Middle Colorado Riparian Restoration Action Plan

4-7-17

Middle Colorado Watershed Council

I. Introduction

The mission of the Middle Colorado Watershed Council (MCWC) is "To evaluate, protect, and enhance the health of the Middle Colorado River Watershed (MCRW) through the cooperative effort of watershed stakeholders."

The Middle Colorado Watershed Plan, created in 2016 for the MCRW, outlines several priority projects including the development and implementation of a riparian restoration plan. The Middle Colorado Riparian Restoration Action Plan initiates this planning process and outlines actions needed to prepare for implementation. The Action Plan will serve as a reference document to guide the MCWC through the planning stages and into implementation stages of riparian restoration.

This document focusses on the riparian areas of the Colorado River and its major tributaries between the head of Glenwood Canyon to the town of DeBeque, excluding the Roaring Fork River.

The Riparian Restoration Action Plan outlines:

- The state of riparian health in the MCRW;
- Steps needed to restore riparian ecosystems to a state of improved health;
- Additional information needed to make informed decisions about riparian restoration activities throughout the MCRW; and
- The formation of partnerships to guide the planning process, examine and evaluate technical information, problem solve, and coordinate restoration work.

Thanks are extended to the Bureau of Reclamation Cooperative Watershed Management Program for supporting riparian restoration efforts through development of this document.

II. Background

To "Develop and Implement a Comprehensive Riparian Restoration Plan" is one priority project outlined in the Middle Colorado Watershed Plan. The project purpose and description excerpted from the Plan is as follows:

> "Reestablish and restore native riparian plant communities in the MCRW. This work would necessarily include the control of TRO [tamarisk and Russian olive] and other infestations of non-native vegetation. Develop a watershed-specific restoration strategy that prioritizes project areas in manageable segments and sets forth an achievable plan for funding and implementing the work."

This document is meant as the first step towards this restoration strategy.

Invasive species management and removal will need to be a major component of restoration efforts. Woody invasives, in particular, negatively impact riparian corridors in the MCRW. The major woody invasives are tamarisk and Russian olive. The following section outlines what we know about woody invasive plants in the MCRW. Much of this information is taken directly from the Middle Colorado Watershed Plan.

III. Invasives in the MCRW

Noxious Weeds

Exotic plant invasion is an increasingly serious problem in Colorado. Colorado now hosts about seventy noxious weed species that infest at least one and one-half to two million acres. Weeds tend to take advantage of any disturbance of the soil. Wind, water, animals, people and vehicles can disperse their seeds. In some cases, weedy species have been planted intentionally. Once established, they often lack the native competitors, predators, and pathogens that would keep them under control in their native habitat (Lyon et. al., 2001).

Within the MCRW, Garfield and Mesa counties conduct weed control activities on public lands and, along with assistance from local conservation districts, provide technical assistance to landowners undertaking weed control on private lands. The following plants have been listed as noxious weeds by Garfield County. Some mapping of noxious weeds has been conducted by the counties, but the coverage is not comprehensive. Some of these weeds occupy particular elevational ranges or vegetative community types (e.g., riparian areas) while others have a broader distribution throughout the MCRW. Those most commonly found in riparian areas are highlighted in yellow.

Canada thistle - *Cirsium arvense*
Chicory - *Cichorium intybus*
Common burdock - *Arctium minus*
Dalmatian toadflax - *Linaria dalmatica*
Diffuse knapweed - *Centaurea diffusa*
Hoary cress - *Cardaria draba*
Houndstongue - *Cynoglossum officinale*
Jointed Goatgrass - *Aegilops cylindrica*
Leafy spurge - *Euphorbia esula*
Musk thistle - *Carduus nutans*
Oxeye Daisy - *Chrysanthemum leucanthemum*
Plumeless thistle - *Carduus acanthoides*
Purple loosestrife - *Lythrum salicaria*
Russian knapweed - *Acroptilon repens*
Russian olive - *Elaeagnus angustifolia*
Tamarisk (Saltcedar) - *Tamarix parviflora and T amarix ramosissima*
Scotch thistle - *Onopordum acanthium*
Spotted knapweed - *Centaurea maculosa*
Yellow starthistle - *Centaurea solstitalis*
Yellow toadflax - *Linaria vulgaris*

Invasive Riparian Vegetation

Tamarisk (*Tamarix* spp. or commonly called saltcedar) and Russian olive (*Elaeagnus angustifolia*) are two riparian invasive species of particular interest in the MCRW due to their high profile status in the Colorado River basin, negative environmental impacts, and proliferation in the western half of the MCRW.

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). The exact date of introduction is unknown, however it is generally understood that tamarisk became a problem in western riparian zones in the mid 1900s (Howe and Knopf, 1991).

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.

Russian olive was introduced to the U.S. in the late nineteenth century as an ornamental shrub or small tree and has since spread from cultivation. Originating in southern Europe and central and eastern Asia, Russian olives are long-lived and resilient plants. They are adapted to survive in a variety of soil types and moisture conditions, are shade tolerant, and can germinate over a longer time interval than native species (Howe and Knopf, 1991). Up until the 1990s, they had been widely promoted and used by state and federal agencies for windbreaks and horticulture plantings in the western U.S. As a result, Russian olives were distributed widely in the west and continue to spread (CHIP, 2008).

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 negatively 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 diversity and can effectively limit regeneration of native cottonwoods.
- Invasives can convert riparian areas to relative drylands with Russian olive as the climax species.
- Dense stands of Russian olives increase fuel loads leading to more frequent and intense wildfires that kill native plants.
- Russian olive trees provide inferior habitat to native vegetation and reduce abundance and diversity of wildlife.

Colorado Headwaters Invasives Partnership

In September 2005 a partnership called the Colorado Headwaters Invasives Partnership (CHIP) was formed to develop a strategic plan for the Colorado River's riparian areas impacted by tamarisk and Russian olive. CHIP was initiated in Garfield County through the leadership of the Colorado River

District, the Nature Conservancy and the Tamarisk Coalition (TC). The vision of CHIP is an overall Colorado River watershed restored as a thriving and diverse riparian ecosystem containing minimal infestations of non-native invasive species (CHIP, 2008).

The CHIP planning effort included a comprehensive tamarisk inventory and mapping component spanning from 2005 through 2008. A map of this 2008 tamarisk inventory is shown in Appendix A. While the inventory work focused on tamarisk, Russian olive infestations were noted and addressed in the Plan. Quantitative findings are summarized as follows.

Colorado River Mainstem. Tamarisk occupied approximately 439 acres in this stretch of river, displacing roughly 65% of the riparian area capable of supporting native cottonwood/willow communities.

Major Tributaries. Inventory work extended up the MCRW tributaries of Roan, Parachute, Government and Rifle Creeks. Tamarisk was found to occupy a collective 41 miles of stream on these four waterways, or a total of 189 acres. It displaces roughly 40% of the riparian area capable of supporting cottonwood/willow communities.

The following excerpt from CHIP further details the general state of woody invasives in the MCRW and recommends basic strategies for restoration of invaded areas.

> **"Colorado River, DeBeque to Silt** – This section of the Colorado River has heavy tamarisk infestations near the town of DeBeque gradually decreasing in density approaching the town of Silt. The recommendations for this area are very similar to those for the Grand Valley area. The primary tamarisk management should be biological control. Some high priority areas such as the DeBeque State Wildlife Area and west of the Rifle I-70 Rest Area could be cleared using mechanical or hand cut stump methods. No herbicide should be needed for resprouts if biological control is active in the area. For some areas it will be appropriate to perform mechanical or hand cut stump removal to form fire breaks or to reduce wildfire potential. Along Interstate 70 near Rifle, mechanical removal with cut stump herbicide application or extraction should be used to assure safety along this roadway.
>
> Russian olive is a significant problem in some areas on this section of the Colorado River. It is present not only in the floodplain, but in fallow fields and along fence rows. Control will require either hand or mechanical cut stump with herbicide application.
>
> Biomass reduction should not be needed for light infestations and some moderate infestations but should be performed for all other situations to reduce the fuel load in riparian areas. This is especially important to protect the valuable cottonwood galleries in many areas. Mechanical methods are recommended with some hand work required on difficult to access areas.
>
> Areas necessitating biomass reduction will require revegetation. Native planting requirements will increase proportionately with the density of infestation and extent of ground disturbance. Weed control will be critical for much of this river section to prevent other noxious weeds from filling the void left by tamarisk and Russian olive removal.
>
> **Colorado River, Silt to Glenwood Springs** – This section of the Colorado River has only isolated pockets of tamarisk. Russian olive is more abundant, but not yet a major problem. Because infestations are contained within the river's narrow, incised banks, it is recommended that hand

control using cut stump method with herbicide be used for control of both species. No revegetation or biomass removal is likely to be needed. Some weed control will, however, be necessary. For areas beyond the floodplain with significant Russian olive infestations, such as the pasturelands west of the I-70 river crossing in Silt, mechanical mulching with cut stump herbicide application is recommended.

Plateau Creek, Roan Creek, Parachute Creek, Rifle Creek, and Government Creek – The tamarisk locations on these major tributaries to the Colorado River vary from light, isolated infestations to large invasions extending miles upstream. Some tributaries, such as Rifle Creek, have relatively minor infestations, while others such as Roan Creek have heavy infestations. In general, where infestations are scattered, it is recommended that hand control be utilized with herbicide. Where infestations are contiguous, it is recommended that biological control be the main approach. Most of these areas should not require biomass reduction or revegetation efforts; however, weed control will be necessary."

Need for Updated Mapping

The CHIP mapping effort serves as a useful tool for understanding the distribution and extent of TRO within the MCRW at a relatively detailed scale. However, since this effort was completed in 2008, more up to date information on the state of invasives in the MCRW may be needed, including more comprehensive mapping on the tributaries. Garfield County and the Conservation Districts have been working to remove invasives in the MCRW, thus altering the area of infestation. The tamarisk beetle has also been active in the MCRW in the years following the 2008 CHIP assessment, thus impacting tamarisk populations. At a minimum, these recent changes to tamarisk should be considered; at a maximum, the entire riparian area of the MCRW may need to be re-inventoried at a refined scale.

IV. Resources for Restoration

Current Efforts of Riparian Restoration within the MCRW

It is important to consider past and on-going restoration efforts in the MCRW. Considerable work has been completed, particularly focused on TRO removal and revegetation, by:

- Garfield and Mesa counties;
- the local Conservation Districts, which include Mount Sopris, Bookcliff, South Side, and Bluestone;
- Natural Resource Conservation Service (NRCS) through providing financial and technical assistance to the counties and conservation districts; and
- Bureau of Land Management.

Efforts described in this Action Plan should complement and build upon that body of work through increasing local capacity for expanded restoration activities. Work currently being done could be leveraged to attract larger sources of funding for efforts completed at a larger scale. There is also much to learn about the success of past efforts through interviews, evaluation of follow-up monitoring

reports, and current field visits. Lessons learned should be incorporated into planning efforts moving forward.

The tamarisk beetle (*Diorhabda* spp.) has impacted tamarisk populations since its release as a biological control agent by the USDA in 2001. Since 2007, the TC has been a leader in providing information on the movement of the tamarisk beetle. TC has worked with many partners to track its distribution, educate the public about its potential ecosystem impacts, and provide strategies that land managers can employ to integrate the beetle into their riverside land management practices. The tamarisk beetle has been documented throughout the MCRW. This insect is believed to eventually cause the death of approximately 70-80% of tamarisk plants in the next 10 years (TC Pamphlet – update this reference and fact based on http://www.coloradomesa.edu/water-center/documents/WC_BeetleStudyReport_1516.pdf). Though this will give native plants a better chance of competing with tamarisk, it will not solve the tamarisk problem completely. Therefore, it is prudent to take additional steps to control tamarisk.

Learning by Example

Control of dense populations of woody invasives such as tamarisk and Russian olive is not unique to the Middle Colorado River watershed, nor is ecological restoration. The MCWC looks to other nearby organizations and watersheds to model effective landscape scale riparian restoration efforts. The Dolores River Restoration Partnership and the Desert Rivers Collaborative are two examples of successful collaborations to remove invasive species and restore riparian areas. The Desert Rivers Collaborative, an effort spearheaded by TC, is heavily invested in restoration along the Colorado River directly downstream of the MCRW. The Escalante River Watershed Partnership has experience with the removal of Russian olive and they are a good source to consult on management of that invasive species. Friends of the Verde River Greenway is another organization to learn from; they are based in the Verde Watershed, a tributary to the Colorado River in Arizona. These efforts will serve as a model to inform restoration in the MCRW. By using the successes and failures of these efforts the MCWC will be better prepared to handle the challenges of invasive species removal and riparian restoration.

Below is a working list of plans and mapping inventories that will be used to inform restoration planning in the MCRW.

Document	Mapping Component?	Source / Author	Summary
Consolidated Woody Invasive Species Management Plan (2009)	Yes	CHIP	Strategic plan for the Colorado River's riparian areas impacted by tamarisk and Russian olive
Colorado Tamarisk Mapping & Inventory Summary Report (2008)	Yes	Tamarisk Coalition	Inventory of tamarisk and Russian olive on CO river and all major tributaries
Desert Rivers Collaborative Implementation Plan	Yes	Tamarisk Coalition	Compilation of information on restoration work performed nearby and presents a strategic approach for controlling invasive along the CO River from the Mesa County line to the Utah Border as well as the lower Gunnison River

Dolores River Riparian Action Plan (DR-RAP) (2010)	Yes	TC, TNC	Comprehensive plan on the management techniques applied in the Dolores River on tamarisk and other secondary species in order to facilitate communication and a consistent approach
Garfield County Noxious Weed Management Plan	No	Garfield County	Guidelines and tactics for the management of noxious weeds in Garfield County
Verde River Cooperative Invasive Plant Management Plan	Yes	Fred Phillips Consulting, presented to Friends of the Verde River Greenway	Details a strategic approach to invasive species management in the Verde River Watershed

GIS Resources

In order to be properly informed, certain GIS resources will need to be assembled and examined by the Riparian Restoration Advisory Group formed within the MCWC and its partners. The following GIS data will be assembled as soon as possible from appropriate sources:

- Most up-to-date tamarisk presence and density (likely source CHIP 2008), as well as other invasives where available;
- Recent project areas of invasive removal and restoration; and
- Land ownership with specific land owners.

Publications

There is a wealth of information available about the management of invasive species as well as restoration. For this reason, this plan will not detail specific techniques as much as note appropriate sources to reference while planning restoration activities. The following table is a list of sources that will be used to inform restoration planning and implementation in the MCRW:

	Document	Source / Author	Summary
Russian Olive	Field Guide for Managing Russian Olive in the Southwest	USFS	Brief overview of Russian olive ecology and management
	Pahranagat Valley Cooperative Weed Management Area Fact Sheet Series #2	Pahranagat Valley Cooperative Weed Management Area	This document is an excellent quick reference guide to use while considering tactics of Russian olive control
Tamarisk	Tamarisk Best Management Practices in Colorado Watersheds	CSU, University of Denver, CO Department of Ag., Denver Botanical Gardens	Details how to remove tamarisk and restore those areas to a state of better ecological function for CO rivers and streams (Summarized in Appendix B)
	Field Guide for Managing Saltcedar in the Southwest	USFS	Brief overview of tamarisk ecology and management
Other Invasives	Weeds of North America	Richard Dickenson and France Royer	Comprehensive book of the biology of all weeds in North America
	Establishing a Weed Prevention Area: A Step-by-Step User's Guide	Area-Wide Project, USDA	A guide to anyone who wishes to organize the prevention of the spread of invasive species in their area.
	The Watch List. Colorado Noxious Weed Management Program	Colorado Department of Agriculture	Color photos and characteristics of invasive plants not documented in CO but could potentially invade.
Revegetation	Best Management Practices for Revegetation after Tamarisk Removal, in the Upper Colorado River Basin	Sher et. al 2010, Denver Botanic Gardens and University of Denver	Guidebook for reestablishing native plant communities after the removal of tamarisk.
	Suggested Methodologies for Cottonwood Pole Willow Whip and Longstem Plantings	Tamarisk Coalition	Practical how-to document about planting willow and cottonwood cuttings as well as rooted materials
Overall Restoration	Managing Riparian Areas	Nueces River Authority	Describes riparian areas and their management, discusses general riparian restoration guidelines, delves into special issues in these areas, and provides assessment and monitoring information.
	Riparian Area Management	BLM, USFS, NRCS	A User Guide to Assessing Proper Functioning Condition (PFC) and the Supporting Science for Lentic Areas

V. Need for Adaptive Management

Site Specific

Ecological restoration is an "intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability" (SER Primer, 2002). Every local ecosystem is unique. "Adaptive Management" seeks to address these unique challenges in each ecosystem. Recommended restoration tactics may differ from site to site based on biotic and abiotic conditions present at that site. There needs to be a level of flexibility after initial implementation in order to ensure long term success.

Each site must have goals that are specific to that site due to the variability of conditions between sites. Quantifiable objectives at a site should be established in order to document measurable results. New information about a site may arise over time that will alter the feasibility of goals and objectives. For this reason, goals may need to adapted over time as well.

Monitoring

Monitoring before and after implementation of a restoration project is key to evaluating its success. Post-implementation monitoring is especially important since it will determine if any follow-up treatments are necessary.

Multi-year monitoring is suggested at least annually to include: soils, vegetation, and ground water. Collaboration with researchers or conservation service staff is recommended. Monitoring of any planted vegetation is important in addition to monitoring invasives.

Follow-up Treatments

Initial removal of invasive species will not prevent regrowth of invasives. Follow-up treatments are an integral part of a successful restoration; therefore, continual monitoring and follow-up treatments are necessary for success.

Revegetation

Much of riparian restoration focuses on invasive species removal, however a large part of the restoration efforts is native species reintroduction. Proper reintroduction of native vegetation will be a key component dependent on the sites characteristics.

VI. Next Steps

Riparian Restoration Advisory Group

Given the wide interest in riparian restoration in the MCRW and the collective of technical experts in our region, the MCWC looks to create a collaborative partnership that will work together towards a set of common goals. This collaborative effort will be approached by way of a "Riparian Restoration Advisory Group" (RRAG). Organizations that will be invited to be part in this Work Group include:

- Garfield and Mesa County weed control programs;

- Mount Sopris, Bookcliff, South Side and Bluestone Conservation Districts;
- Tamarisk Coalition (and Desert Rivers Collaborative);
- NRCS USFWS and BLM;
- Colorado Parks and Wildlife;
- Colorado Mesa University;
- cities interested or involved in riparian restoration; and
- interested stakeholders and experts from the public.

This Action Plan along with available resources it cites will be presented to the RRAG. RRAG members will be encouraged to share any additional information they may be aware of that could enhance the work group's efforts.

Equipped with the current knowledge of MCRW riparian health, the RRAG will be tasked with identifying next steps towards implementation activities. These next steps will be informed by the CHIP plan and explore questions such as:

- What are the overarching goals and objectives of this restoration campaign and this partnership?
- Is there a desire or need to structure a partnership among organizations? If so, what might that look like?
- What additional resources might we need moving forward with planning work (e.g., more detailed invasives mapping, land ownership map, compilation of completed/ongoing restoration projects, assessment of local project monitoring results, etc.)?
- Is a prioritization scheme important and, if so, how do we develop that? Which specific sites are priorities for restoration?
- How do riparian health assessments fit into the planning process? Are they important, how would they be used, what methods are appropriate?
- How to set project- or site-specific goals? How will success be measured?
- How can the RRAG work with private landowners to restore riparian vegetation in a way that is beneficial to the landowner and the environment?
- What specific methods should be used to remove invasive species? To restore native vegetation?
- What is the timeline for restoration efforts? (see end of this section for suggested timeline)
- Is there additional capacity needed at the regional level to carry out the physical restoration work?

Overall RRAG Goals (subject to revision by RRAG):

- Work towards increasing the collective capacity to undertake restoration work comprehensively in the watershed
- Form long-lasting working partnerships
- Leverage resources among entities engaging in restoration work – both technical and financial
- Facilitate communication of various organizations restoration efforts
- Develop joint funding proposals for restoration in the MCRW
- Develop best management practices for riparian areas in the MCRW, especially areas affected by invasive species

Site Specific Restoration Plans

The Riparian Restoration Action Plan is meant to guide restoration planning and implementation but is not a site-specific plan for restoration. The RRAG will be tasked to recommend and prioritize restoration sites. Once identified, MCWC personnel with assistance from RRAG members will complete a site-specific restoration plan that will include: methods for implementation, monitoring, and goals for riparian restoration for that individual site.

These site-specific plans will be based on the conditions present at that site including:

- Invasive species densities, especially tamarisk and Russian olive;
- Native plant community health;
- Site access;
- Land ownership;
- Biological agents presence and effectiveness (i.e., are there beetles?); and
- Funding availability.

Timeline

The following is a general timeline of actions to be taken to initiate on-the-ground restoration work within the MCRW. This is a guideline and is subject to change.

Goal	2017		2018		2019		2020 and Beyond…	
Assemble Mapping Documents and GIS Resources			**Continue to map work being done. Update riparian maps as necessary.**					
Reach out to potential advisory group members								
Riparian Restoration Advisory Group (RRAG) meetings								
Develop funding proposal, apply for grants						**As Needed**		
Compose site specific restoration plans for priority areas outlined by RRAG								
Active Restoration including invasives removal (Implementation)			**Pilot Projects**					
Conduct follow up treatments, monitoring, and adaptive management								

References Cited

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

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

Middle Colorado Watershed Council. 2016. The Middle Colorado River Watershed Plan.

Nissen, S. J., A. A. Sher, and A. Norton. 2010. Tamarisk: Best management practices in Colorado watersheds. Colorado State University, Fort Collins, CO.

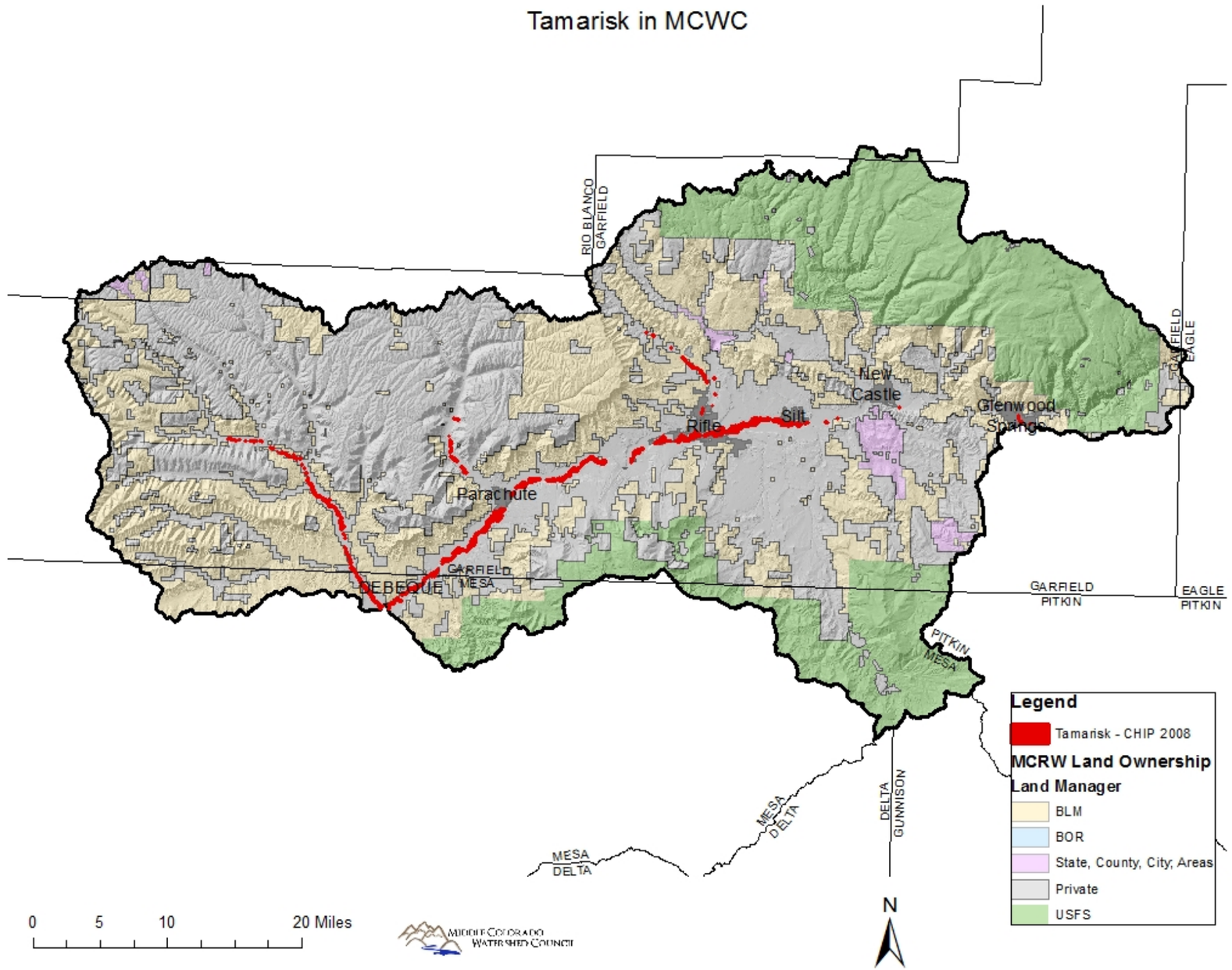
"The SER Primer on Ecological Restoration". 2002. Society for Ecological Restoration. A Publication of the Science & Policy Working Group. www.ser.org/

Tamarisk Coalition. 2008. Colorado Headwaters Invasives Partnership – A Consolidated Woody Invasive Species Management Plan for Colorado's Colorado, Gunnison, Uncompahgre, Dolores, White and Yampa/Green Watersheds. 157 p. Available at: http://tamariskcoalition.org/resourcecenter/documents/colorado-headwaters-invasive-partnership McDaniel, K.C., DiTomaso, J.M., Duncan, C.A. 2004. Tamarisk or Saltcedar (Tamarix spp.) Allen Press.

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

USDA Forest Service. 2014. Field Guide for Managing Siberian Elm in the Southwest. TP-R3-16-17. 12 pp.

Appendix A – Tamarisk map in the MCRW. Source: CHIP 2008



Appendix B: Methods of Tamarisk Removal and Restoration

Colorado State University, along with University of Denver, Colorado Department of Agriculture, and Denver Botanic Gardens, put out a very informative booklet titled "Tamarisk Best Management Practices in Colorado Watersheds" in 2009 (Nissen et al). This booklet is an excellent guide for anyone looking at control of tamarisk in Colorado. The following is a summary of the control methods presented in this booklet.

Mechanical

Some type of removal/management of tamarisk plants, dead or alive, is likely prudent to reduce fire danger and clear to make room for native species.

Mulching

Heavy equipment such as skid steers with mulching attachments, such as a Hydro-Ax, are able to remove large continuous areas of tamarisk at considerable speeds. Several models of heavy equipment exist. One downside of utilizing these machines is the large amount of ground disturbance that can allow other invasive species to invade.

Individual Tree Removal

Another type of heavy equipment that can be employed is a track hoe or excavator equipped with an attachment to extract single trees. This can be useful in areas that are hard to get to since these types of equipment have long arms. Burning or mulching of dead tamarisk is necessary after removal. Herbicide will still be required to treat stumps and possible other invasives that emerge.

Chemical

Imazapyr

Imazapyr kills plants, including tamarisk, through absorption in the leaves or roots. Non-target native plants can be affected as this chemical controls almost all broad-leafed plants and grasses. Imazapyr is water soluble and degrades quickly after dissolving in water. It degrades on top of soil via microbe metabolism. Products that have Imazapyr as an active ingredient include: Habitat, Arsenal, and Powerline. (CSU Booklet)

Triclopyr

Triclopyr also kills through both absorption of the leaves and roots. It can take weeks for it to kill large plants. Triclopyr harms most broadleaf plants, including native willows and cottonwoods, but most established grasses are resistant to its effects (CSU Booklet). It breaks down in a manner similar to Imazapyr in water and soil. A number of products exist including: Garlon 3A, Gorlon 4 Ultra, and Remedy Ultra.

Chemical Application Techniques

Ground Application. Ground application typically will include a backpack or ATV transported tank of herbicide with an accompanying sprayer. Appropriate labeling required.

On Foliage. Imazapyr is most effective if leaves are being sprayed. This is an excellent treatment for isolated plants or for treating regrowth.

On Basal Bark. Treating the bark of tamarisk stems with Triclopyr or Imazapyr is a more selective method of herbicide application. The entire stem of a tamarisk plant should be covered from all sides to a height of at least 12 inches. This technique is best used in spring or fall when there is little foliage to intercept spray and many native plants are dormant. This is a good method for using a low volume of herbicide. Another method termed "thinline" and includes application of undiluted Triclopyr to tamarisk in a thin ring around the entire stem. This technique is ineffective against very large, mature trees that are greater than 6 inches in diameter and it requires smooth bark.

Cut Stump. Using a chainsaw to cut a tamarisk down to the soil surface and then applying a small amount of herbicide can be an effective, though expensive control technique. A skilled chainsaw operator is a must. This treatment can be done just about any time of the year though it is best to avoid the spring when the majority of growth occurs.

Aerial Application. This method employs aircraft, most practically helicopters in Colorado, to disperse the herbicide Imazapyr. This technique should be employed when the tamarisk is actively growing in August or early September. Tamarisk Leaf Hoppers (*Opsius stactogalus*) tend to cause defoliation of tamarisk in early September that reduces Imazapyr effectiveness.

Other Control Techniques

Biological

There are already a number of biological control agents at work in the MCRW. This includes the Tamarisk Beetle, which was selected by the USDA to be the agent of choice. See Current Efforts section on page 7 for more information.

Fire

Fire is not necessarily the best tactic for removing tamarisk. Results of a burn are often unpredictable. Tamarisk is adapted to survive frequent fires. Regrowth after fire can also be harder to control than regrowth after mechanical removal. Tamarisk foliage contains a large concentration of oils that can readily burn, but may not burn hot enough to kill 2-3 inch diameter plants. Fire is often more applicable as a technique of biomass or wildfire reduction after other techniques have already controlled the tamarisk.

Table 1. Methods of tamarisk removal

	Technique	Tool / Chemical	Best Time of Year	Concerns / Comments
Mechanical	Mulching	Hydro-Ax or similar equipment	Any	Heavy disturbance, future invasives, less herbicide needed
	Individual Tree Extraction	Excavator with modified attachment	Any	Less herbicide needed, more selective, need to dispose of dead plants

Chemical	Foliar	Imazapyr	August or early September	Damage to native species
	Basal Bark	Triclopyr	Late fall, early spring	Ineffective on large trees (>6in) and on rough, furrowed bark
	Thin line	Triclopyr	Late fall, early spring	Ineffective on large trees (>6in) and on rough, furrowed bark
	Cut Stump	Chainsaw, Imazapyr or Triclopyr	Any except spring	Cost of labor, uses less herbicide though, need skilled chainsaw operator
	Aerial	Helicopter, Imazapyr	August or early September	Accuracy, Cost of helicopter rental
Biological		Tamarisk Beetle	All	Completely hands-off
Fire	Controlled Burn	Fire crew	Fall	Dangerous, unpredictable results

Revegetation

Tamarisk restoration includes removal of tamarisk as well as replacement with native vegetation. This may take the form of passive or active revegetation. Tamarisk control techniques affect revegetation techniques. Specifically, there may be herbicide residues remaining, large disturbed areas from heavy equipment, and soil chemistry effects from fire. Once again much of this comes from the CSU Booklet "Tamarisk Best Management Practices in Colorado Watersheds".

Passive Revegetation

In cases where desirable species are already present in relative abundance or conditions exist that will promote desirable species it is often sufficient to allow natural recovery of the plant community. Some of the MCRW is likely to be in this category. Suggested thresholds for desirable species to justify passive revegetation:

- Moist to mesic riparian sites with favorable hydrology: 10% cover of desirable species, and
- Arid to xeric riparian sites: 25% cover of desirable species.

When considering if conditions are favorable enough to promote desirable species, the following factors should be considered:

- *Hydrology.* Should be at least 50 feet from a permanent, actively flooding water source
- *Control method and intensity*. Chemical residues? Heavily altered soil due to heavy machinery?
- *Use of the treatment site*. Recreation site? Livestock grazing? Agriculture? The planned use of the area needs to managed effectively to promote riparian vegetation health.

Active Revegetation

Plantings of poles and rooted vegetation. This is the fastest method to re-establish a native plant community. It is also the expensive and labor intensive. Plantings may be wanted to more quickly stabilize banks after removal of dense tamarisk stands.

Seeding. This method takes a little longer but is very hands off and inexpensive. This technique may also be employed in areas of saline and alkaline soils. Results may be variable due various factors including predation and drought.

Site Preparation

Root Raking / Plowing. Root Raking and plowing is effective at controlling tamarisk; however, it requires broad floodplains that are unlikely to be found in Colorado.

Mulching. Mulching may promote native plant species and prevent other invasive species from taking hold. One downside is that the debris may be an obstacle to revegetation efforts such as seeding.

Burning. Burning of tamarisk can sometimes alter soil chemistry in favor of tamarisk over native species. Fires should be kept to low intensity if possible.

Soil Preparation. In dense, mature stands of tamarisk soil conditions may need to be altered to make native species establishment feasible. *Tilling* can increase seed contact and penetration of precipitation. *Soil salinity* can be reduced by flooding of the area or perhaps furrow irrigation. *Soil nitrogen* is often low in tamarisk-invaded areas, but native species often do well under such conditions. *Soil microbes* are often lacking in tamarisk-invaded areas. This can be assisted by the addition of soil from sites nearby or of purchased inoculants.