independently or in collaboration with others; however, in all cases proper credit will be given to the efforts of those parties contributing to the publication. In the event no agreement is reached concerning the manner of publication or interpretation of results, any one party may publish data after due notice and submission of the proposed manuscripts to the others. In such instances, the party publishing the data will give due credit to the cooperation but assume full responsibility for any statements on which there is a difference of opinion.

Freedom of Information Act (FOIA) - Any information furnished to the Forest Service under this instrument is subject to the Freedom of Information Act (5 USC 552).

Participation in Similar Activities - This instrument in no way restricts the Forest Service or the Cooperators from participating in similar activities with other public or private agencies, organizations, and individuals.

Non-Fund Obligating Document - This instrument is neither a fiscal nor a funds obligation document. Any endeavor or transfer of anything of value involving reimbursement of contributions of funds between the parties to this instrument will be handled in accordance with applicable laws, regulations, and procedures including those for Government procurement and printing. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the parties and shall be independently authorized by appropriate statutory authority. This instrument does not provide such cooperators of any contract or other agreement. Any contract or agreement for training or other services must fully comply with all applicable requirements for competition.

Responsibilities of Parties - The Department of Agriculture and Cooperators and their respective agencies and office will handle their own activities and utilize their own resources, including the expenditures of their own funds, in pursuing these objectives. Each party will carry out its separate activities in a coordinated and mutually beneficial manner.

Establishment of Responsibility - This instrument is not intended to, and does not create, any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or equity, by a party against the United States, its agencies, its officers, or any person.

Article VIII. Signatures

Authorized Representatives - By signature below, the cooperators certify that the individuals listed in this document, as representatives of the cooperators, and are authorized to act in their respective areas for matters related to this instrument.

In witness hereof, the parties hereto have executed this MOU on the dates set forth below.

Joette Langianese (signed)
Joette Langianese, Chair, Grand County Council — 8/29/06 Date

Lynn H. Stevens (signed)
Lynn H. Stevens, Chair, San Juan County Commission — 9-15-06 Date

David J. Sakrison (signed)
Dave Sakrison, Mayor, City of Moab — 9-18-06 Date

(signed)
Damian Bollerman, Mayor, Town of Castle Valley — 9/20/06 Date

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NPS #G13410606

for Kate Cannon, Superintendent, National Park Service — 8-29-06 Date

Margaret Wyatt, Field Manager, Moab Field Office, BLM — 8/29/06 Date

Sandra Meyers, Field Manager, Monticello Field Office, BLM — 9-14-06 Date

Lee Johnson, District Ranger, Moab/Monticello Ranger District, USFS — 9/14/06 Date

Larry Crist, Acting Field Office Supervisor, U.S. Fish and Wildlife Service — 8/24/06

Hugh Kirkham, District Engineer, Utah Department of Transportation — 12 Oct 06 Date

Tim Smith, Region Manager, SE Region, Utah Division of Parks and Recreation — 8-29-06 Date

Kim Christy, Assistant Director, Utah School and Institutional Trust Lands Administration — 8/22/06 Date

Bill Zanotti, Area Manager, Utah Division of Forestry Fire and State Lands — 8/29/06 Date

Derris Jones, Regional Supervisor, SE Region, Utah Division of Wildlife Resources — 8/31/06 Date

Bill Hedden, Executive Director, Grand Canyon Trust — 8/30/06 Date

Dave Livermore, Utah State Director, The Nature Conservancy — 8/21/06 Date

Tim Carlson, Executive Director, Tamarisk Coalition — 8/30/06 Date

FS Agreement Number 06-MU-10041000-035

NPS #G1341060604

	Date
Kara Dohrenwend, Chair of the Board, Rim to Rim	08/30/06
Scott Groene, Executive Director, Southern Utah Wilderness Alliance	10-30-06
Terry Shepherd, Executive Director, Red Rock Forests	9/20/06
Chair, Castleland Resource Conservation and Development Council, Inc.	8/30/06
Michael Smith, Executive Director, Plateau Restoration	10/6/2006
John Dohrenwend, Southwest Satellite Imaging	9/20/06
Michael Johnson, Utah State University Extension	9/18/06
Jennifer Speers, Landowner	9/11/06
John Weisheit, Executive Director, Living Rivers	8/30/06
Denise and Don Oblak, Owners, Canyon Voyages	10/23/06
Theresa Butler, Owner, Red River Canoe Company	8.30.06

Appendix B

Grand County and San Juan County Noxious Weed Resolutions

01/23/2007 12:03 4352592574 GRAND COUNTY COUNCIL PAGE 01

RESOLUTION NO. 2006-2733

RESOLUTION DECLARING SALT CEDAR AND RUSSIAN OLIVE AS NOXIOUS WEEDS IN GRAND COUNTY

WHEREAS, the Tamaricaceae (Tamarisk) Family more commonly known as Salt Cedar, and Elaeaghaceae (Russian Olive) are non-native plants that have invaded many sites in Utah including Grand County; and

WHEREAS, Salt Cedar and Russian Olive are deep-rooted plants that deplete water tables and displace Cottonwood and Willow trees, which provide habitat for native species of plants and animals; and

WHEREAS, Salt Cedar and Russian Olive have been declared noxious weeds to be prevented and controlled by Colorado, New Mexico, and other adjoining states; and

WHEREAS, the Grand County Weed Control Board recommends that Salt Cedar and Russian Olive be added to the County's list of noxious weeds;

NOW, THEREFORE, THE GRAND COUNTY BOARD OF COUNTY COUNCIL DECLARES that Salt Cedar and Russian Olive shall be and hereby are noxious weeds within the County, and shall be and hereby are added to the County's list of noxious weeds, pursuant to power granted the Board of Council in Utah Code Annotated, section 4-17-5(3).

APPROVED AND ADOPTED BY THE GRAND COUNTY COUNCIL at its regularly scheduled meeting, on this 2nd day of May, 2006.

Joette Langianese, Chairman

Attest: Fran Townsend
Fran Townsend, Clerk/Auditor

Jan 23 07 12:18p p.1

AHN: Elenor

GENERAL NOTICE TO CONTROL NOXIOUS WEEDS

Notice is hereby given this 5th day of June, 2006, pursuant to Section 4-17-7 of the Utah Noxious Weed Act, to every person who owns or controls land in San Juan County, Utah, that noxious weeds standing, being, or growing on such land shall be controlled and the spread of same prevented by effective cutting, tillage, cropping, pasturing, of treating with chemicals or other effective methods, or combination thereof, approved by the County Weed Supervisor, as often as may be required to prevent the weed from blooming and maturing seeds, or spreading by root, root stalks or other means.

Upon failure to comply with this notice, the owner or person in possession of property upon which noxious weeds are present shall be deemed negligent and enforced control measures may be imposed at the discretion of the County authorities. Expenses of control measures employed by the County shall be paid directly by the owner or person in possession of the property and become collectible by taxes.

The following are declared noxious weeds for the State of Utah:

Bermudagrass
Field Bindweed (Wild Morning Glory)
Broad-leaved Peppergrass
(Tall Whitetop)
Canada Thistle
Johnsongrass
Hoary Cress
Squarrose Knapweed
Leafy Spurge
Dyer's Woad
Jointed Goatgrass
Silverleaf Nightshade
Russian-Olive

Musk Thistle
Quackgrass
Russian Knapweed
Diffuse Knapweed
Scotch Thistle
Whitetop
Spotted Knapweed
Perennial Pepperweed
Camelthorn
Buffalobur
Western Whorled Milkweed
Yellow Starthistle
Tamarix (Saltcedar)

Approved this 5th day of June, 2006 by the San Juan County Weed Board and the San Juan County Commission.

S. Rigby Wright, Chairman
San Juan County Weed Board

Lynn H. Stevens
Lynn H. Stevens, Chairman
San Juan County Commission

Appendix C

Utah Strategic Tamarisk Management Plan

The purpose of this Strategic Plan is to provide common goals, criteria for prioritizing projects and funding, measures of success that can be used in planning and evaluating success of projects, and an overview of current tamarisk management strategies that can be used in conjunction with the Guiding Principles developed by Team Tamarisk in coordinating a statewide effort to manage tamarisk. Specific measures of success and project objectives should be developed for each project.

Tamarisk and associated non-native invasive plants are known to have economic and environmental impacts, affecting Utah's natural and agricultural resources, water quality and quantity, biodiversity of plant and animal communities, as well as affecting human health and safety due to increased fire risk and visibility/access concerns along roads. Tamarisk management within Utah will require active long-term management programs with sustainable funding.

The following strategic goals, prioritization criteria, and measures of success can be used by all involved with tamarisk management projects. As you use this template, please fill in the information to your project which, based upon your analysis, will bring you the most cost efficient and management effective solution to your specific issue involving Tamarisk.

Strategic Goals and Objectives

Goal I. Protect the State's natural, agricultural, and ranching resources including water quality and quantity, native plant communities, and wildlife habitat from the impacts of tamarisk through early detection, control, and restoration efforts.

Objective IA. Water quality and quantity will increase as ____% of tamarisk is eradicated and/or controlled in riparian areas by (Date).

Objective IB. Wildlife habitat will improve as beneficial native plants replace ____% of tamarisk infestations in Utah within five years.

Objective IC. All new infestations of tamarisk are eradicated upon detection throughout Utah by (Date) and into the future.

Goal II. Safeguard lives, property and assets and improve the quality of life for communities we serve by managing tamarisk to reduce fire and other safety risks.

Objective IIA. Thickets of tamarisk will be managed in ways that reduce the potential for wildland fire in Utah by ____% by (Date).

Objective IIB. Tamarisk infestations will be eradicated in ____% of the areas in Utah where they obscure line of sight for traffic by (Date).

Objective IIC. Tamarisk infestations in Utah will be eradicated in ____% of the areas where they hamper rescue efforts in the event of traffic accidents by (Date).

Objective IID. Tamarisk infestation will be eradicated in ___% of the areas where they prevent access to designated roads and trails by (Date).

Goal III. Improve the quality of recreational opportunities by enhancing safety and access within tamarisk infested areas.

Objective IIIA. _______percent of private property in Utah currently infested with tamarisk will be treated and restored to healthy cropland by (Date).

Objective IIIB. Municipalities will identify and treat tamarisk infestations on ____% of their land by (Date) and restore to healthy vegetation by (Date).

Measures of Success

Measure IA (1). A baseline amount of tamarisk infestation in riparian areas will be established via current inventory measures during (Date); a monitoring measure will be established in (Date) and the final measure in (Date).

Measure IA (2). Soil moisture will be analyzed in select areas of infestations and eventual restored areas during (Date), (Date), and in (Date).

Measure IA (3). Land Health (wetland, riparian, and upland areas): Percent or number of acres or stream/shoreline miles treated for tamarisk that now achieve desired conditions as specified in management plans, consistent with applicable requirements of State and Federal water laws.

Measure IA (4). Water Quantity: The number of surface and ground water systems protected or restored as specified in management plans and consistent with State and local resource managers, as appropriate, to meet human and ecological needs.

Measure IA (5). Salinity Control: Tons of salt loading prevented from entering Colorado River System.

Measure IA (6). Water Quality: Miles of stream with measured improvements in water quality within a watershed.

Measure IB (1). Baseline assessments of wildlife habitat will occur in (Date) and compared to habitat assessments in (Date).

Measure IB (2). Habitat restoration: number of acres and stream or shoreline miles restored or enhanced to achieve habitat conditions to support species conservation consistent with management documents, program objectives, and consistent with substantive and procedural requirements of State and Federal water law.

Measure IC. Weed managers will promote reports of new tamarisk infestations, log them, and log their response making an annual report to the Utah Department of Agriculture and Food.

Measure ID. Percent change from baseline in the number of acres infested with invasive plant species within a defined area (e.g. watershed or CWMA).

Measure IIA (1). Acres of tamarisk infestation on the wildland urban interface will be measured as a baseline and compared the acres of infestation in (Date).

Measure IIA (2). Number of acres identified as high priority through collaboration and treated that are in the Wildland Urban Interface.

Measure IIA (3). Percent of wildland fires within tamarisk infested areas controlled during initial attack.

Measure IIA (4). Reduce Hazardous Fuels: Number of acres or stream/shore miles achieving desired fuel levels through vegetation management.

Measure IIA (5). Restore Fire Adaptive Ecosystems: Percent of acres degraded by wildfire with post-fire rehabilitation treatments underway, completed and monitored; number of acres determined to be in a better condition class as a result of plan implementation.

Measure IIB. Areas of tamarisk infestation that obscure traffic line of sight will be logged in (Date) and compared to areas of tamarisk infestation that obscure line of sight in 2008.

Measure IIC. During (Date) local emergency services will report areas where tamarisk infestations hamper rescue efforts of traffic accident victims, and second survey will be done at season's end in (Date).

Measure IID. Complaints of tamarisk infestations blocking access to roads and trails will be logged in (Date) as a baseline for comparison to complaints in (Date).

Measure IIIA. Private landowners will report acres of tamarisk infestation on their property to local USU Extensions Agents in (Date) for comparison to acres of tamarisk infestation to be reported in (Date).

Measure IIIB. Municipalities will report acres of tamarisk infestation on their property to local County Weed Supervisors in 2006 for comparison to acres of tamarisk infestation to be reported in (Date) and (Date).

Measure IIIC. Changes in Degree of Satisfaction with quality of experience as determined through user surveys and comments for treated areas or riparian systems.

Measure IIID. Access: percent or number of accessible facilities or sites with improved access due to tamarisk management.

Measure IIIE. Education and Awareness: The number of interpretive displays or signs, literature distribution, educational presentations, etc.

Project Prioritization and Funding Allocation Criteria

- Does the project meet one or more of the Strategic Goals
- Is project within a statewide priority or critical watershed
- Does it benefit Threatened and Endangered species?
- Are there existing partnerships and multi-land ownerships in place? Is it within a cooperative weed management area?
- Will project result in potential water savings or reduced salinity? (measurable quantifiable and achievable targets)
- Does project enhance fire suppression or reduce risk in high use recreation area or Wildland Urban Interface (WUI).
- What is the probability of long term success? (Are natives currently present? Is water regime conducive to native vegetation with high early season flows? Have upstream/headwater sources of invasive species been controlled?)
- Does it meet the intent of authorizing legislation (note: this may not be critical, we can choose to fund “good” projects by other means)
- Are there other project benefits? (e.g. enhanced recreation opportunities)

Integrated Pest Management

Control Tactics

Control of salt cedar will require an integrated approach utilizing all available tools and control methods, including herbicides, mechanical/physical removal, flooding, prescribed fire, and biological controls. Depending on the specific site and circumstances these methods could be used individually or in any combination providing maximum flexibility. The Colorado Tamarisk Coalition with EPA funding is currently putting together a Best Mgmt Practices guide for tamarisk control tactics.

What follows is a broad overview of general control methods, specific information is available through local agricultural extension, BLM, USFS offices and the Tamarisk Coalition based out of Grand Junction, Colorado.

A. Herbicides: Commonly used herbicides used for control of tamarisk are listed in Table 1. Always follow label directions and rates, utilizing local recommendations for specific treatment rates, based on application method, timing, infestation size, etc...

Table 1. Some commonly used herbicides for Salt Cedar Control (contact local extension agents for current recommendations)

Chemical Name	Trade Name(s)
Imazapyr	Arsenal®
Metsulfuron methyl	Escort®XP
Ammonium salt of fosamine	Krenite®S
Triclopyr	Garlon*4, Remedy*, Pathfinder II

B. Mechanical/Physical Removal: Mechanical controls involve cutting down or uprooting entire stands of salt cedar plants. Methods include mowing, sawing, chaining or ripping, hand pulling, and bulldozing. Uprooting methods are effective in the short-term because uprooted trees do not re-sprout. For sawing and mowing, chemical treatment may be necessary to prevent re-sprouting. Immature plants may often be physically removed by hand with care given to complete removal of the root structure and disposal of the plant by burning or deep burial. Hand removal is useful for small-scale or sparsely populated infestations.

C. Flooding: Managed flooding can effectively kill salt cedar on a long-term basis. Repeated flooding is necessary to kill salt cedar seedlings that are rapidly established from windborne seeds. Established salt cedar plants can tolerate flooding for up to 3 months. Conditions suitable for controlled flooding exist in relatively small areas such as highly managed wildlife refuges.

D. Burning: Prescribed burning alone is not an effective control method for salt cedar because it generally promotes sprouting and flowering. However, burning followed by herbicide application has been shown to be effective (Barranco, 2001).

E. Biological Control: Biological control methods do not expect to eradicate salt cedar in any area. The object of insect release or the use of grazing (goats, sheep) is to reduce the abundance of salt cedar to below the level where ecosystem damage occurs. Salt cedar is expected to remain as an uncommon or common, but non-damaging, component of riparian plant communities. It is expected that native vegetation will return rapidly and naturally, at least in areas where remnant native plants exist and soil salinity and water tables permit. Currently the salt cedar leaf beetle (*Diorhabda elongata)* is available for experimental use. Approval for more widespread dispersal is expected soon. Initial study results have been impressive, showing rapid expansion and near complete defoliation. Repeated defoliation after several years appears to be resulting in tamarisk death.

F. Vegetation Controls: A healthy, weed-resistant plant community consists of a collection of species diverse enough to occupy all niches. The general objective should be to develop a healthy plant community that is relatively weed-resistant while meeting other land-use objectives --- for instance, forage production, wildlife habitat development, recreational land maintenance or natural area conservation. Once a desired plant community has been chosen, an ecologically-based weed management plan can be developed. A site or niche must be available for desirable species and unavailable for undesirable ones. Disturbances, whether it is cultivation, timed herbivory (including Biological controls), burning or herbicide application, create available sites. There are three mechanisms causing succession (disturbance, colonization and performance). All three must be considered as a package. Designing disturbances to either create sites for desirable plants alone, or controlling colonization without making sites available, or increasing their performance without making them available, is unlikely to shift the plant community in the desired direction. Management strategies must be carefully chosen to ensure that on technique is complementary with another. Once this is achieved, conversion from a weedy community to a desirable one can occur.

Restoration/Revegetation Steps:

1. Create niches for desired plant species.
2. Using techniques to prevent weed encroachment or altering environmental or managerial conditions to exploit dispersal mechanisms or germination requirements will favor establishment of desirable species.
3. Use techniques, procedures or methods that exploit the weaknesses of salt cedar as well as possible other weedy invaders and favor the strengths of desired plants.
4. Monitor effectiveness of plan and make adjustments as needed.

Team Tamarisk Guiding Principles

In April 2004 a diverse group of 350 individuals met at the Team Tamarisk Conference held in Albuquerque, New Mexico. Through their collective efforts attendees drafted “Guiding Principles” addressing salt cedar and associated riparian weeds in the Western United States. Upon approval these principles will be presented to the Invasive Species Advisory Committee in order to seek their advice in developing grant criteria that the Departments of the Interior and Agriculture would use to fund tamarisk projects reflecting these principles, as resources become available and consistent with other funding priorities.

Guiding Principles

Team tamarisk is an inclusive alliance of cooperating agencies, tribes, diverse organizations, and individuals devoted to the control of tamarisk (salt cedar, Tamarisk spp.) and associated non-native invasive plants.

Tamarisk and associated non-native invasive plants cause economic and environmental harm, affect the public health and welfare, and require active long-term management programs with sustainable funding.

Team Tamarisk subscribes to the following guiding principles, in no particular order of importance:

A. To facilitate the prevention and control of tamarisk and associated non-native invasive plants with the ultimate goal of restoring healthy, productive ecosystems, leadership at all levels should: maximize the spirit of cooperation; foster sharing of information, strategies, tools, and research; leverage funding; and coordinate actions.

B. Public and private partnerships across jurisdictional and watershed boundaries should maximize effective on-the-ground efforts, while respecting private property rights, tribal rights, and local customs and cultures.

C. Actions will comply with established federal, state, tribal, and local laws, regulations, and policies.

D. Existing frameworks of funding, technical assistance, and expertise should be identified, used, and publicized to optimize resources and maximize local effectiveness.

E. Funding should be directed to proposals and mechanisms that maximize resources on-the-ground while minimizing administrative overhead.

F. Objective criteria must be developed at all levels – local, state, tribal, and regional – for control, restoration, and monitoring projects based on sound science and economics, local community and regional involvement, cultural and traditional values, cost-benefit analysis, and urgency.

G. Diverse interest groups should be organized and mobilized to manage the control of tamarisk and non-native invasive plants for the benefit of healthy, productive ecosystems and the greater public.

H. To improve management decisions, data from inventories, monitoring, and control actions should be comparable and shared at all levels through a web-based clearinghouse.

I. Performance measures for control of tamarisk and associated non-native invasive plants should include quantifiable units (e.g., water quality and quantity, acres treated and restored, fuel reduction), leading to the long-term recovery of healthy, productive ecosystems.

J. The policy makers and public should be informed about tamarisk and associated non-native invasive plant issues through development of comprehensive educational and outreach efforts.

K. Research efforts should develop innovative tools and technologies to aid in the management and monitoring of tamarisk and associated non-native invasive plants in a variety of environments.

L. Proactive management and control strategies for tamarisk and associated non-native invasive plants should be developed at multiple scales in accordance with recognized planning principles and guidelines, including consensus-based goals and objectives.

Appendix D

SEUTP
SE Utah Tamarisk and Russian olive Mapping & Inventory Objectives, Protocols, and Guidelines

Purpose: The purpose of this project is to provide a relatively accurate understanding of the extent of the tamarisk and Russian olive problem in Southeastern Utah's Colorado River Watershed. Quantifying and characterizing tamarisk infestations provides a wealth of information for many diverse users. The data produced will inform planning efforts; policy; and state, federal, and local decision-making concerning tamarisk control and riparian restoration efforts.

Goal: The goal of this mapping and inventory project is to identify 80 to 90 percent of the tamarisk and Russian olive infestations in the SEUTP study area. The majority of the remaining 10 to 20 percent of tamarisk 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 good understanding of these infestations in the study area, a comprehensive data set was collected. This data provides essential information for developing effective cost estimates for tamarisk control and subsequent revegetation, as well as to better understand impacts such as water losses and wildlife habitat effects. The protocol for this project is based on tamarisk mapping protocols developed by the Tamarisk Coalition in partnership with the US Geological Survey (USGS) and the National Institute of Invasive Species Science. As a result, the data collected in this effort is compatible with the national database system (www.niss.org). The inventory was completed in the following manner:

1) High resolution aerial photos were acquired from the National Agricultural Imagery Program (NAIP-2006). These images are ortho-rectified, one-meter resolution, and are available for no cost at http://datagateway.nrcs.usda.gov/NextPage.asp. Images provided by the BLM and Google Earth were cross checked with the NAIP imagery to ensure the best possible knowledge of available data.

2) ArcGIS shapefiles of tamarisk infestations were produced through photo interpretation of the NAIP imagery. Essentially, polygons were drawn over tamarisk locations indicated on the photographs by growth pattern, texture, and prior knowledge of tamarisk infestation. The results were then made available to the partners of the SEUTP for review and revisal. Changes were made to reflect local knowledge of tamarisk stands. Some conveniently located sites were also ground truthed from major roads. This practice was not widely used due to its monetary and temporal costs. Each set of tamarisk and Russian olive denoting polygons is attached to a tabular data set recording the following attributes of the infestations:

- ✓ GPS coordinates of tamarisk or Russian olive stand (Universal Transverse Mercator-UTM)
- ✓ Percent cover (canopy)
- ✓ Percent riparian area: defined as the portion of area currently occupied by tamarisk or Russian olive found in the floodplain corridor where native phreatophytes such as cottonwoods and willows could exist
- ✓ Percent floodplain terrace area: defined as the remaining land within the floodplain where dryland plant species would be more prevalent after control is achieved
- ✓ Accessibility (good or poor for mechanized removal)
- ✓ Presence other significant species (Russian olive, willow, cottonwood)
- ✓ Width: greater than or less than 50 feet; a designation that is important for revegetation purposes
- ✓ Level of confidence: due to the subjective nature of the mapping, the mapper designates his/her confident in each polygon assessment as high, moderate, or low
- ✓ Collection Method: designates whether the data was collected by photo interpretation, ground truthing, or through local knowledge

3) These shapefiles and their related attributes were subsequently utilized to calculate the total areas of infestation in the SEUTP study area, estimated costs of removal, as well as estimated current and future water losses due to tamarisk.

Deliverables:

1) Shapefiles characterizing each infestation with an attribute table including the following fields: acreage, percent cover, percent upland, accessibility, other significant species presence, tamarisk stand width, level of confidence, and the collection method used. 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) 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.

3) Excel spreadsheets providing 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* (February 2007, Tamarisk Coalition www.tamariskcoalition.org). 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.

Appendix E

Templates and Protocols

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. 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.

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 mission of the community as the central component for selecting an appropriate control strategy. For the Colorado River watershed within the SEUTP planning area, this mission is the ***commitment to restore, protect, and maintain a healthy riparian ecosystem***. 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 essential in order to identify the reasonable approach(s) for control and will provide a point from which to compare and measure future changes.	Gather the following information: o Does the project adhere to the State and watershed plans and their priorities? o Terrain type o Land ownership o Adjacent land use o Size and shape of parcel identified for control o Type of existing and historic vegetative stand including density and diversity

Templates	Protocols
	o Susceptibility to erosion o Hydrologic integrity, floodplain connectivity, water table depth, and availability of irrigation water or periodic flood waters o Soil characteristics especially texture, depth, and salinity o Threatened or endangered species habitat and other species of concern o Local landowner attitudes and desires o State, local, and community attitudes and desires 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 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.
	o Hand labor using chainsaws with herbicide applied to the cut stump
	o Hand applied herbicide to basal bark
	o Foliar herbicide application:
	    ➢ Spraying from the ground
	    ➢ Spraying with helicopters or fixed wing aircraft.
	o Mechanic removal:
	    ➢ Root plow
	    ➢ Extraction
	    ➢ Mulching followed by cut stump herbicide application
	    ➢ Roller chopping followed by cut stump herbicide application
	o Biological control
	    ➢ Goats
	    ➢ tamarisk leaf beetle

4. Identify alternatives for dead vegetation management – Each control alternative must be linked to at least one alternative for handling the dead vegetative mass.	Select alternatives for the dead vegetation management: o Stack and burn o Burn in place o Mulch in place o Mulch in discrete areas o Remove from site for disposal o Utilize as a resource such as fuel, commercial commodity, or to support sustainable local businesses that generate a value-added product o Leave in place; i.e., no further action required
5. Identify alternatives for	Select specific revegetation alternatives as described in detail in

Templates	Protocols
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.	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: o Monitoring the success of control and revegetation measures o Performing resprout treatment o Reestablishing desired vegetation o 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: o Control o Dead vegetation management o Revegetation o Landowner monitoring and maintenance o Administration
8. Develop impacts associated with each alternative	Quantify the potential impacts associated with each fully developed alternative for the following: o Community and landowner support o Re-infestation from adjacent un-controlled sources o Other noxious weeds or other undesirable plant infestations o Increase in water availability and water quality based on the establishment of the desired vegetative state o Wildlife habitat o Biodiversity o Herbicide use, both short-term and long-term impacts o Increase in sediment loads to rivers and streams and other erosion impacts o Local employment and business potential o Fire and its consequential impacts o 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: o Erosion protection o Smaller demonstration plots to establish refined approaches for new technologies o Tours of restored sites to increase public understanding
10. Compare each combined	Determine the preferred approach based on costs and impacts

Templates	Protocols
alternative and select the preferred control approach	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: o Public notification on the specifics of the control project; such as method, dates, participation, etc. o Development and dissemination of valuable insights derived from project experiences to the public. o Signage explaining the stage of control/revegetation. o Tours of sites in various stages of control and revegetation. o Annual landowner training through CSU Cooperative Extension and/or NRCS o 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: o Terrain type o Land ownership o Adjacent land use o Size and shape of parcel to be revegetated o Type of existing and historic vegetative stand including density and diversity o Susceptibility to erosion o Hydrologic integrity, floodplain connectivity, water table depth, and availability of irrigation water or periodic flood waters o Soil characteristics especially texture, depth, and salinity o Threatened or endangered species habitat and other species of concern o Local landowner attitudes and desires 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 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, acceptability, effectiveness, as well as others that may be appropriate.	Select appropriate alternatives based on the existing setting and objectives for each site. o Natural revegetation o Irrigation and seeding o Flooding with native seed dispersal o Pole plantings of cottonwood and willows o Nursery stock plantings o Use of livestock to facilitate seeding establishment

Templates	Protocols
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: o Development and dissemination of valuable insights derived from project experiences to the public. o Signage explaining the revegetation/reclamation efforts. o Tours of sites in various stages of revegetation. o Annual landowner training through CSU Cooperative Extension and/or NRCS 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. Most importantly, monitoring is used to determine if objectives are being met. Two considerations important to the SEUTP 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 usually located on 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, to 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, or capability of sites or collaborators.

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

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.

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

- 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.

- 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, landowner 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 landscape-scale and landowner monitoring levels.

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 Utah's universities and through federal agencies are in the best position to perform this type of monitoring activity.

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	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

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

Templates	Protocols
the water inventory are occurring due to control and remediation actions?	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 Utah Division of Wildlife Resources 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 B. Soil moisture C. Erodability 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 water, wildlife habitat, endangered species, etc.

These protocols are only guidelines to help identify information that is typically important to collect and should not be considered as absolutes. 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.

Table 4: Small-Scale Landowner 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. 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. B. Note areas for additional active revegetation and develop adaptive management plan and future monitoring needs. 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: o Non-native phreatophyte control o Conservation easements o Wildlife habitat improvement o Endangered/sensitive species habitat management 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

Concepts of Riparian Ecology and Plant Materials for Restoration

The presence and patterns of invasive woody species and the benefits of restoration within a specific riparian area are dictated by ecological factors. A riparian area is a site which expresses vegetation dependent upon the presence of surface or subsurface water. The potential of a riparian area is determined by the interaction of hydrologic, geologic, soil and vegetative components of the site. (USDI, BLM TR 1737-9, 1993). The mere definition of a riparian ecosystem dictates that hydrologic influences are the most critical of site components. Varying combinations of these components form specific types and patterns of ecological sites (or ecosites) which are individual to each riparian area. The various types of riparian ecosites described below may not always be present within a particular riparian area or be consistently located within a specific site, generally requiring site specific analysis to determine specific riparian potential.

Most riparian ecosystems depend on periodic flooding, scour and deposition of sediment for establishment of seed beds and recruitment of woody species essential to sustain ecosite development and a functioning riparian system. (USDI, BLM TR 1737-9, 1993). Natural shifts in the stream course or water patterns result in a "dynamic ecosystem", with frequent changes and patterns in ecosites which require unique monitoring techniques to quantify characteristics.

Wet Ecosites- Wet ecosites are commonly located along either bank of a river, stream, or supported near spring sources or within sub-irrigated meadows. These ecological sites are dependent upon permanent water availability (either surface or subsurface water) to maintain saturated soils and support a wide array of riparian vegetation which require water (obligate species) such as cattails, rushes, bulrushes, water cress, grasses other grass-like species. Along a stream, these sites normally border active portions of stream channel, extending horizontally on both or either streambank, generally between 0 to 500 feet wide. These ecological sites receive the most destructive flood energies associated with surface flows, and permanent vegetation is generally limited to those plants with fibrous root masses or small stems which can bend to withstand severe flooding. Woody seedlings such as willows, cottonwoods, as well as invasive tamarisk and Russian olive, can develop in these ecosites, but due to frequent flooding are often temporary and scoured away. Depending on the degree of flooding, soil types and saturation, wet ecosites can form mosaics along frequent overflow channels, create swamps or marshes, or be completely absent along cobble scour areas or along collapsed vertical terraces.

Regeneration Ecosites-Regeneration sites occur along streams, springs or in overflow channels where elevations are slightly higher than adjacent wet ecosites, located along the frequent flood line of the channel (overbank flooding occurring 1-3 yrs). This ecological site is where regeneration of young woody species develop, supporting bands of willows, cottonwoods, waterbirch and other trees, including invasive tamarisk and Russian olive. Depending on the degree of flooding and soil saturation (generally <5 feet to depth of water), this ecological site often contains a mixture of wetsite vegetation and young woody saplings flexible enough to withstand high flood energies, extending 0 ft to ½-mile from water. Where native vegetation is supported, these ecological sites can compete for sun and space with invasive tamarisk, but native woody species are often literally choked out in the presence of tamarisk and Russian olive. Riparian vegetation within this ecosite generally require or prefer the presence of surface or subsurface water (obligate or facultative species).

Flooded Mid-Terrace Ecosites-Mid-terrace ecosites often develop in lower terraces, slopes and benches between regeneration sites and drier high terraces within the floodplain. Mid-terrace ecosites receive periodic flooding during high water, and exhibit mixed age groups of young and intermediate native trees and shrubs, or “stringers” of same age trees parallel to the stream course where flood events have resulted in new recruitment. Mid-terrace sites contain depths to water which are within rooting depths of native riparian trees (generally 5-10 ft deep) and generally support vegetation which require or prefer (obligate or facultative species). Mid-terrace ecosites are often found intermingled with regeneration and other riparian ecosites in overflow stream channels. Invasive tamarisk and Russian olive can be found in these sites sometimes in heavy density, but natives can compete for sun, water and space where a functioning riparian system is maintained.

Non-Flooded High Terrace Ecosites-These ecosites commonly develop along the fringes between a riparian area and upland areas. High terrace sites are no longer subject to flooding or accessible to groundwater for recruitment of native riparian vegetation. High terrace ecosites often contain mature native riparian galleries including cottonwoods, Gooding willows, ash, oaks, boxelder established during early flooding sequences; or often contain mixed or dense monotypic stands of invasive tamarisk, Russian olive or Russian knapweed. Many high terrace sites are remnant areas which can no longer support recruitment of native trees once they have died due to excessive depths to water, even following removal of invasive tamarisk. Due to the non-flooded nature of these ecosites many high terraces now exhibit only shrubs and grasses such as rabbitbrush, oak-leaf sumac, sagebrush, or Indian ricegrass, and sand dropseed (facultative species which are facilitated by water). The distance to surface water (0 to ½-mile) or depth to groundwater (>10 feet deep) largely dictates the presence of riparian vegetation and potential for recovery from invasive exotic species. Following extreme flooding events, bank collapse or gullying is often common along the flooded river edges of these sites, resulting in high vertical and unstable edges of the terrace, often eliminating all other ecosites to the stream edge. These sites have the least potential for riparian restoration, even following removal of invasive species, due to inaccessible depths to groundwater. Surface irrigation of restored vegetation is often required in these sites until rooting depths to groundwater are naturally achieved, but are expensive and difficult to maintain over time. Remnant riparian communities within these high terrace ecosites are extremely susceptible to catastrophic destruction since they are no longer able to regenerate naturally, which are often now supported by inflow from upland drainages, cliffs, roads where alterations to waterways should be avoided.

Invasive woody species-Invasive woody vegetation alter the natural influences of water, soil and vegetation within a functioning native riparian ecosystem. Over time, tamarisk generally entrenches a river system, by capturing and building sediment along banks, reducing overbank flooding critical for native recruitment. Tamarisk root depths also out-compete native woody species such as cottonwoods and willows for groundwater due to its rooting depths in excess of 75 feet deep, where mature native species only contain maximum root depths of 20-25 feet. Where native riparian plants can often withstand natural accumulations of salts and alkaline soils, tamarisk actually secretes and concentrates salts which can impair native seedling establishment citation. Eventually, tamarisk reduces the functioning and diversity of the riparian vegetation, as well as the wildlife and prey-base communities found within native riparian ecosystems.

The biological characteristics and impacts of Russian olive are not as well documented as tamarisk. Russian olive prefer regeneration or mid-terrace ecosites, due to a relatively shallow and unstable root mass, and virtually push out native riparian species by eliminating sun and space for native riparian development. While Russian olive produces a prolific berry used by wildlife in winter periods, it displaces native riparian species which provide more diverse and nutritious food sources.

Plant Materials for Restoration

Plant material lists can be obtained for site-specific restoration purposes from respective SEUTP agencies as well as other organizations such as Utah Partners for Conservation Development (UPCD), which can act as a clearing house of information.

Appendix G

Suggested Components to Structure a Monitoring Program

The following discussion provides suggestions for appropriate components to structure a monitoring program. This information was developed by members of the SEUTP Control and Revegetation Committee.

Monitoring goals should be clearly defined. In general monitoring goals are:

1. To detect change over time and inform adaptive management of treated areas.
2. To compare results of methods in treatment areas vs. control (non-treatment) areas.
3. To compare results amongst different treatments.

Specifically, monitoring protocols will be determined by:

1. The desired level of detectible change to be observed. A greater sampling intensity should detect lower levels of change
2. Funding available
3. Degree of accuracy or reproducibility desired. This will dictate the level of knowledge, skills and experience required of observers.

Other considerations for developing monitoring protocols:

1. Monitoring should include biotic (plants and animals) as well as physical components. In addition, records should be kept of climate, river flows, etc.

Physical components include:

   a) Geomorphic surface (mapped by aerial photography/ satellite imaging with ground truthing)
   b) Soil properties with depth (texture, compaction, moisture content, chemistry and stability/physical or biological crust development)
   c) Disturbance

Components of vegetation monitoring include:

   a) Species diversity
   b) Cover by species
   c) Canopy structure
   d) Size of individual trees/shrubs
   e) Herbivory

2. Some of the challenges to monitoring riparian areas include:
   a) How to define the area to be sampled (e.g. high water mark of ?? to edge of riparian zone and how that is defined)
   b) Physical challenges to relocating sampling plots for follow-up monitoring, given that permanent stakes placed in the ground cannot be counted on to stay put in such a dynamic system (they can also affect the system by collecting strainers, etc.)

c) The ephemeral nature of forbs (i.e. there are good years and bad years for all species, especially annuals)
d) The difficulty of identifying seedlings and how/whether to count them.
e) Grass species are especially difficult to identify, particularly when not bearing flower or seed heads (e.g. when heavily grazed).
f) Monitoring protocols will probably be different for main stem river sections versus side canyons because of time/funding constraints.
g) How to measure shrub sizes should take into account affects of flooding (e.g. shrubs could be flattened or covered with silt following a flood event)
h) Definition of geomorphic surfaces tends to be complex.

Some additional monitoring (pre and post control) notes:

1. Before and after photographs
2. GPS monitoring sites
3. X-section vegetation transects: (paced or established) perpendicular to waterway (across all ecosites)
4. Ecosite vegetation transects: (longitudinally within each ecosite)
    - Wetsite (greenline)
    - Regeneration site
    - Terrace sites
5. Groundwater monitoring, to determine:
    - Potential net water gain post control
    - Total depth or seasonal fluctuations for rehab potential
6. Noxious weeds:
    - Map distribution in site (pre and post)
    - Pre and post vegetation transects to determine current species and densities pre control and determine potential spread or density increase post control