Dolores River Riparian Action Plan (DR-RAP)

Recommendations for Implementing Tamarisk Control & Restoration Efforts

March 2010

Until about thirty years ago, environmental degradation and habitat loss were addressed, if at all, on a piecemeal basis, river segment by river segment, species by species. Over time, however, scientists working to resolve problems of species and habitat loss understood what now seems obvious: the crucial aspect of watersheds and other natural systems is the interconnectedness of their component parts.[1]

Dolores River

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Table of Contents

Dolores River Riparian Action Plan (DR-RAP):

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March 2010

Figures

Tables

Appendices

Full text appendices are not included in this version of DR-RAP. They are provided externally in the Data DVD and are accessible via in-text hyperlinks on the Appendices Summary page.

Dolores River Riparian Action Plan Executive Summary

Though a myriad of factors affect the health of the Dolores River, the invasion of tamarisk is a particular focus for land managers due to its extensive growth patterns which can displace native vegetation and affect the health and sustainability of these vegetative communities. In 2008, The Nature Conservancy completed a tamarisk control project on the San Miguel River and turned to the Dolores River. In the spring of 2009, The Nature Conservancy and the Tamarisk Coalition began working with local land owners and managers to develop a watershed-wide tamarisk control and restoration strategy, which is embodied in the Dolores River Riparian Action Plan (DR-RAP). As a result of these efforts, the Dolores River Restoration Partnership was formed.

DR-RAP's **Purpose** is to: (1) to articulate the science-driven, tamarisk related vision, goals, and site selection criteria common to Dolores River stakeholders in both Colorado and Utah to facilitate a consistent approach throughout the watershed; and (2) to initiate and facilitate an increased level of collaboration and communication among the stakeholders to enhance information transfer, adaptive management, and likelihood of large scale, meaningful success.

DR-RAP's **Vision** is: *A Dolores River watershed dominated by native vegetation, where the threats from tamarisk and other associated invasive species have been mitigated and the riparian areas of the watershed continue to become more naturally functioning, self-sustaining, diverse, and resilient over time*. This ecologically focused vision is a step toward the overarching vision of the Dolores River Restoration Partnership of . . . *a thriving Dolores River system that is ecologically, socially, and economically sustainable in a multiuse context.*

The **Guiding Principles** for the execution of the **Vision** include: (1) a collaborative approach, (2) funding must sustain short-term monitoring & maintenance to a determined point of restoration success, (3) minimize harm to wildlife species, (4) concurrent restoration work throughout the watershed, and (5) educate the public and Dolores River stakeholders at every opportunity.

The main ecologic and anthropogenic "stressors" that affect the Dolores River are tamarisk, tamarisk treatment and associated restoration/revegetation methods, the tamarisk leaf beetle, hydrology, livestock and wildlife grazing, geomorphology, saline soils and arid conditions, herbaceous and woody invasives, and climate change. DR-RAP makes various assumptions that the plan's goals can be met even in the presence of these stressors.

DR-RAP's **5 Year Goals** are:

- Ecologic – increase the number of sustainable, healthy riparian plant communities while reducing those dominated by tamarisk and other invasive, non-native plant species.
- Social – develop a professional, competitive, and efficient work force; improve aesthetic enjoyment; increase public safety; and increase the protection of property.
- Economic – increase employment opportunities, improve cost benefit ratio for contractors and youth service corps, improve effectiveness and financial efficiency of riparian restoration, and enhance visitor travel to the area.
- Management – manage adaptively, incorporate education and interpretation, garner support from agency budgets and attract other sources of funding, facilitate communications between land managers and partners.

DR-RAP defines **Criteria for Prioritization** and a **Decision Tree** to help land managers determine where restoration should occur to best meet these goals on the Dolores River. At the sites selected, the following methods will be used to meet DR-RAP's goals; tamarisk removal, biomass removal or remediation, non-native woody species control, non-native herbaceous species control, revegetation, short and long-term monitoring and maintenance, and adaptive management.

The Dolores River Restoration Partnership makes the following recommendations for 2010:

- The Dolores River Restoration Partnership should be formalized through MOUs;
- Pilot projects should be established to answer pressing management questions;
- A two day winter workshop should be convened to incorporate lessons learned in 2010 to inform 2011 actions; and
- Monitoring, Funding, Education, and Science Subcommittees should be formed to address such issues as adaptive management challenges and tributaries.

Introduction

Dolores River Riparian Action Plan – Recommendations for Implementing Tamarisk Control and Restoration Efforts

The Dolores River Riparian Action Plan (DR-RAP) was developed with the understanding that controlling invasive tamarisk (*Tamarix* spp. also known as salt cedar) and comingled secondary invasives while reestablishing native species are only a few components of a watershed restoration plan. Other issues that must be considered in a comprehensive riparian restoration project include the capacity to improve flow regimes, ensure responsible livestock grazing, ensure responsible rangeland management, and to alter stream structure where necessary. These issues are being addressed by other organizations and agencies within the Dolores River Restoration Partnership. For instance, the Dolores River Dialogue (DRD) is working specifically to address the alteration of peak flows in order to support native vegetation and fish populations. Additionally, as the largest landowners in the Dolores watershed (see Figure 1), the four Bureau of Land Management (BLM) offices are responsible for the majority of livestock grazing, rangeland management, and decision making on many of the other issues along the river.

DR-RAP's **purpose** is twofold: (1) to articulate the science-driven, tamarisk related vision, goals, and site selection criteria common to Dolores River stakeholders in both Colorado and Utah to facilitate a consistent approach throughout the watershed; and (2) to initiate and facilitate an increased level of collaboration and communication among the stakeholders to enhance information transfer, adaptive management, and likelihood of large scale, meaningful success. DR-RAP also strives to consider the social needs, economic realities, and management challenges that interact with and affect the ecological health of the watershed and to address these issues accordingly.

Recognizing the ultimate decision making responsibility of landowners, most notably the BLM offices, DR-RAP has been created as a resource to aid each BLM district in creating consistent, site specific, tamarisk management implementation plans. (For example, Appendices A, B, and C provide a detailed discussion of tamarisk ecology, biological control, and an evaluation of tamarisk management technologies.) These implementation plans will provide detailed approaches for actual work sites including but not limited to: site specific project goals; project timeline and scheduling; a site specific, pre-project, baseline data monitoring plan; work force selection; determination of active or passive tamarisk management techniques and materials; a post-project monitoring plan; and mechanism for maintenance determination and schedule. Each plan may vary from office to office, but their content should be driven by criteria presented in the DR-RAP in order to lend consistency to restoration projects. These consistencies will aid in creating a holistic view of restoration activities throughout the watershed.

Ultimately, the decisions embodied in the BLM's implementation plans are paramount over any suggestions laid forth in DR-RAP as they will consider aspects of the watershed that are outside of DR-RAP's scope. Figure 2 provides a flow diagram depicting the interaction such decision making has with DR-RAP. The combination of these individual BLM plans and DR-RAP will provide the basis for cost estimates, helping to inform funding commitments.

Figure 1: Dolores River Watershed Map

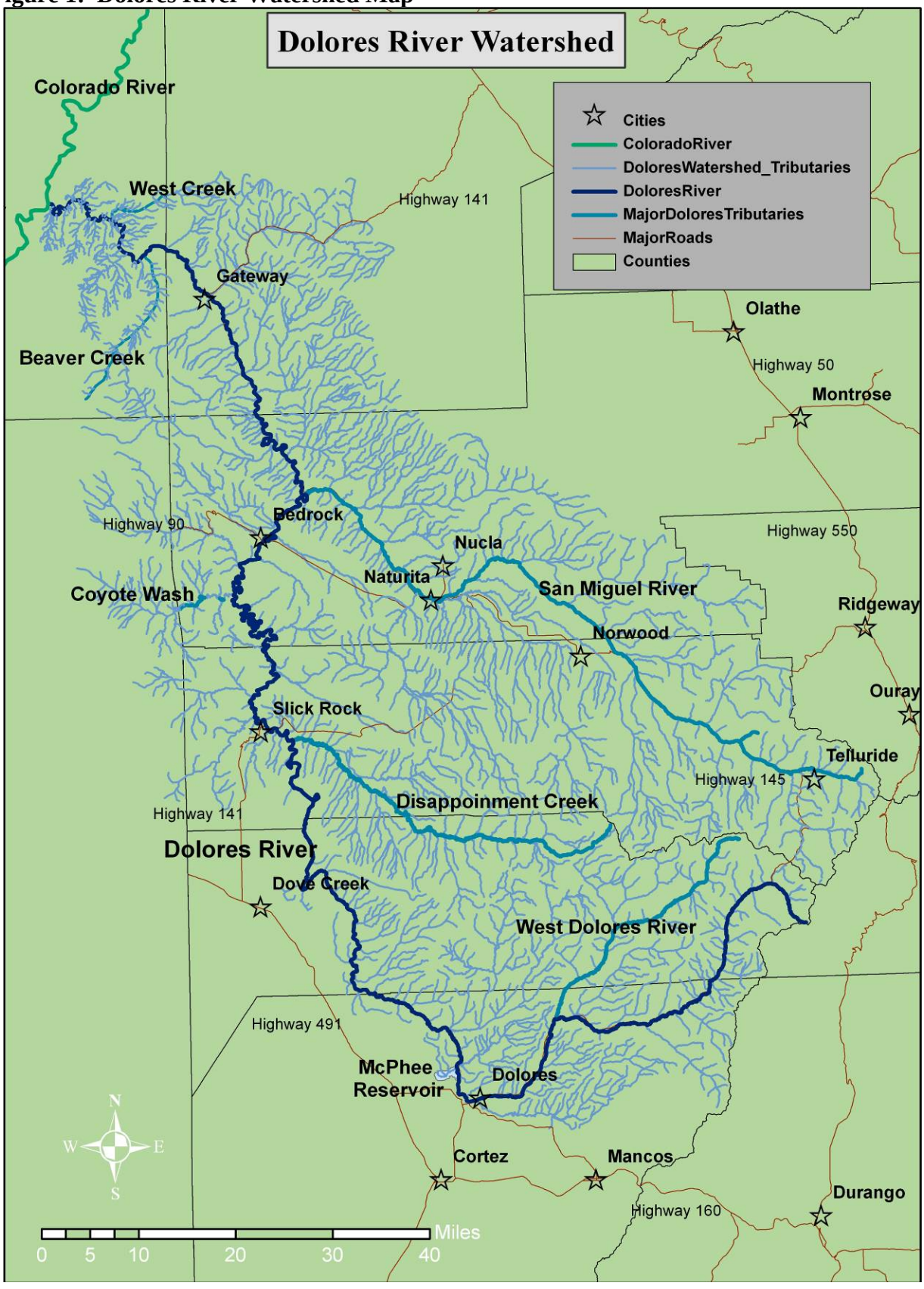
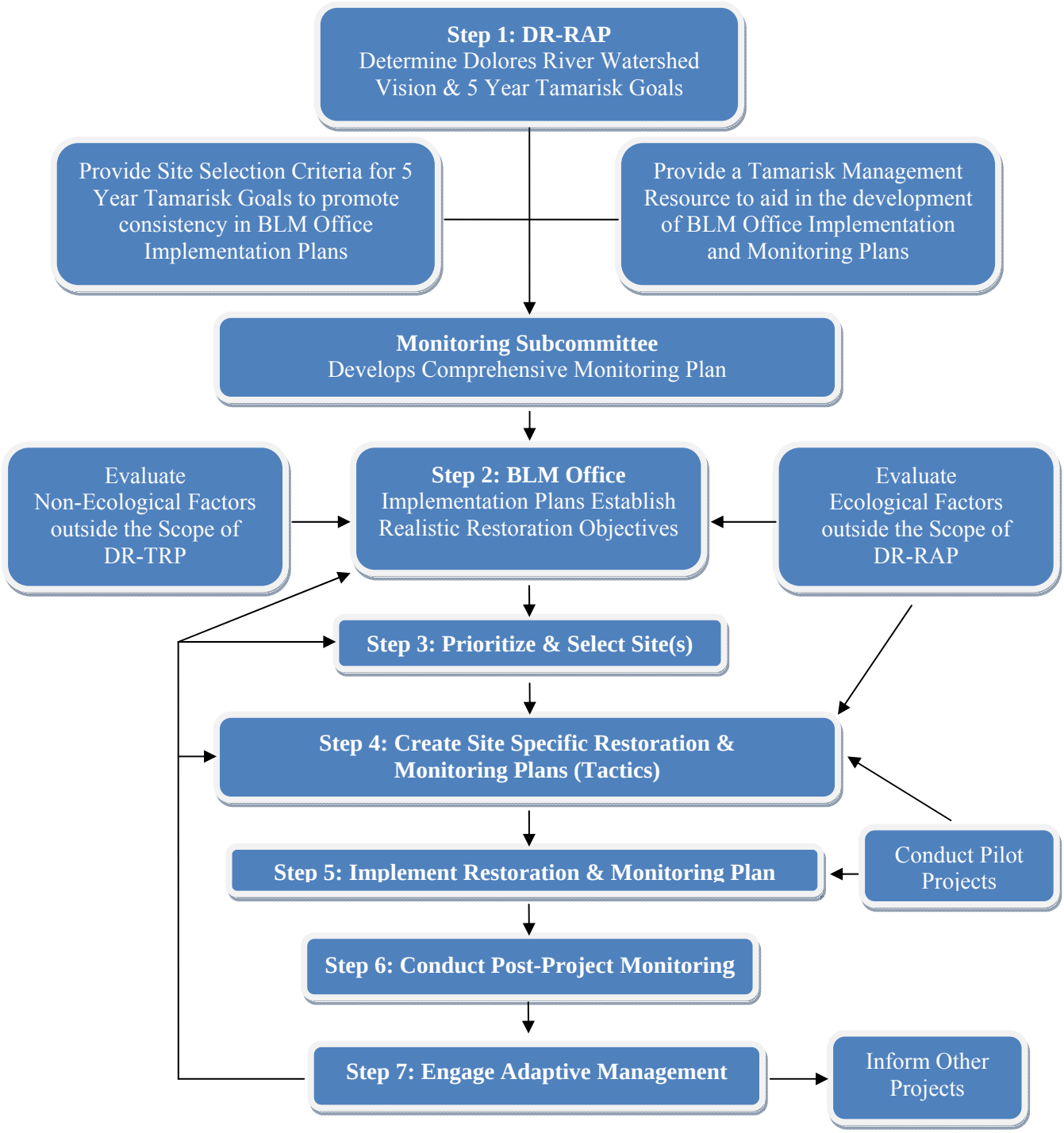


Figure 2: Flow Diagram for Tamarisk Management on the Dolores River[1]



[1] (Adapted from Sher, A.A., K. Lair, M. DePrenger-Levin, and K. Dohrenwend. 2010. "Best Management Practices for Revegetation after Tamarisk Removal in the Upper Colorado River Basin Handbook". Denver Botanic Gardens, Denver, CO, USA.)

Planning Effort Background

The Dolores River: The Dolores River is a testament to the diversity of riparian ecosystems found on the western slope of the Rocky Mountains. Winding down from its headwaters in the San Juan Mountains of Colorado, the Dolores passes through deep canyons, broad valleys, and beneath the breathtaking topography of Gateway to join the Colorado River in Utah. Highly valued by recreationalists, especially during the release of high flows that support a lauded whitewater float trip, a journey along the Dolores River is traded among outdoor enthusiasts as a tale of beauty and unparalleled appreciation for the wonders of nature. The Dolores River is also heavily used by the agricultural community, both within and outside the watershed. Its waters support the production of several valuable crops such as alfalfa and corn.

Historic diversions for irrigation purposes and modern day storage in McPhee Reservoir near the town of Dolores have altered traditional flow regimes and divert much of the watershed's flow to the San Juan River watershed in southwestern Colorado. As a result, the conditions that support a natural riparian vegetative community on the Dolores River have been highly altered. The health of these plant communities is vital as they protect water quality, provide wildlife habitat, provide invaluable recreational opportunities, and can be sustainably used for livestock grazing purposes.

The Partnership: In 2008, The Nature Conservancy completed a successful tamarisk control project on the San Miguel River and turned its attention to the Dolores River. In the spring of 2009, a grant from the Packard Foundation provided the Tamarisk Coalition and The Nature Conservancy the opportunity to begin working with local land owners and managers to develop a watershed-wide tamarisk control and restoration strategy, which is embodied in DR-RAP. As a result of these efforts, the Dolores River Restoration Partnership was formed. This informal partnership includes communications and collaborations with:

- Bureau of Land Management (BLM) Field Offices that manage the majority of the Dolores River: the Moab, Grand Junction, Uncompahgre, and Dolores Field Offices
- BLM Colorado and Utah State Offices
- County weed managers in Colorado from Dolores, San Miguel, Montrose, Montezuma, and Mesa Counties, Colorado; and Grand County, Utah

- Montezuma Valley Irrigation Company
- Colorado Department of Agriculture, Palisade Insectary
- Colorado State University
- Natural Resources Conservation Service (NRCS)
- Four Corners School/Canyon Country Youth Corps, Southwest Conservation Corps, Western Colorado Conservation Corps
- Dolores Tamarisk Action Group (DTAG)
- Dolores River Dialogue (DRD)
- Southeastern Utah Tamarisk Partnership (SEUTP)
- Bureau of Reclamation
- Dolores Water Conservancy
- U. S. States Fish and Wildlife Service
- Colorado Department of Wildlife
- Packard Foundation
- Private landowners through interaction with The Nature Conservancy
- Walton Family Foundation

Partnership Subcommittees: A monitoring subcommittee has been formed to address the need for consistent monitoring approaches throughout the watershed. Other subcommittees recommended by the partnership to form in 2010 are: (1) Funding opportunities, (2) Education and outreach, and (3) Science.

Information Source: DR-RAP is informed by collaborations with these agencies as well as by extensive field surveys conducted along the river from McPhee Reservoir to the confluence of the Dolores and Colorado Rivers. This work, performed in the spring and summer of 2009 by the Tamarisk Coalition, collected information on native and non-native vegetation through field surveys, soil samples at many recommended sites, a photo journal, and a verification and refinement of previous tamarisk mapping completed by the Tamarisk Coalition for the Colorado Water Conservation Board. This information, by its nature, is extensive and is provided in the attached Data-DVD.

Regional Context: The DR-RAP is a natural extension of several other projects. Upstream, the Dolores Conservation District is successfully controlling tamarisk infestations above and around McPhee Reservoir. Downstream, the Southeastern Utah Tamarisk Partnership[2] restoration group's scope includes the Utah portion of the Dolores River. This group has designated the portion of the Colorado River from the Dolores confluence to Potash as a focus area for tamarisk control and restoration. A major restoration effort has also occurred on the Dolores's largest tributary, the San Miguel River. In a six year effort, the Nature Conservancy and San Miguel County have removed tamarisk and other invasive trees from the majority of the San Miguel River. Additionally, the DR-RAP falls in line with recommendations made in the *Colorado Headwaters Woody Invasive Species Management Plan for the Colorado River* (CHIP)[3].

[2] *Southeast Utah Tamarisk Partnership – Woody Invasives Management Plan,* July 2007.
[3] *Colorado Headwaters Invasive Partnership – A Consolidated Invasive Species Management Plan for Colorado's Colorado Gunnison, Uncompahgre, Dolores, White, and Yampa/Green Watersheds,* Revised

Vision and Guiding Principles

Vision – DR-RAP's vision is: *A Dolores River watershed dominated by native vegetation, where the threats from tamarisk and other associated invasive species have been mitigated and the riparian areas of the watershed continue to become more naturally functioning, self-sustaining, diverse, and resilient over time*. This ecologically focused vision is a step toward the overarching vision of the Dolores River Restoration Partnership of . . . *a thriving Dolores River system that is ecologically, socially, and economically sustainable in a multiuse context.*

As discussed in DR-RAP's vision, "naturally functioning" is defined as dominated by native riparian and upland floodplain terrace vegetation, having diverse species composition and structure compared to other non-impacted sites, providing habitat for a broad range of animals, and with geomorphologic function unimpaired by the presence of tamarisk. "Self-sustaining" is defined as having processes of plant establishment and growth, sediment accumulation and erosion, and hydrology that requires only modest on-going investments to maintain natural function. A conceptual framework describing the interactions amongst the various factors affecting the river systems function is provided in Appendix D.

In working towards this ecologically focused vision, considerations must be made for the successful achievement of the social, economic, and management components of the Dolores River Restoration Partnership's broader vision. In order to highlight potential interactions of DR-RAP's ecological focus with the partnership's broader vision, the "Goals" section of this

document outlines some basic social, economic, and management issues that should be considered in the implementation of tamarisk management.[4]

The **Guiding Principles** for the execution of the Vision include:

1. **A collaborative approach.** The restoration actions chosen will incorporate the knowledge and priorities of land owners, land managers (federal, state, local agencies), stakeholders, and action groups while maintaining adaptive management that will respond to lessons learned during the DR-RAP's implementation.

2. **Funding must sustain short-term monitoring & maintenance to a point of success.** Every project initiated will set aside enough funding to monitor and maintain the site in the short-term to a point of success that can be maintained by the land owner or manager in the long-term. (The exact mechanism to achieve this principle will be determined by the Dolores River Restoration Partnership's Funding Opportunities Subcommittee).

3. **Minimize harm to wildlife species**. While healthy, native vegetation communities create almost universally superior wildlife habitat to non-native plants; inferior or improperly restored native habitats can create a net loss of habitat. For this reason, DR-RAP recommends staging implementation activities to minimize impacts to key wildlife habitat and, where necessary, revegetating with a mixture of plant species and to a level of success appropriate to improve habitat.

4. **Concurrent restoration work throughout the watershed.** Tamarisk seeds are likely dispersed as widely through wind as water and are as likely to affect restoration efforts upstream as those downstream[5]. Restoration efforts should occur throughout the watershed in discrete sites likely to achieve success; thus, all projects move the entire river towards greater sustainability.

5. **Educate the public and Dolores River stakeholders at every opportunity.** Informing the public of the need for restoration, and of the process and goals of DR-RAP, will be important throughout the watershed to: (1) explain ecological restoration and its goal of improving ecosystem function, (2) protect project areas from human disturbance, (3) limit noxious weed introductions.

[4] "Tamarisk management" includes all the components necessary to achieve restoration of the desired vegetation community including tamarisk control, biomass reduction, revegetation, other invasive species control, monitoring, maintenance, and adaptive management.

[5] Pearce, Cheryl, and Smith, Derald G., 2003, Saltcedar: Distribution, Abundance, and Dispersal Mechanisms, Northern Montana, USA, WETLANDS, v. 23, No. 2, p. 215-228.

System Stressors & DR-RAP's Assumptions

To successfully work towards DR-RAP's **Vision** it is necessary to prioritize areas throughout the river where restoration actions will best meet the plan's ecologic, social, economic, and management **Goals (**described in the next section**)**. Therefore, DR-RAP provides a list of **Criteria for Prioritizing Restoration Actions** as well as a **Decision Tree for Tamarisk Control**.

In order to define these site selection criteria, it is important to identify the many ecological and anthropogenic "stressors" that affect the relationship between tamarisk and native species dominance on the Dolores River. Some of these stressors can be mitigated through tamarisk control and revegetation efforts. Other stressors are not directly addressed in the DR-RAP but still have bearing on the site prioritization criteria due to their ecological impacts. The Criteria **for Prioritization** are based on scientifically founded **Assumptions** that direct how this plan addresses these stresses which are termed "**System Stressors**".

These **Assumptions** link the restoration actions recommended in this document back to DR-RAP's **Goals** by allowing that: if the sites recommended by the **Criteria for Prioritization** are restored, based on the **Assumptions** listed below, DR-RAP's **Goals** will be met.

Stressors associated with the Dolores River system are listed below along with the **Assumptions** that this plan is operating under to mitigate these pressures. For brevity purposes, this list is a concise version of the more in-depth Appendix E: System Stressors & DR-RAP's Assumptions. For an explanation of the rationale behind any of these issues please reference that text.

System Stressors & Associated Assumptions

The **Assumptions** below are overarching, informing the entire document and planning effort, or inform specific **Guiding Principles** (previously presented), **Goals**, or **Criteria for Prioritization** that follow in the document.

Tamarisk – In many cases, tamarisk control and the reestablishment of native vegetation is the most critical activity necessary to begin the restoration of western river systems. These stands can out compete and displace native riparian and adjacent upland vegetation, exploit valuable water resources, provide inferior habitat and forage for wildlife, increase the risk of damage to native vegetation by wildfire, and provide a seed source for continued infestations (see Appendix A).

Tamarisk Assumptions:

- Tamarisk Eradication is Not Possible – Informs Ecological Goal 1
- As Eradication is Not Possible, Tamarisk Seed Sources Will Always Be Present – Informs Guiding Principle 4
- Healthy Native Vegetation is Superior to Tamarisk – This is an overarching Assumption in the plan but also directly informs the Vision and Ecological Goals 1 and 3

Tamarisk Treatment and Restoration/Revegetation Methods – Best Management Practices (BMPs) for tamarisk control and subsequent restoration and revegetation are constantly evolving. Due to this evolution and the inherently site specific nature of restoration work, it is difficult to create a definitive guide to tamarisk control and restoration work. However, there are many resources available for restoration practitioners to use, along with professional judgment, in the process of Implementation Planning.

Tamarisk Treatment and Restoration/Revegetation Method Assumptions:

- Implementation Plans will Provide Detail necessary to Conduct Successful Restoration – This is an overarching Assumption in the plan
- Where Feasible, Passive Restoration is Preferred Over Active Restoration –This is an overarching Assumption in the plan.
- Tamarisk Treatment Methods Must be Chosen with Revegetation Methods in Mind – This is an overarching Assumption in the plan.
- Sites With Good Native Seed Sources Present are More Likely to Succeed – Informs Table 1: Criteria A, D, & F and Table 2: Criteria E and both Decision Trees.
- Site Specific Revegetation Efforts will Consider Revegetating with Understory Grasses and Shrubs – This is an overarching Assumption in the plan.

Tamarisk Leaf Beetle (*Diorhabda spp.*) – The tamarisk leaf beetle as a system stressor is complex as it is directly affecting another stressor, tamarisk. While the beetle is indeed interacting with the system as a whole, currently little is known about those interactions. Therefore, it is considered here mainly as a tamarisk stressor.

Tamarisk Leaf Beetle Assumptions:

- Percent Tamarisk Mortality Could Equal 50% & Will Be Monitored – Informs Ecological Goal 5 and all of Table 2.
- Stressed & Healthy Tamarisk will Experience Some Level of Mortality – Informs Ecological Goal 5 and all of Table 2.
- Beetle will Decrease Tamarisk Seed Production –Informs Guiding Principle 4 and all of Table 2.
- Vegetation Present, Native or Non-Native, in Surrounding Area will Replace Tamarisk – Informs Goal 5 and all of Table 2.

Hydrology – The Dolores River's flow regime has long been altered by historic irrigation and municipal diversions and was significantly changed again when McPhee Reservoir was completed in 1985. While it is known that the hydrologic alterations in the Dolores River watershed exacerbate the tamarisk issue and compound the complications of native species restoration, the intricacies of these relationships are not entirely known. Pilot projects examining tamarisk and sediment interactions in the context of flow would be helpful to better understand these interactions in the Dolores River watershed. For a more complete discussion on hydrology related to tamarisk infestations see Appendix A.

Hydrology Assumptions:

- Restoration Actions will be Guided by the Current Flow Regime – Informs Ecological Goal 1 and Table 1: Criteria A & E
- Native Vegetation is More Likely to Successfully Establish & Persist in Riparian Areas Through Active or Passive Restoration – Informs Ecological Goal 1 and Table 1: Criteria A & E.
- Native Vegetation is Less Likely to Successfully Establish & Persist in Upland Floodplain Terrace Areas Through Active or Passive Restoration and will Likely Require Active Revegatation –Informs Ecological Goal 1 and Table 1: Criteria A & E.
- Tamarisk Establishment that is Likely Under Any Flow Regime can be Mitigated – Informs the Vision, all Ecological Goals, and all Criteria.
- Dolores River Restoration Sites Below the San Miguel River May be More Likely to Succeed – This is an overarching Assumption in the plan and informs Guiding Principle 4.

Livestock and Wildlife Grazing –
Livestock grazing within the Dolores River watershed has important implications, economically and ecologically, that land managers incorporate into their management practices. Livestock and wildlife grazing can degrade grass, shrub, and tree plantings.

Thus, it is important to protect newly planted grasses, shrubs, and trees and it may be equally important to protect existing ones as well, particularly cottonwoods.

Livestock and Wildlife Grazing Assumptions:

- Best Management Practices (BMP) for Livestock Grazing will be Used on Project Sites – Informs the Feasibility Characteristic – "Landowner is willing"
- Appropriate Exclusions will be Placed for Wildlife and Livestock – Informs the Feasibility Characteristic – "Landowner is willing".

Geomorphology – Tamarisk can affect the geomorphology of a river system by trapping sediments and converting braided channels into single thread channel configurations. In the Dolores River these conditions are complicated and are closely associated with hydrology, dense vegetation growth, altered low-flow levels and truncated high seasonal flows.

Geomorphology Assumptions:

- Removing Tamarisk can Improve Geomorphology – Informs a portion of the Vision that replacing tamarisk with native vegetation is beneficial.

Saline soils and arid conditions – Both saline soils and arid conditions are common to the Dolores River system due to natural and anthropogenic influences. Such conditions have given halophytic tamarisk a competitive advantage over many native species and provide many restoration challenges.

Salinity and Aridity Assumptions:

- Riparian Areas Slated for Restoration are Less Affected by These Issues – Informs Ecological Goal 1 and Table 1: Criteria A & E.
- Salt Tolerant Plants will Survive in Saline and Arid Project Areas – Informs Ecological Goal 3 & 7 and will inform Implementation Plans.

Herbaceous and Woody Invasives – The Dolores River is both extensively and intensively infested with Russian knapweed. Other herbaceous weeds of concern include hoary cress and Dalmatian and yellow toadflax. Woody species of concern include Siberian

elm and Russian olive. Implementation Plans concerning other herbaceous or woody invasive species should use current Best Management Practices (BMP).

Herbaceous and Woody Invasives Assumptions:

- These Species Must be Controlled at Project Sites to Achieve Success – Informs Ecological Goal 2.
- Specific Treatments for These Species will be Included in Site Specific Implementation Plans – Informs Ecological Goal 2.

Climate Change – Climate change could alter factors in the watershed such as temperature and storm intensity as well as precipitation amount, frequency, seasonality, and form. The ecological and water system responses to these factors are, as yet, unknown.

Climate Change Assumption:

- Potential Impacts are Unknown –This is an underlying Assumption in the plan that will be addressed using Adaptive Management.

5 Year Goals for DR-RAP

- Specific, Measureable, Attainable, Realistic, & Timely -

The Goals described below have been agreed upon by the Dolores River Restoration Partnership. These goals will be achieved with actions reflecting the framework created by the guiding principles, system stressors, and assumptions. When accomplished, these goals will have both realized DR-RAP's Vision and moved toward the Dolores River Restoration Partnership's overarching vision for the watershed. DR-RAP's ecologic, economic, social, and management goals are listed below.

Ecologic – Over the next 5 years (2010 to 2014) the Partnership will increase the number of sustainable, healthy riparian and floodplain plant communities in the watershed while reducing those dominated by tamarisk and other invasive, non-native plant species. Achieving this goal can result in improved ecosystem services, increased forage and wildlife habitat, wildfire reduction, improved water resources, and overall improved ecosystem integrity. To accomplish these ecologic goals:

1. Tamarisk will be reduced to less than 5 percent of the vegetation cover within riparian areas (i.e., groundwater ≤ 2 meters). This will be accomplished using:
    a. Active Control Measures: in areas that meet the Criteria for Prioritization (Table 1)
    b. Tamarisk Biological Control: in areas that meet the Criteria for Prioritizing sites for Passive Tamarisk Control

2. Other invasive, non-native plants growing in areas where tamarisk is actively treated will be reduced to less than 15 percent of the vegetation cover within riparian areas and less than 25 percent within the drier upper terrace areas of the floodplain.

3. The remaining percent vegetative cover where tamarisk is actively treated will be composed of desirable or native species at each tamarisk treatment site.

4. Each of the active removal projects will be monitored and maintained to a point of success (meeting Goals 1, 2, and 3) requiring a reduced and sustainable level of management, and/or funds and labor will be identified to do so, within the five year span of DR-RAP.

5. Passive restoration sites where tamarisk biological control is the main control mechanism will be monitored for vegetation response and mortality over the next five years to:
    a. Develop an enhanced understanding of the tamarisk leaf beetle's role and impacts on the riparian community;
    b. Incorporate, or plan for, their impacts in restoration treatments.

   Additionally, beetle population movements along the length of the river will be monitored in coordination with the Colorado Department of Agriculture and the Southeastern Utah Tamarisk Partnership.

6. 90 percent of all riparian lands within the Dolores River watershed will meet Goals 1, 2, 3, and 5 stated above without surpassing the capacity to accomplish Goal 4.

7. Remaining riparian and upper terrace tamarisk infestations will be controlled through biological control accompanied by monitoring. The Dolores River Partnership Funding Opportunities Subcommittee will identify funding to control secondary invasive species and restore native species in these areas where necessary.

There are approximately 2,600 acres of tamarisk infestation along the Dolores River main stem below McPhee Dam. Approximately 1,900 acres of these tamarisk infestations were estimated in 2009 to occur on riparian sites[6]. Therefore, this 5 year effort seeks to control tamarisk and actively or passively revegetate approximately 1,900 acres along the Dolores River at sites that will likely support riparian to mesic species.

Social – Over the next 5 years (2010 to 2014) the following social goals will be achieved through tamarisk management. Measurements of these social goals are being addressed through other avenues of the Dolores River Restoration Partnership. They are listed here with the understanding that their implementation may alter decision making in tamarisk management issues. As such, the following must be considered when creating DR-RAP Implementation Plans:

1. Develop a professional, competitive, and efficient work force by enhancing contractor capabilities and youth conservation corps programs. DR-RAP implementation will require specialized skills relating to all aspects of tamarisk management and revegetation activities that will serve to augment the current workforce. Additionally, youth *programs*

[6] These estimates are based on vegetation mapping completed by the Tamarisk Coalition in 2009. Riparian acreage estimates are based on field staff's estimate of tamarisk canopy cover occupying riparian versus upland areas.

emphasize job skill training, work ethics, stewardship ethics, and an understanding and respect of public land conservation management. All of these points are extremely important for federal land management agencies that are encountering a significant loss in staff due to retirement and will need dedicated, knowledgeable new staff to fill these voids.

2. Improve aesthetic enjoyment for recreationalist and create a positive framework for them to interact with restoration work by pairing tamarisk control with intensive active restoration at sites frequented by the public.

3. Increase public safety from wildfires, improve highway safety, and increase scenic value by increasing sight distance along state and county roads. This will be achieved by conducting tamarisk removal and shrub restoration on sites selected in coordination with CDOT.

4. Increase protection of public and private property from wildfire by removing tamarisk from around buildings, fences and other fire susceptible infrastructure.

Economic – Over the next 5 years (2010 to 2014) the following economic goals will be achieved through tamarisk management. Monitoring protocols for these economic goals will be included within the assessment of each project's completion reports. They are listed here with the understanding that their implementation may alter decision making in tamarisk management issues. As such, the following must be considered when creating DR-RAP Implementation Plans:

1. Increase employment opportunities for contractors and youth in the Dolores River area.

2. Improve cost benefit ratio for using contractors and youth service corp.

3. Improve effectiveness and financial efficiency of riparian restoration actions by reducing the cost per acre of invasive plant control.

4. Enhance visitor travel to the area for recreation (e.g., rafting and hiking), hunting, and wildlife viewing (e.g., bird watching).

Management – Over the next 5 years (2010 to 2014) the following management goals will be achieved through tamarisk management:

1. Lessons learned during restoration efforts can inform later work, improving efficiencies and the likelihood of long-term, large-scale success; (i.e., adaptive management). These "lessons learned" can also inform work in other watersheds.

2. Incorporate educational and interpretative practices to enhance public understanding and appreciation of riparian restoration actions.

3. Utilize this comprehensive watershed-scale approach to garner support for agency budgets and attract other sources of funding.

4. Facilitate communications between land managers and partners to help coordinate treatments, share lessons learned and increase treatment effectiveness/efficiency by sharing resources and crossing administrative boundaries.

Criteria and Feasibility Characteristics for Prioritizing Restoration Actions

To successfully work towards the DR-RAP **Vision** for the Dolores River of a thriving, sustainable riparian system with specific ecologic, social, economic, and management tamarisk related **Goals** requires specific **Criteria for Prioritizing Restoration Actions**. Suggested criteria for land managers to use to prioritize sites are articulated in Table 1 for active tamarisk control measures and in Table 2 for biological control measures with the tamarisk leaf beetle. These criteria are principally driven by the Ecological Goals for the Dolores River. The Social, Economic, and Management Goals provide direction for the manner in which the sites selected are managed. An earlier version of these criteria was used to identify the recommended work sites described in Appendix M.

As with all other aspects of the DR-RAP, a collaborative approach involving Dolores Watershed stakeholders was used over several months to establish a base set of criteria. These initial criteria are intended to be used to select priority sites in 2010. They should be revisited each year to reflect knowledge gained and modified if needed. However, it is important to note that the process for selecting actual work sites will be qualitatively driven by each BLM office using the goals of the DR-RAP as a tool in the context of the many other issues in the watershed (i.e. land-use issues, workforce availability, budget limitations, and logistical hurdles). As a result, actual work sites may not mirror exactly the recommended sites in this plan.

Feasibility Characteristics: There are three characteristics that dictate the feasibility of a site to be successfully restored. All of the characteristics listed below must be met by any site prioritized by the following criteria and decision tree for restoration to proceed:

1. Funding is available to complete the entire project, including monitoring and maintenance, to a point of success.

2. The landowner is willing. Cooperation, commitment, and common goals with the land owner or land manager are essential. Without long-term collaboration, monitoring, and maintenance, restoration is unlikely to succeed.

3. Site access is economically feasible. The accessibility of a site is important to consider due to the difficulty in management, monitoring, and maintaining the site. If there are adequate financial resources to properly monitor and maintain remote sites this is not an issue.

Although the characteristic listed below is not required for success, its presence greatly increases the likelihood of restoration success:

4. Native vegetation is present in or around a restoration site that can potentially provide a seed source for passive restoration.

Table 1: Criteria for Prioritizing Sites for Active Tamarisk Control

Criteria Category	Criteria Objective	Achievable Goals
A. Existing healthy native vegetation, especially those indicating good hydrologic connectivity	Cottonwood stands, especially those indicating good hydrology, i.e. young recruits. Box elder and privet communities impacted by tamarisk competition. Islands of healthy native vegetation providing important seed sources for adjacent, tamarisk infested areas. Reduce the potential damage from tamarisk supported wildfire to cottonwood and other valuable plant species, especially shrubs which are important for wildlife habitat.	Ecologic Social Management
B. Colorado Division of Wildlife and Utah Division of Wildlife Resources identified important wildlife areas impacted by tamarisk	Bird habitat – cottonwood/willow plant communities that provide potential habitat for Yellow-billed cuckoo. Canyon tree frog which need pools in side canyons for breeding. Bighorn sheep – watering holes and spring sites on tributaries. Fish habitat – sites proximate to areas identified as likely areas for spawning, nursery, or otherwise important areas for warm water fish species such as roundtail chub, flannel mouth sucker, and bluehead sucker that tamarisk may stabilize sediment in critical backwaters.	Ecologic Social Management
C. Critical safety risk areas	Reduce the risk to human life and private property from tamarisk supported wildfires. Increase visibility along highways by removing tamarisk. Reduce the risk to the public at campsites, boat launch areas, and highways from tamarisk supported wildfires.	Ecologic Social Economic Management

Table 1: Criteria for Prioritizing Sites for Active Tamarisk Control

Criteria Category	Criteria Objective	Achievable Goals
D. Outstanding or imperiled plant communities	Sites that contain or are proximate to outstanding or remarkable plant communities such as hanging gardens, columbine-eastwood monkey flower, kachina daisy. Colorado Natural Heritage Program's plant communities considered to be globally imperiled due to rarity – boxelder/river birch, box elder-cottonwood/re-osier dogwood, and strap leaf willow.	Ecologic Management
E. Tamarisk infestations indicating good hydrologic connectivity	Low lying areas with well established stands of tamarisk along channel margins that are likely scoured by high flows and that could provide for cottonwood recruitment following an overbank flooding event.	Ecologic Social
F. Islands of seed source	Continuous stretches of high density tamarisk (>50% canopy cover) where no active restoration is planned but where the tamarisk leaf beetle will be active and a sufficient native seed source is lacking. Upland areas defoliated by the tamarisk leaf beetle where monitoring indicates that revegetation is needed.	Ecologic, Social, Economic, Management
G. Social, Economic or Management "value-based" criteria represent conditions that do not fit into ecologic based criteria A-H	Other value-based criteria are difficult to categorize but can benefit riparian restoration efforts nonetheless. These include: aesthetics, desires of funding source, logical extension of other control projects, educational opportunity, training opportunity, etc.	Ecologic, Social, Economic, Management

Table 2: Criteria for Prioritizing Sites for Monitoring Biological Tamarisk Control

Criteria Category	Criteria Objective	Achievable Goals
A. Costs	• Areas with insufficient funding to adequately address all aspects of restoration; i.e., active tamarisk control, revegetation, herbaceous weed control, monitoring, and maintenance.	Ecologic, Economic, Management
B. Landowner considerations	• Sites that are experiencing livestock grazing practices that are not considered BMPs. • Sites without landowner permission. • Sites with landowner requirements for control and revegetation that do not meet with the Vision, Guiding Principles, or Goals of the DR-RAP.	Without positive landowner involvement, ecologic, social, economic, and management goals will be difficult to achieve
C. Accessibility	• Areas generally inaccessible except through extraordinary measures.	Ecologic, Economic, Management
D. BMP under development	• Areas of high herbaceous weed infestations along with tamarisk that are best left to a future effort that is informed by pilot projects.	Ecologic, Economic, Management
E. Other situations	• Areas with very light tamarisk infestations with good native plant seed source. • Areas that could have sufficient native plant communities that are not considered as significant as cottonwood and New Mexico privet. Examples being rabbitbrush, sagebrush, and greasewood. • Cultural resource sites that would be damaged by active control. • Wildlife and plant species of concern that could be harmed by active control.	Ecologic, Economic, Management

Decision Trees for Prioritizing Criteria to Choose Restoration Sites

The two decisions trees represented below were developed as a practical guide for implementing recommendations made in the citeria for prioritization of riparian restoration efforts in sites occuppied by tamarisk (Figure 3). The first details the process by which tamarisk infested sites are prioritized and the second provides decision guidance for those tamarisk dominated sites also infested with other invasive species, primarially in the herbaceous understory (Figure 4). Figure 4 can also serve as a stand alone decision tree for other projects where tamarisk is not the main focus. DR-RAP's goals are directed at tackling other invasive species only where they interfere with tamaisk related restoration. These prioritization decision trees are explicitly linked together because actions within one affect the other; however, for simplicity they are provided in separate figures.

Although the path for decision making is relatively straightforward, professional judgment must always be used to validate decisions. For instance, it is practical to use the decision tree for tamarisk as a primary filter and then filter through the secondary invasives decision tree to see if that might change priorities.

Decision Tree for Prioritizing Tamarisk Control (Figure 3) – This decision tree assumes that any actions taken to control, contain or eradicate a tamarisk infestation will consider the implications of other invasive species and will be followed by monitoring of treatment success and re-treatment where necessary. A site must meet the following requirements to be prioritized for tamarisk control using this flow chart:

1. The existing tamarisk infestation must be an ecological problem (i.e., greater than 5 percent cover) or have the potential to spread and become a problem.
2. Natural and/or human resource values must be present (listed in Table 1).
3. Hydrologic connectivity (shallow groundwater; $\leq$ 2m) must be intact, human safety concerns must be present, or the site must have **critical** natural resources. If human safety concerns are present the site is automatically categorized as having a high priority.
4. Land management practices at the site must be compatible with restoration goals.

All sites that do not meet these requirements for prioritization will be monitored for biological control impacts. Tamarisk biological control is present in the Dolores River and is considered an active treatment method in the watershed. However, there are many 'unknowns' in how effective the beetle will ultimately be and how it will interact with the larger ecosystem. Thus, its movements and impacts in the watershed will be monitored.

The sites chosen for restoration using this **Decision Tree** are then prioritized by the extent to which they are dominated by native species (excepting those sites with human safety concerns which are automatically the highest priority). Ultimately, the measure of success in tamarisk removal is the eventual domination by native species. Those stands of tamarisk that are immediately surrounded by or interspersed with a high percentage of native vegetation are more likely to be actively replaced by desirable vegetation without intensive revegetation. These projects are considered high priority based on their lower cost of implementation and higher probability for success. In the same way, patches with low percentages of immediately adjacent native cover (e.g. through displacement by non-native understory species, harsh environmental

factors, or large, homogeneous patch size), are more likely to require greater efforts and incur larger costs and are rated as lower priority. While these projects are worthwhile and are sometimes the most compelling to undertake, resources used on them are subsequently not available for projects deemed more likely to succeed.

Once sites have been designated as High, Moderate, or Low priority for treatment based on safety and vegetative characteristics, they are filtered by factors affecting the likelihood that they will progress successfully. These factors include availability and appropriateness of funding options, landowner cooperation, site accessibility, and site location in relation to other restoration projects. Funding sources must be matched to appropriately suited projects to ensure a project can move forward. Landowner cooperation must be secured to ensure that land use and management practices will support restoration attempts in the short and long term. Site accessibility strongly affects the cost benefits ratio of a project and may limit the ability to revisit a site for secondary weed treatments, monitoring, and maintenance. Sites with high priority for treatment but very challenging access issues may be considered treated with beetle activity and monitored. The proximity of the site to other treatments is important as projects are more likely to positively affect local ecosystem functions when clustered in a smaller area vs. scattered throughout the entire basin.

Decision Tree for Non-Tamarisk Invasive Species (Figure 4) – This decision tree assumes that any actions taken to control, contain, or eradicate an infestation of other invasive plants will be followed by monitoring of treatment success and re-treatment where necessary.

If there are non-tamarisk invasive species present at a site, the criteria determines the designated class of the species in question, as determined in the Colorado and Utah invasive species lists. Class A invaders, those which are especially virulent or with very small leading-edge patches, call for aggressive treatments and monitoring with the express goal of eradication. Species rated as Class B or C, those which are already widespread or lesser concern, are considered for their probability of spreading through vectors such as roads, rivers, animals, etc. If the probability of spread is high and the patch is small and/or isolated, it may warrant eradication efforts. If the patch size is larger and near the main population, efforts will focus more on containment of spread and control though integrated management methods.

If the stand in question has a low probability of spreading, the next question is whether the patch has a high or low probability of increasing its domination of a site over time, or with immanent changes in land use. This is a primary consideration for tamarisk stands scheduled for control treatments with an understory of Russian knapweed that will likely dominate when released from tamarisk competition. If the probability of increased dominance is low, for instance in sites where the patch is strongly interspersed with or surrounded by robust native vegetation, the chosen approach is to monitor the patch but not take an active role in either containment or control. If the invasive species patch is likely to increase domination, either eradication or control/containment will be used, depending on the size and relative isolation of the patch. Any site that is a potential candidate for non-tamarisk invasive treatment is likely to have a mix of patch densities and amounts of native cover. Individual site plans will likely utilize a variety of treatment options ranging from aggressive replanting efforts to periodic monitoring of ecosystem changes.

Figure 3: Decision Tree for Prioritizing Tamarisk Control

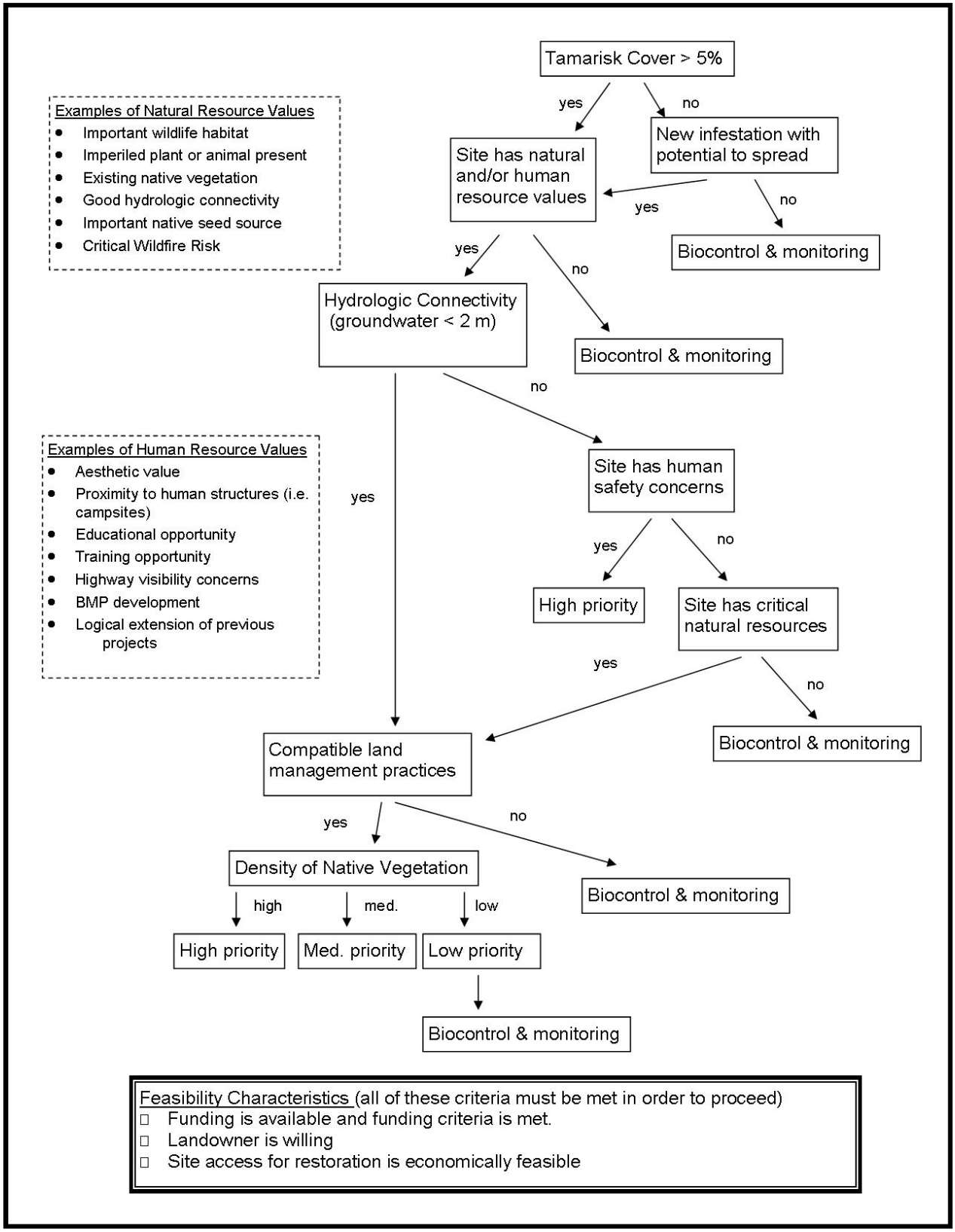
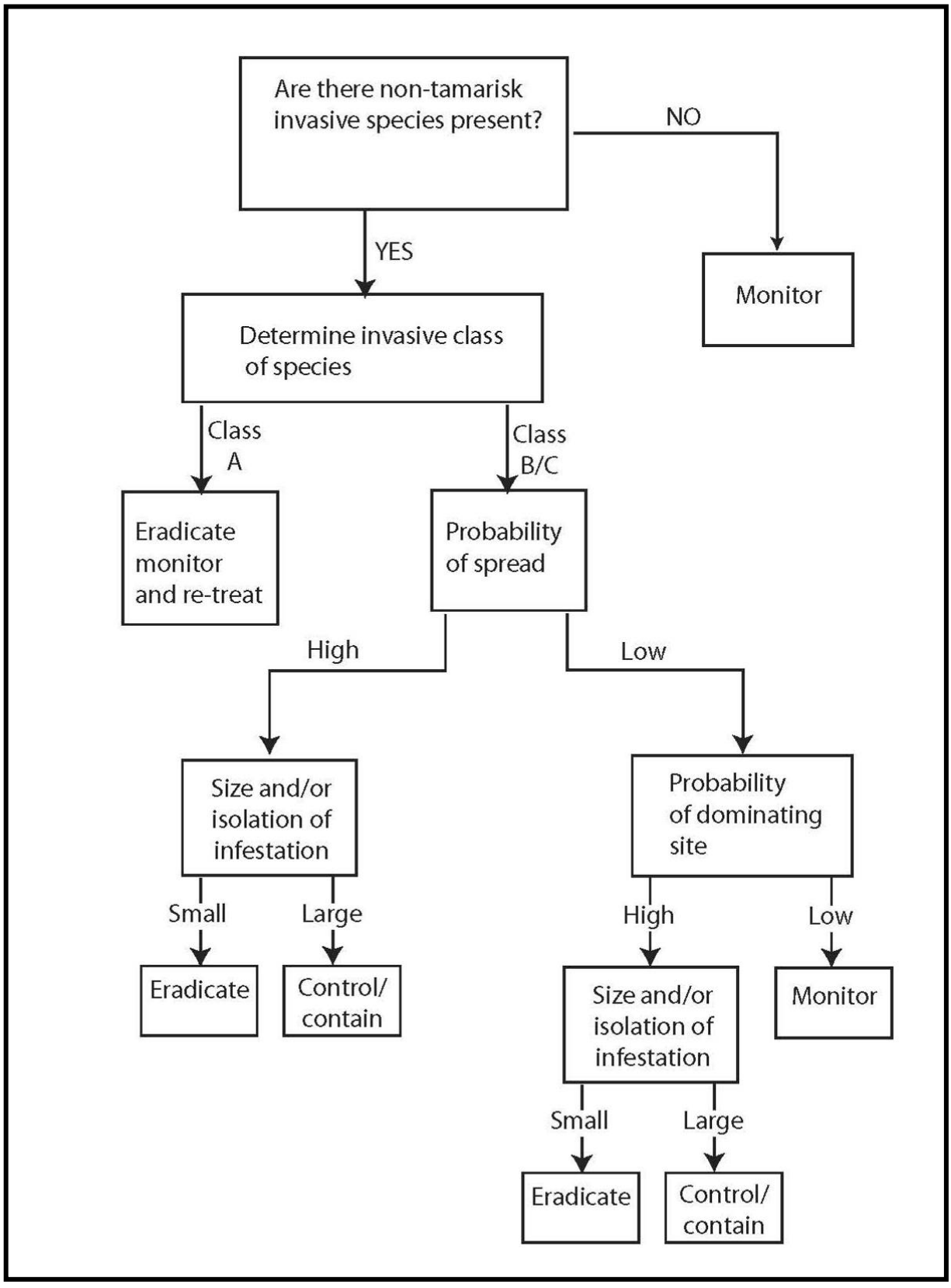


Figure 4: Decision Tree for Prioritizing Non-Tamarisk Invasive Species Control



Methods for Achieving DR-RAP's 5 Year Goals

- **Tamarisk Removal Method**: Tamarisk control will occur in high priority areas based on the criteria described in the previous section. Selection of appropriate control mechanisms should be determined by an Integrated Pest Management approach as described in Appendix C.

- **Biomass Removal Method**: Biomass reduction may or may not be needed based on tamarisk canopy cover, access, landowner requirements, and presence of native vegetation. These options and decision making criteria are more thoroughly explored in Appendix C.

- **Non-native Woody Control**: Where possible, woody, non-native, invasive species such as Siberian elm and Russian olive should be controlled where they co-occur with tamarisk infestations. Removal methods for these species are similar to hand, mechanical, and herbicide tamarisk control.

- **Non-native Herbaceous Control**: Herbaceous, non-native invasive species should be controlled where they will interfere with passive or active revegetation. Appendix F describes control methods for invasive species common to the Dolores River watershed.

- **Revegetation**: Coinciding with non-native, invasive species control (primarily tamarisk), areas should be evaluated to determine if active revegetation or passive revegetation with native species should occur. It is important to note that, in some cases, non-native plant materials that are not invasive may be desirable by land managers; e.g., intermediate wheatgrass (*Thinopyrum intermedium*). Riparian zones that are connected to the river hydrology tend to respond better to passive revegetation efforts. Thus, areas that are more connected to the flood regime, such as those sections below tributaries such as the San Miguel, are more likely to experience passive restoration success. As a general rule 5% to 10% native vegetation canopy cover, reduced salinity, and favorable hydrology is necessary in riparian areas to hope for passive revegetation success. In upland areas with higher salinity and unfavorable hydrology, 25% cover is necessary for passive revegetation to occur[7]. Appendix G provides some basic information on Best Management Practices for livestock grazing and fencing important for successful revegetation efforts.

- **Short & Long Term Monitoring and Maintenance**: Short-term monitoring and maintenance is important to ensure a successful end point to each restoration project that will then be monitored and maintained over time. Long-term monitoring and maintenance is necessary to ensure the restored site is not degraded over time.

  Monitoring is the observation of changes that are occurring or are expected to occur with, or without, remediation actions. The purpose of mo*nitoring is to provide*

[7] Sher, A.A., K. Lair, M. DePrenger-Levin, and K. Dohrenwend. 2010. "Best Management Practices for Revegetation after Tamarisk Removal in the Upper Colorado River Basin Handbook". Denver Botanic Gardens, Denver, CO, USA

information to inform decisions to initiate, continue, modify, or terminate specific actions, restoration activities, or programs – better known as "adaptive management."

Maintenance is the physical action to sustain restoration goals over time. These actions, carried out over years to decades, focus activities to sustain progress made during restoration activities. Monitoring provides information for making informed decisions to ensure "maintenance" will continue to remediate or improve the ecological processes of the watershed. Examples of maintenance actions are continued secondary weed control and supplemental establishment of native species that may fail after restoration activities.

- **Adaptive Management**: Adaptive management is the process of adjusting restoration approaches based on gained knowledge. Adaptive management acknowledges the complexity of the watershed systems by treating restoration efforts as experiments. This allows decision making to proceed in the face of scientific uncertainty and emerging scientific understanding. Through detailed reporting systems and monitoring, adaptive management provides direction for future restoration actions. Basically, as lessons are learned from past restoration actions, restoration approaches are adjusted to improve effectiveness and efficiency. From the review of large-scale ecosystem restoration case studies[8] one of the principle conclusions is:

  . . . "*The theory of adaptive management, widely endorsed by project planners and authorizers, is still largely untested*." . . . To be a functional part of a restoration plan . . . "*adaptive management requires that the parties have an effective process for making changes in place, which, if followed, will set the project on a new, scientifically sound course in an expeditious way*."

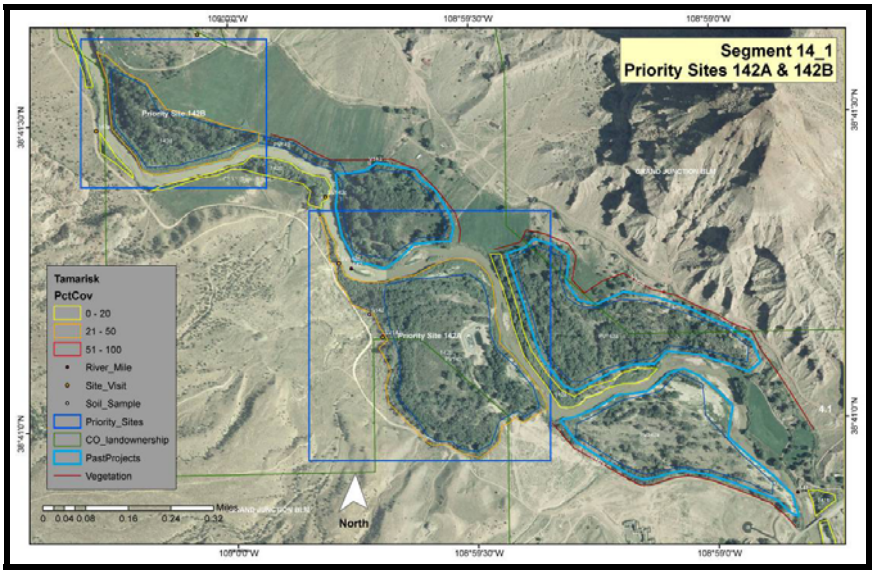
Monitoring, Maintenance, & Adaptive Management Challenges

Through observation (*monitoring*), land managers can adjust restoration approaches to improve success (*adaptive management*), and sustain restoration goals (*maintenance*). However, these interacting activities are only effective if there is also effective communication between those who monitor, land managers, and maintenance staff. Thus, a communication and information storage system is critical to effective monitoring, adaptive management, and maintenance. Tamarisk management and restoration activities along the Dolores River will greatly benefit from an organized approach to such communications (See Recommended Restoration Actions for 2010 – Number 7: Monitoring, Research, & Maintenance Subcommittee).

[8] Doyle, Mary. Introduction: The Watershed-Wide, Science-Based Approach to Ecosystem Restoration, *Large-Scale Ecosystem Restoration – Five Case Studies from the United States*. Society for Ecological Restoration International, Island Press, 2008.

Estimated Costs for Restoration

The process outlined above to identify restoration sites was put into practice by the Tamarisk Coalition to recommend the Dolores River project site locations that appear in Appendix M[9]. The Coalition then used professional knowledge (much of which is articulated in Appendices A, B, and C) and an understanding of local ecological conditions (based on 2009 mapping and field work) to draft appropriate methods for tamarisk removal and restoration for each site. Cost algorithms were then used to estimate the cost of total tamarisk control, biomass reduction, revegetation, secondary weed control, and short-term monitoring and maintenance for each site. These cost algorithms, which are presented and explained at length in Appendix C, were created by the Tamarisk Coalition using cost, efficacy, and appropriateness data collected from tamarisk control and restoration projects that have occurred in the west and plains states over the past five years. They have been adjusted to reflect 2009 costs.



Recommended restoration sites and associated information resulting from these efforts appear in Appendix M in the following forms:

1. Highlighted by blue boxes in the maps.
2. Described in text in documents 1 - 5 along with recommended control mechanisms and cost summaries.
3. Listed in the "Tamarisk Attributes_Rec Control Tech_Cost Estimates" table which describes the nature of the tamarisk infestation, native vegetation presence, type of control mechanisms recommended, and the total estimated cost to restore each site.

This table provides total estimated costs for each site via a completed cost calculation (a blank version is available in Appendix L) reflecting the recommended control mechanisms for each site. Table 3 below summarizes this information for the entire Dolores River.

[9] These preliminary site recommendations will be reviewed and modified by Dolores River land managers and stakeholders at a meeting scheduled for April 22, 2010.

Table 3: Summary of Estimated Costs for Tamarisk Management – Dolores River.

Summary of Costs for Dolores River Recommended Sites

Technologies for Control, Biomass Reduction, Revegetation, & Weed Control	Restoration Details & Costs within Dolores BLM District	Restoration Details & Costs within Uncompahgre BLM District	Restoration Details & Costs within Grand Junction BLM District	Restoration Details & Costs within Moab BLM District	TOTALS
Sites Appropriate for ACTIVE Tamarisk Management					
Total Recommended Acres for ACTIVE Tamarisk Management	207	271	237	248	964
Estimated Riparian Acreage	133	221	171	190	715
Active Tamarisk Management Costs					
Hand control -- Crew Time basis	$31,200	$0	$0	$0	$31,200
Hand control -- Acreage basis	$152,436	$273,794	$226,632	$261,196	$914,059
Mech. Extraction	$0	$0	$0	$0	$0
Mech. Mulching	$69,025	$96,302	$58,141	$21,189	$244,657
Mech. Grab & cut-stump	$0	$2,449	$10,094	$0	$12,542
Biological control	$0	$0	$0	$0	$0
Biomass Reduction by Mulching	$0	$832	$3,958	$0	$4,789
Biomass Reduction by Fire	$1,419	$0	$0	$0	$1,419
Biomass Reduction by Natural Decomposition	$0	$0	$0	$0	$0
Weed Control -- Percent area infested	$69,975	$82,512	$83,267	$64,960	$300,714
Revegetation -- percent area needing revegetatior	$74,114	$107,186	$67,444	$85,408	$334,152
Subtotal Control, Biomass reduction, & Revegetation Costs for Site	$398,169	$563,074	$539,443	$432,754	$1,933,440
Cost Multiplier for Access & Remoteness of Worksite	$79,634	$112,615	$139,033	$86,551	$417,833
Total Control, Biomass reduction, & Revegetation Costs for Site	$477,803	$675,689	$678,476	$519,305	$2,351,273
Monitoring and maintenance over 3 to 5 years for active control and revegetation	$123,313	$183,137	$139,033	$129,826	$575,310
Monitoring over 5 years for Biological Control	$0	$0	$0	$0	$0
Total Monitoring and Maintenance Costs over 3-5 years	$123,313	$183,137	$139,033	$129,826	$575,310
Total Tamarisk Management Costs within BLM District	$601,116	$858,826	$678,476	$649,131	$2,787,549
Sites Appropriate for BIOLOGICAL CONTROL					
Disappointment Creek Remaining Acreage	735				735
Dolores River Remaining Acreage	121	738	486	378	1,723
Other Tributaries: William's Draw, Nash Wash, Davis Canyon, La Sal Creek, and West Creek Acreage	19	153	7		180
		Total Acres for Biological Control Tamarisk Management =			2,638
Estimated Riparian Acreage	705	479	433	296	1,912
Biological Control Costs					
Biological control	$8,756	$8,912	$4,938	$3,777	$26,383
Biomass Reduction by Mulching	$0	$76,517	$0	$23,908	$100,425
Biomass Reduction by Hand Cutting & Fire or stacking for wildlife habitat	$172,499	$227,652	$117,429	$115,459	$633,038
Biomass Reduction by Natural Decomposition	$0	$0	$0	$0	$0
Weed Control -- Percent area infested	$86,421	$132,696	$58,956	$60,430	$338,503
Revegetation -- percent area needing revegetatior	$49,464	$164,696	$49,484	$66,464	$330,108
Subtotal Biological Control, Biomass Reduction& Revegetation Costs	$317,140	$610,474	$230,806	$270,037	$1,428,457
Cost Multiplier for Access & Remoteness of Worksite	$63,428	$122,095	$46,161	$54,007	$285,691
Total Biological Control, Biomass Reduction & Revegetation Costs	$380,568	$732,568	$276,968	$324,045	$1,714,149
Monitoring and maintenance over 3 to 5 years for vegetatior	$92,362	$185,204	$68,007	$80,067	$425,640
Monitoring over 5 years for Biological Contro	$87,564	$89,124	$49,377	$37,769	$263,833
Total Monitoring and Maintenance Costs over 3-5 years	$179,925	$274,329	$117,384	$117,836	$689,474
Total Tamarisk Biological Control Management Costs	$560,493	$1,006,897	$394,352	$441,880	$2,403,622
Total Tamarisk Management Costs for Dolores River Watershed	$1,161,609	$1,865,723	$1,072,827	$1,091,012	$5,191,172
Total Acres for Active & Biological Tamarisk Management	1083	1,163	731	626	3,602
Total Acres of Riparian Lands for Active & Biological Tamarisk Management	838	700	604	485	2,627

Recommended Restoration Actions for 2010

Restoration Actions Completed in 2009
In the fall of 2009, a tamarisk removal demonstration project was conducted to promote the efficiency of using Conservation Youth Corps organizations to control tamarisk infestations along the Dolores River. This effort involved removing tamarisk along 54 river miles between McPhee Reservoir and Disappointment Creek. Initial reporting following that effort is available as Appendix H.

Recommended Restoration Actions for 2010
Decisions to determine priority sites and how to proceed on each of these actions will be made by the BLM field offices or through collaboration between the BLM and NRCS specialists representing private landowners. Based on interactions between these agencies and other partners the following recommended actions in 2010 are suggested to meet the ecologic, social, economic, and management goals described above.

1. Formalize the Dolores River Restoration Partnership through a Memorandum of Understanding by all of the agencies, organizations, and others involved with the riparian restoration effort.

2. For Disappointment Creek, establish several pilot project sites in 2010 to assess revegetation response in high salinity soils and arid conditions, and restoration success in relationship to Russian knapweed presence, livestock grazing under BMP, and control techniques.

3. For the remainder of the Dolores River system, establish in 2010 several pilot project sites in each of the four BLM areas to assess different control techniques (i.e., hand and mechanical), Russian knapweed and other herbaceous weed control, and active and passive revegetation techniques. This would include efficacy and efficiency analysis.

4. Establish several pilot projects in 2010 for biological control to assess degree of tamarisk defoliation, and vegetative response both native and non-native.

5. Establish a pilot project site to improve dynamic geomorphic processes (channel adjustments) by controlling tamarisk and restoring native dominance where tamarisk establishment appears to have "armored" the riverbanks and/or caused channelization and possible down cutting.

6. Convene a two-day workshop in winter 2010-2011 to review 2010 accomplishments and use Adaptive Management principles to make restoration decisions for 2011 through 2014 based on the data collected through the above pilot projects. This practice should continue each year to inform decisions for restoration efforts for subsequent years.

7. Establish the following four subcommittees:

Monitoring & Maintenance Subcommittee: To incorporate adaptive management principals, it is recommended that a process be established in 2010 to collect, assess, and disseminate monitoring data for use on future projects.

Suggested methods to accomplish this task include:

(1) Establish uniform monitoring protocols;
(2) Create or use an existing website to upload Dolores River restoration project information using standardized forms and monitoring protocols;
(3) Identify an organization to take on archiving and distribution of restoration "lessons learned"; and/or
(4) Establish and maintain direct communications with adjoining watershed groups such as the Southeastern Utah Tamarisk Partnership and San Juan Watershed Woody-Invasives Initiative.

Funding Opportunities Subcommittee: To identify and pursue funding options to enhance and leverage existing funding sources.

Two preliminary tasks for this committee have been identified as:

(1) Identifying a mechanism to ensure each project initiated has sufficient funding to sustain short-term, monitoring and maintenance to a point of success;
(2) Identify a funding source to control secondary invasive species and restore native vegetation on upper terraces where it is found to be necessary following biological control.

Education and Outreach Subcommittee: To identify education and outreach opportunities and appropriate materials.

Science Subcommittee: To provide technical advice and to recommend restoration adjustments based on monitoring and adaptive management to include revegetation, beetle data interpretation, land management BMPs and information management.

Preliminary tasks of this subcommittee will be to:

(1) Identify a mechanism to address tamarisk control in Dolores River tributaries, and
(2) Provide information to the Partnership on the key management questions that have been adequately researched and identify mechanisms to answer those that have not.

Appendices Summary

Due to the length and complex content of the following appendices, full text versions are not included in this document. Complete versions of the appendices summarized below are provided externally in the Data DVD and are accessible via the in-text hyperlinks in blue.

Appendix A: Tamarisk & Russian olive Management State-of-the-Science

Appendix A contains a discussion on the state-of-the science of tamarisk and Russian olive (TRO) extracted from the recently published report *Colorado River Basin Tamarisk and Russian olive Assessment, December 2009.* It reflects the current understanding of the impacts of both tamarisk and Russian olive in the Colorado River watershed with the discussion modified to specifically apply to the Dolores River watershed.

Appendix B: Biological Control State-of-the-Science

Appendix B gives a brief background of the tamarisk leaf beetle's discovery, testing process, and field releases including subsequent tamarisk defoliation and mortality reports. The document then contains an explanation of beetle presence and impact on the Dolores River specifically. The state-of-the-science of the various tamarisk leaf beetle species' characteristics and ranges are also discussed along with preliminary knowledge of: ecosystem response, monitoring efforts, pattern and extent of tamarisk mortality, riparian vegetation restoration, secondary invasion, erosion & hydrological changes, wildfire risk, soil salinity interactions, wildlife abundance and diversity, and pollutants interactions.

Appendix C: Tamarisk Management and Restoration – Description of Available Control, Biomass Reduction, Revegetation, Monitoring & Maintenance Techniques and Costs in the Dolores River Watershed

In order to plan a successful tamarisk management project, appropriate methods for tamarisk removal and associated restoration must be chosen in consideration of both site specific ecological conditions and available funds. This document is a tool that examines available technologies for each component of a restoration project along with algorithms that estimate their costs. These algorithms were created by the Tamarisk Coalition using cost, efficacy, and appropriateness data collected from tamarisk control and restoration projects that have occurred in the West and Plains States over the past five years and adjusted to reflect 2009 costs.

Appendix D: Conceptual Framework for Dolores River Riparian Action Plan

Achieving the vision of DR-RAP requires a conceptual framework that guides planning and implementation. The conceptual framework is a model of how the river system and associated riparian areas function currently and how they are expected to function in the future.

Appendix E: System Stressors & DR-RAP's Assumptions

This is the expanded version of the "**System Stressors & DR-RAP's Assumptions"** section in this document. In essence the document defines the stressors that are associated with the Dolores River system along with the assumptions this plan is operating under to mitigate these pressures.

Appendix F: Management Assessment for Invasive, Non-native Species

Appendix F is a tool intended to help assess the invasive species management needs of a given restoration site. This appendix does not include specific control recommendations (e.g. for herbicides) for the following reasons: (1) site variables at the management scale differ from site to site and need to be analyzed individually; (2) new herbicides, and new research, come out every year and regional experts (e.g. county weed managers) should be consulted prior to management implementations; and (3) based on the adaptive management approach outlined in DR-RAP, adjusted methods and techniques may be applied to improve rates of success.

Appendix G: Best Management Practices for Livestock Grazing & Fencing for Riparian Areas

Appendix G provides information extracted directly from *Riparian Area Management: Grazing Management Processes and Strategies for Riparian-Wetland Areas (2006),* a handbook produced by the BLM. This information is intended to provide background information on successful livestock riparian grazing strategies and exclusion techniques while guiding the reader to the resource mentioned above for more information.

Appendix H: Conservation Youth Corps – Dolores River Restoration Pilot Program 2009 Report

Appendix H is a summary report of the tamarisk removal work completed on the Dolores River in 2009 by the Conservation Youth Corps. This work was the first implementation work associated with the Dolores River Restoration Partnership and DR-RAP.

Appendix I: Key Management Questions

Appendix I is a list of key management questions solicited from the four BLM Offices managing lands on the Dolores River. These questions represent critical gaps in: (1) knowledge necessary to inform management decisions and (2) communication to and amongst land managers of existing restoration information. Currently, these knowledge gaps inhibit the efficiency and effectiveness of riparian management on the Dolores River. These key management questions are listed in the spirit of increased collaboration across the basin.

Appendix J: Dolores River Restoration Partnership Executive Summary

Appendix J provides additional background information on the Dolores River Restoration partnership including its history, decision making process, funding mechanisms, and the roles and responsibilities of the organizations involved.

Appendix K: Grant Opportunities for Tamarisk and Russian Olive Control & Restoration

Appendix K is a list of possible grant opportunities available for addressing tamarisk and Russian issues as well as riparian restoration. This list of grant opportunities was compiled in the summer of 2007 as a starting point for grant funding research. As a result some of the information may be out of date. The list is not exhaustive and is designed only to provide an overview of available grants.

Appendix L: Cost Calculator

Appendix L is an excel spreadsheet with embedded formulas based on the cost algorithms presented in Appendix C. This spreadsheet allows one to apply these algorithms to any given restoration site along the Dolores River. The spreadsheet requires that total average tamarisk canopy cover and total project site acreage (or number of crew days required) are known for a given site. Total number of crew days is needed for those sites in which total site acreage is so large in relation to total tamarisk canopy cover that cost is a function of time spent rather than acres cleared. These pieces of information drive all of the algorithms imbedded in the table.

Once the tamarisk canopy cover and site acreage (or crew days) are known, the percent of the total site acreage designated for various control techniques can be entered to determine an estimated cost. The control and restoration options included in the table are as follows (each technique is described in detail in Appendix C):

1. Hand Control – Crew Time Basis (for extremely sparse tamarisk infestations)
2. Hand Control – Acreage Basis (for low to high tamarisk infestations)
3. Mechanical Extraction Tamarisk Control
4. Mechanical Mulching Tamarisk Control
5. Mechanical Grab & Cut-Stump Tamarisk Control
6. Biological Control
7. Biomass Reduction by Mulching
8. Biomass Reduction by Fire
9. Biomass Reduction by Natural Decomposition
10. Russian Knapweed Control – Percent Area Infested
11. Revegetation – Percent Area Needing Revegetation

When summed, the costs of each approach for the project constitute the total estimated control, biomass reduction, and revegetation. A cost multiplier is then used to account for remoteness and access difficulties common to the Dolores River. The short-term monitoring and maintenance costs for active control is then calculated as a percentage of these combined restoration costs: 20% for light infestations, 25% for moderate infestations, or 30% for heavy infestations.

Appendix M: Recommended Restoration Sites Text, Photos, Mapping, Attribute Tables, & Cost Estimates

Appendix M is a folder containing documents, spreadsheets, photos, and maps (PDF and shapefiles) describing preliminary sites recommended for restoration along the Dolores River as well as the **Criteria for Prioritization** that they meet. **These preliminary site recommendations will be reviewed and modified by Dolores River land managers and stakeholders at a meeting scheduled for April 22, 2010.**