TULEYOME

Pope Creek Weed Management Plan

Napa County, California

Horizon WATER and ENVIRONMENT

DECEMBER 2015

1.0 INTRODUCTION

1.1 Purpose and Organization

Pope Creek is a major tributary of Lake Berryessa in Napa County, California (Figure 1). Tuleyome, a non-profit organization dedicated to protecting the wild and agricultural heritage of the Inner Coast Range, proposes to implement weed management activities along a 2.7 mile reach of Pope Creek (Figure 1). Tuleyome has identified tamarisk (*Tamarix* sp.), Himalayan blackberry (*Rubus armeniacus*), Arundo (*Arundo donax*), and tree of heaven (*Ailanthus altissima*) as target invasive plant (weed) species. This document presents a Weed Management Plan (WMP) for the 2.7-mile project reach. This document is organized as follows:

Section 1 - Introduction

Section 2 - Goals & Objectives

Section 3 - Physical Setting

Section 4 - Management Species Descriptions

Section 5 - Weed Management Strategies & Techniques

Section 6 - Implementation Strategy & Restoration

Section 7 - Monitoring, Adaptive Management & Uncertainties

Section 8 - Costs Estimate

Section 9 - Regulatory Compliance

Section 10 - References

1.1 Previous Assessments

In 2014, Tuleyome contracted the Napa County Resource Conservation District (RCD) to conduct an aquatic habitat assessment of the project reach (Napa RCD 2014). The RCD's assessment included a stream habitat survey and a snorkel survey. Tuleyome also contracted Napa Botanical Survey Services to perform a rare plant study in the project area (NBSS 2014) and assist with the mapping of invasive plants. These previous assessments are referenced where appropriate in this WMP.

2.0 GOALS & OBJECTIVES

2.1 Goals

The primary goals of the WMP are to:

- Preserve and enhance the quality of native plant and wildlife habitat, and
- Preserve and restore hydro-geomorphic functions in Pope Creek.

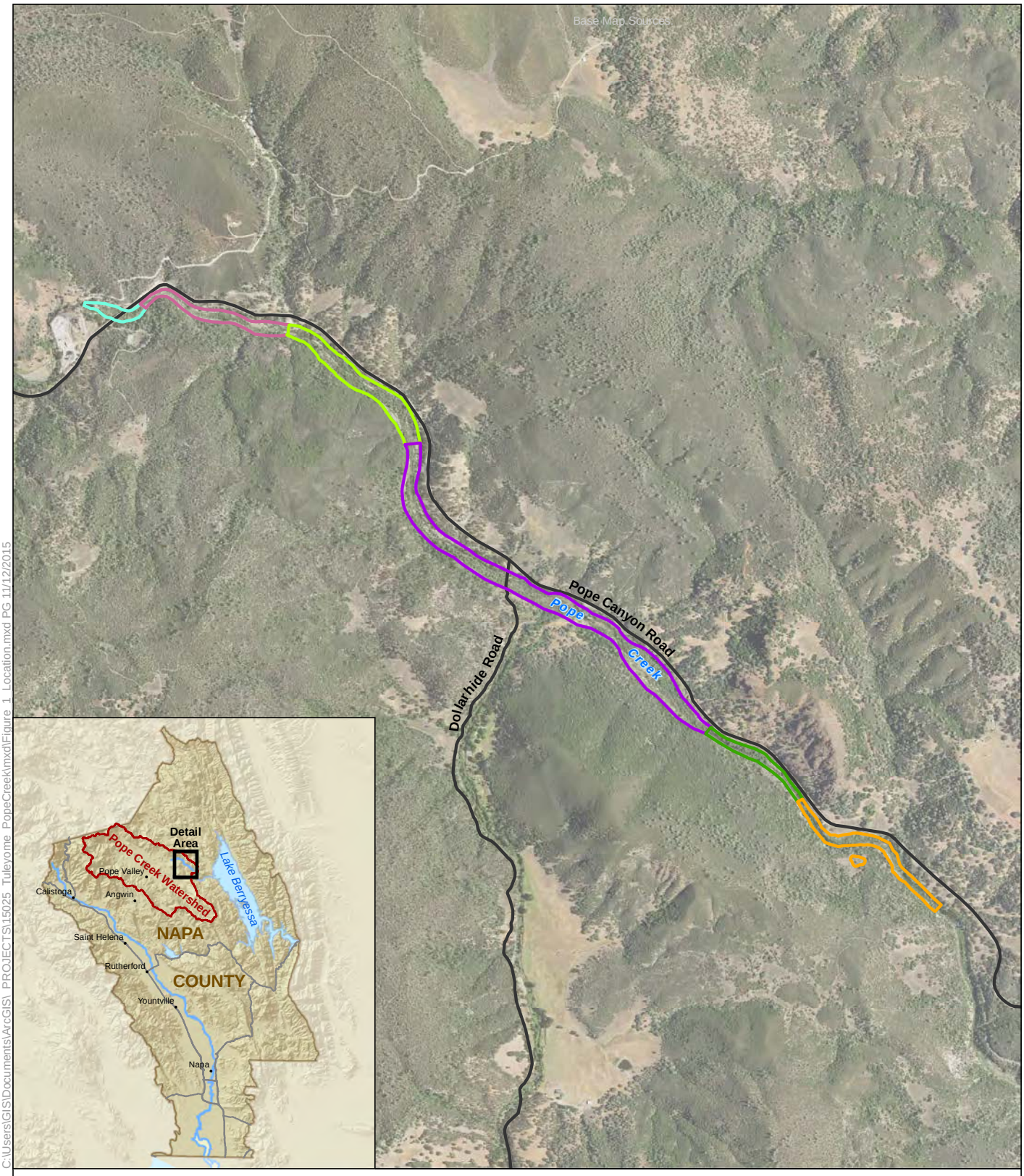
Controlling invasive tamarisk may also lead to increased water yield by reducing evapotranspiration, as well as increasing groundwater recharge in the project reach.

2.2 Objectives

The objectives of the WMP are listed below in order of their priority:

- Suppress and/or contain tamarisk
- Eradicate Arundo
- Eradicate tree of heaven
- Suppress or contain Himalayan blackberry
- Restore native vegetation communities and/or floodplain functions in areas previously occupied by tamarisk and other management species listed above

More detailed information on objectives for individual management units within the project reach are discussed in Section 6.



C:\Users\GIS\Documents\ArcGIS_PROJECTS\15025_Tuleyome_PopeCreek\mxd\Figure_1_Location.mxd PG 11/12/2015

Figure 1

Project Location

3.0 PHYSICAL SETTING

The Pope Creek watershed encompasses 50,560 acres or 79 square miles (mi^2). Elevations in the watershed range from 439 to 2,971 feet (ft). The watershed is largely undeveloped, with only 0.1 percent impervious land cover.

Pope Creek is a perennial, unregulated (i.e., no major dams or flow control structures) stream that drains portions of Pope Valley, Chiles Valley, Cedar Roughs and other mountainous terrain in the Inner Northern Coast Range. The project reach extends from just above the Pope Canyon Road Bridge to the high water mark of the lake. Maxwell Creek is a major tributary which enters Pope Creek midway through the project reach.

3.1 Geology and Soils

Underlying geology in the Pope Creek watershed is largely Great Valley Complex, with some Clear Lake Volcanics and Franciscan Complex. Surficial deposits are found along the stream (WICC 2015).

Much of Pope Canyon sits atop ultramafic bedrock. Serpentinite is also found in the watershed. Serpentinite is high in magnesium and typically laced with heavy metals such as nickel and chromium. As it weathers they lead to serpentine soils, which support a variety of unique plant species adapted to life on these harsh substrates.

Soils in the watershed are largely Henneke-Montara-Rock outcrop complex, Henneke gravelly loam, Bressa-Dibble complex, Okiota-Henneke-Dubakella association and Rock outcrop-Kidd complex. Soils in the project reach area are largely Henneke gravelly loam and river wash.

3.2 Climate and Hydrology

The Pope Creek watershed, like most of California, experiences a Mediterranean climate characterized by warm, dry summers and cool, wet winters. Precipitation is greatest between October through April. Total annual precipitation in the watershed averages approximately 38.1 inches (USGS 2015).

A stream gauge on Pope Creek at the downstream end of the project reach was active from January 1961 through September 1980. Flood frequency analysis based on the gage data predict the 2-year peak flood to be 7,250 cubic feet per second (cfs), a 10-year flood of 13,500 cfs, and the 100-year event to be 27,200 cfs.

3.3 Geomorphology

Pope Creek in the project reach is a moderate gradient, moderately confined alluvial channel. The active channel width is approximately 80 to 150 feet, and the floodway ranges from about 150 to 250 feet wide. The channel exhibits pool-riffle morphology with frequent areas of multi-thread (i.e. braided) channel (Napa RCD 2014). Deep scour pools are present in areas of higher confinement and bed resistance. Throughout most of the project reach the channel has good connectivity to the adjacent floodplain and appears to be highly dynamic with evidence of natural creation and destruction of aquatic and riparian habitats. Sediment delivery to the project reach appears to be high from both upstream watershed sources and hillslope erosion and mass wasting within the reach (Photo 1).

Photo 1: Steep, unstable hillslope adjacent to the channel contribute a large volume of sediment to the creek.

3.4 Vegetation

Pope Creek supports a riparian zone that ranges from approximately 80 to 200 feet wide in the project reach. The plant community along the stream is most commonly riparian scrub, mainly Brewer's willow (*Salix brewerii*) and Arroyo willow thickets (*S. lasiolepis*). Tamarisk is dominant or co-dominant in many portions of the project reach (see Section 6).

The hillslopes adjacent to the stream primarily support shrublands and annual grasslands. The upper slopes support Ghost Pine Woodland, which is dominated by grey pine (*Pinus sabiniana*) and contains various oak species. The hillslopes on the south side of the creek support Mixed Oak Forest with several oak species (*Quercus agrifolia*, *Q. douglasii* and *Q. lobata*).

Serpentine soils occurring in the area support local and regional endemic plant species. During initial botanical surveys, two plants listed by the California Native Plant Society (CNPS) as rare and endangered in California were identified (Napa Botanical Survey Services 2014). Four plant species with a CNPS List 4 (Limited Distribution) ranking were observed (Napa Botanical Survey Services 2014).

3.5 Land Use and Ownership

Land use in the Pope Creek watershed is largely open space and agricultural land-uses. Within the project reach, there are parcels owned by California Department of Fish and Wildlife (CDFW), Bureau of Land Management (BLM), and private landowners. The parcels owned by CDFW and BLM are managed for wildlife conservation and wilderness preservation.

4.0 MANAGEMENT SPECIES DESCRIPTIONS

This section provides a general description of the ecology of the target management species along with information on their spatial distribution in the project reach.

4.1 Tamarisk

Tamarisk, also called saltcedar, is a deciduous shrub or tree that typically ranges in height from 5 to 30 feet. Most tamarisk in North America is a hybrid of *T. ramosissma* (native to Russia) and *T. chinensis* (native to China) (Sher 2010); *T. gallica* and *T. parviflora* have also colonized stream in the western U.S. (Bell et al. 2010). Tamarisk was intentionally introduced in the U.S. in the late 1800s for erosion control, wind breaks, shade, and ornamental purposes (Sher et al. 2010). Tamarisk has spread rapidly throughout the western U.S., displacing well over a million acres of native riparian habitat (Sher et al. 2010).

Tamarisk spreads primarily by seed but may also reproduce vegetatively by adventitious root sprouting or from cuttings rooting in damp soil (Lovich 2000, Sher 2010). Tamarisk seed production is prolific: an individual plant may produce 500,000 seeds, and dense stands may

produce 100 seeds per square inch (Lovich 2000). Seeds are very small, weighing 0.1 mg, and may be transported long distances by wind and water (DiTomaso 1996, Lovich 2000). The transport of seeds downstream to Lake Berryessa is a concern, as this species could easily colonize the lake's shoreline and spread in to tributary drainages.

Adverse effects of tamarisk infestations include altered channel morphology and degraded floodplain functions, decreased or altered plant and animal diversity, increased evapotranspiration, and increased fire risk (Sher et al. 2010). These adverse outcomes appear evident in portions of Pope Creek. Tamarisk can outcompete many native riparian species and establish dense monocultures that drastically reduce species diversity.

Within portions of Pope Creek mature stands of tamarisk are so dense that the stream can no longer migrate within the floodplain. This degrades channel functions and results in a simplified channel form that lacks habitat heterogeneity and complexity (Photo 2).

Photo 2: Dense stands of tamarisk alter the channel morphology and physical processes in portions of the project reach.

4.2 Arundo

Arundo (*Arundo donax*), also known as giant reed, is a cane-like grass which grows 9-30 feet high (Dudley 2000). It is originally from the Indian subcontinent, although it likely came to North America from the Mediterranean region (Dudley 200). It reproduces vegetatively, either through rhizome growth or when plant fragments are transported downstream during floods (Dudley 2000). It can form very dense stands which displace native vegetation and provide little habitat value to native wildlife (Dudley 2000). It may also alter hydrology, and is a known fire hazard (Dudley 2000).

There are a few isolated stands of Arundo in Pope Creek. Eradication of these plants before they spread and become a larger issue within the watershed would be an effective use of resources, as treatment of invasive plants before they become extremely well established is more cost-effective.

4.3 Tree of Heaven

Tree of heaven (*Ailanthus altissima*) is a compound-leaved deciduous tree which may grow 30-65 feet high (Hunter 2000). It often sprouts from the roots, and also reproduces by seed (Hunter 2000). It is native to China, and was widely planted in California prior to the 1890's (Hunter 2000). Tree of heaven can produce dense thickets which displace native vegetation, especially in riparian zones (Hunter 2000). It spreads by wind-dispersed seeds, as well as through abundant root sprouting (Hunter 2000).

There are several areas affected by tree of heaven in Pope Creek, and one significant stand along the Cedar Roughs trail to the south of Pope Creek. At this time, this species is still relatively patchy in its invasion of Pope Creek.

4.4 Himalayan Blackberry

Himalayan blackberry (*Rubus armeniacus*) grows as a vine or shrub, and has canes with

stout prickles. This species of blackberry is native to Western Europe, and was introduced to North America in the late 1800s as a crop (Hoshovsky 2000). Birds and animals eat the berries and distribute the seeds (Hoshovsky 2000). Vegetative reproduction by rooting at the cane tips also occurs (Hoshovsky 2000).

This species tends to grow in disturbed areas. It is a very competitive plant, and also forms dense thickets which exclude native plants (Hoshovsky 2000).

Himalayan blackberry is found sporadically along Pope Creek. It is excluding or displacing native species, but is not yet a dominant invader. Suppression/control of this species is the recommended strategy.

5.0 WEED MANAGEMENT STRATEGIES & TECHNIQUES

This section provides an overview of weed management terminology and techniques that are used to manage invasive species. Emphasis is placed on techniques that are considered to be best suited to target species and physical conditions in the project reach.

5.1 Terminology & Strategies

The following terms are commonly used in WMPs to describe the general approaches to managing invasive species (adapted from Norton 2010).

***Eradicate*:** Completely eliminating an invasive species from within a defined management area.

***Suppress*:** to reduce abundance of an invasive species within a defined management area. This is typically measured or estimated in terms of plant cover or density.

***Contain*:** to confine an infestation so that it does not expand, but not necessary reduce the infestation.

Eradication is generally considered very difficult to accomplish unless the target species is present in very small numbers (Norton 2010). Complete eradication of tamarisk throughout the project reach is not considered to be practical, whereas, it may be possible to eradicate it in certain management units. It may be possible to eradicate tree of heaven and Arundo in the entire project reach. A more detailed discussion of the proposed management actions is provided Section 6.

5.2 Weed Management Techniques

Weed management techniques are often grouped into the following categories: biological, cultural, chemical, and mechanical (or physical) controls. The control methods can be used independently, but are often used in conjunction with one another in what is referred to as Integrated Pest Management (IPM). This section provides an overview of the weed management techniques that will be used in the project reach. Appendix A includes invasive species descriptions, some with control recommendations.

Chemical Control

Chemical control will include both foliar and cut-stump application of herbicide to targeted invasive species. Ground-based herbicide application will be used in most cases, but aerial application of herbicide from a helicopter may be the most cost-effective method in areas with dense monocultures of tamarisk. In these extremely dense areas, herbicide-treated tamarisk stands would be allowed to deteriorate naturally over time.

Photo 3: Aerial herbicide application on tamarisk

Herbicides used for cut-stump application may include triclopyr and imazapyr. Foliar spray herbicides may consist of glyphosate, imazapyr, and triclopyr. These herbicides will be used according to label instructions, and will only include formulations approved for aquatic use. Trade names of these herbicides include products such as Habitat® (imazapyr), Garlon 3A® (triclopyr), Aquamaster® and Rodeo® (glyphosate). Labels for these herbicides are provided in Appendix B. Foliar spraying would take place in the late summer/early fall to maximize translocation of herbicide to the roots (DiTomasso 2010, Nissen 2010). Foliar spray of tamarisk should use imazapyr, as it is the most effective herbicide (Nissen 2010). Cut-stump treatment of tamarisk should use imazapyr or triclopyr (Nissen 2010). For Himalayan blackberry, triclopyr or glyphosate should be used (DiTomasso 2010). For Arundo control, foliar application of glyphosate or a combination of glyphosate and imazapyr is effective. Cut-stump application of these herbicides may also be used, however this is more labor intensive and may be less effective than foliar spray (Bell 1997). Tree of heaven is most effectively controlled using the cut-stump method with glyphostate or triclopyr (Hunter 2000). Mechanical removal without herbicide application for this species will result in growth of abundant root suckering and stump sprouts (Hunter 2000).

Mechanical

Mechanical removal of invasive species may include both heavy equipment and removal with hand tools such as chainsaws. The technique used will depend upon equipment access within each management unit and potential for inadvertent damage to non-target species. Heavy equipment may include a skid steer or tractor with a mastication attachment, or an excavator with a bucket modified for tree extraction, or other types of masticating equipment.

Photo 4: Skid steer with masticating/mulching attachment

Invasive plant biomass will be mulched in place, moved to an appropriate upland disposal area, or stacked in upland areas outside of the active floodway. No un-mulched material will be left in the active floodway.

6.0 IMPLEMENTATION STRATEGY & RESTORATION

6.1 Overview

Invasive plant management in Pope Creek will include both chemical and mechanical treatments. This section provides a general discussion of the treatment methods followed by a treatment prescription for each reach.

Treatment recommendations for each reach are primarily based on the level of infestation and accessibility for treatment.

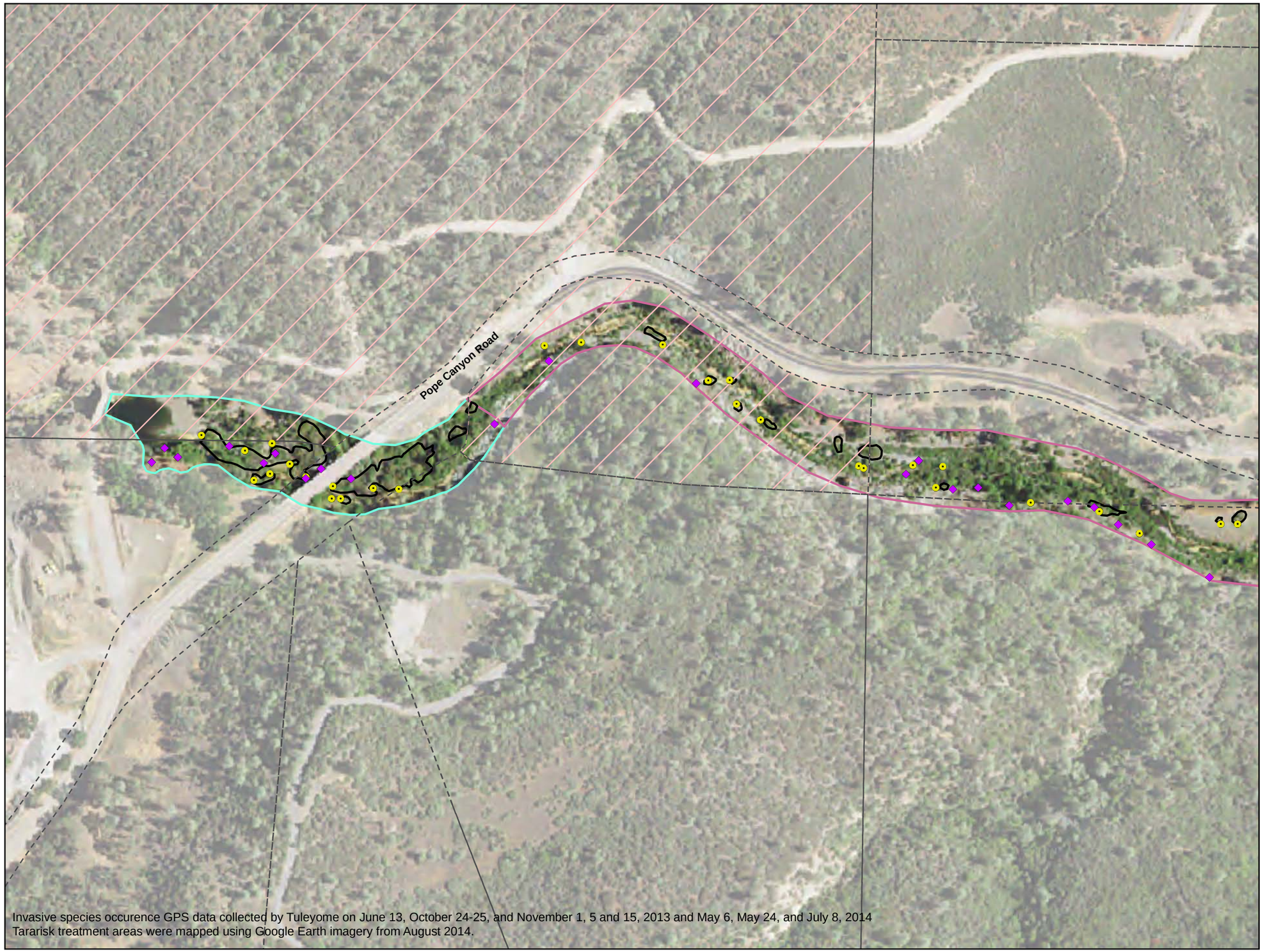
6.2 Spatial Distribution of Weeds

The distribution of target weed species was mapped on June 13, October 24-25, and November 1, 5 and 15, 2013 by Claudia Morgan and on May 6, May 24, and July 8, 2014 by Jake Ruygt and Claudia Morgan. The locations of invasive species were mapped using a Garmin Oregon 400 Global Positioning System (GPS).

To facilitate development of this WMP, a reconnaissance field survey of the project reach was conducted on October 9, 2015 by Kevin Fisher and Robin Hunter of Horizon Water and Environment, and Will Johnson of Hanford ARC. During the reconnaissance assessment the project reach was sub-divided into six management units based primarily on the infestation level of tamarisk and access to the stream for heavy equipment. Land ownership and land use were also considered. This WMP proposes specific management actions based on conditions and opportunities within each of the management units (Figures 2a through 2f).

Pope Creek
Weed Management Plan

Figure 2a



Invasive Species Occurrences

- Tamarisk *(Tamarix)*
- Blackberry *(Rubus armeniacus)* sp.
- Tree of Heaven *(Ailanthus altissima)*
- Arundo *(Arundo donax)*

Tamarisk Treatment Areas

Management Units

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F

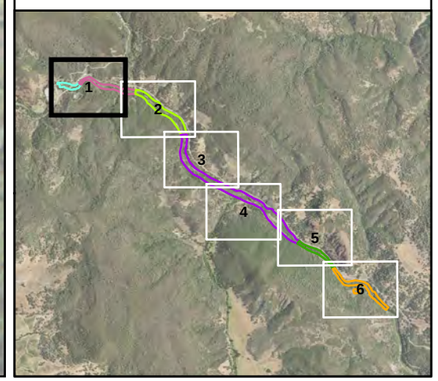
Parcel Boundary

Protected Lands

N

0 100 200 400

Feet



Invasive species occurence GPS data collected by Tuleyome on June 13, October 24-25, and November 1, 5 and 15, 2013 and May 6, May 24, and July 8, 2014
Tararisk treatment areas were mapped using Google Earth imagery from August 2014.

Pope Creek
Weed Management Plan

Figure 2b

Invasive Species Occurrences

- Tamarisk *(Tamarix)*
- Blackberry *(Rubus armeniacus)*
- Tree of Heaven *(Ailanthus altissima)*
- Arundo *(Arundo donax)*

Tamarisk Treatment Areas

Management Units

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F

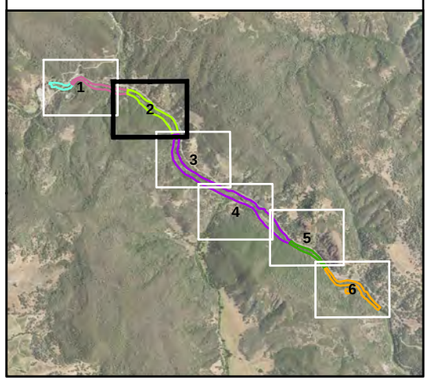
Parcel Boundary

Protected Lands

N

0 100 200 400

Feet



Invasive species occurence GPS data collected by Tuleyome on June 13, October 24-25, and November 1, 5 and 15, 2013 and May 6, May 24, and July 8, 2014
Tararisk treatment areas were mapped using Google Earth imagery from August 2014.

Pope Creek
Weed Management Plan

Figure 2c

Invasive Species Occurrences

- Tamarisk *(Tamarix)*
- Blackberry *(Rubus armeniacus)* sp.
- Tree of Heaven *(Ailanthus altissima)*
- Arundo *(Arundo donax)*

Tamarisk Treatment Areas

Management Units

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F

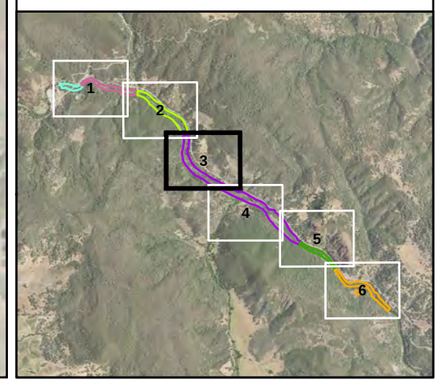
Parcel Boundary

Protected Lands

N

0 100 200 400

Feet



Pope Canyon Road

Invasive species occurence GPS data collected by Tuleyome on June 13, October 24-25, and November 1, 5 and 15, 2013 and May 6, May 24, and July 8, 2014
Tararisk treatment areas were mapped using Google Earth imagery from August 2014.

Pope Creek
Weed Management Plan

Figure 2d

Invasive Species Occurrences

- Tamarisk *(Tamarix)*
- Blackberry *(Rubus armeniacus)* sp.
- Tree of Heaven *(Ailanthus altissima)*
- Arundo *(Arundo donax)*

Tamarisk Treatment Areas

Management Units

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F

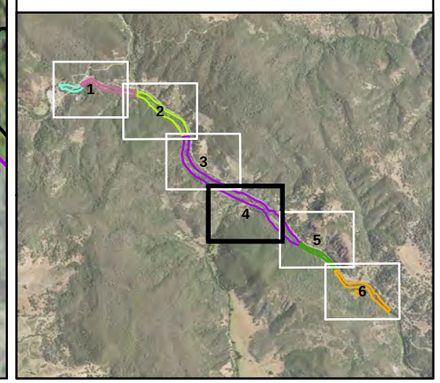
Parcel Boundary

Protected Lands

N

0 100 200 400

Feet



Invasive species occurence GPS data collected by Tuleyome on June 13, October 24-25, and November 1, 5 and 15, 2013 and May 6, May 24, and July 8, 2014
Tararisk treatment areas were mapped using Google Earth imagery from August 2014.

Pope Creek
Weed Management Plan

Figure 2e

Invasive Species Occurrences

- Tamarisk *(Tamarix)*
- Blackberry *(Rubus armeniacus)* sp.
- Tree of Heaven *(Ailanthus altissima)*
- Arundo *(Arundo donax)*

Tamarisk Treatment Areas

Management Units

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F

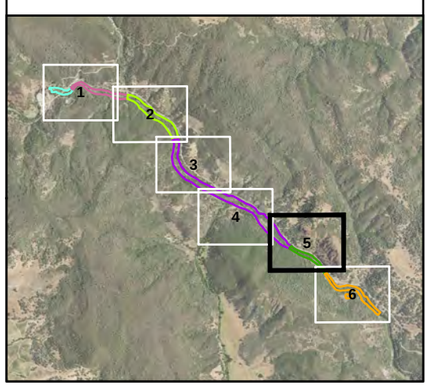
Parcel Boundary

Protected Lands

N

0 100 200 400

Feet



Pope Canyon Road

Invasive species occurence GPS data collected by Tuleyome on June 13, October 24-25, and November 1, 5 and 15, 2013 and May 6, May 24, and July 8, 2014
Tararisk treatment areas were mapped using Google Earth imagery from August 2014.

Pope Creek
Weed Management Plan

Figure 2f

Pope Canyon Road

Invasive Species Occurrences

- Tamarisk *(Tamarix)*
- Blackberry *(Rubus armeniacus)* sp.
- Tree of Heaven *(Ailanthus altissima)*
- Arundo *(Arundo donax)*

Tamarisk Treatment Areas

Management Units

- Unit A
- Unit B
- Unit C
- Unit D
- Unit E
- Unit F

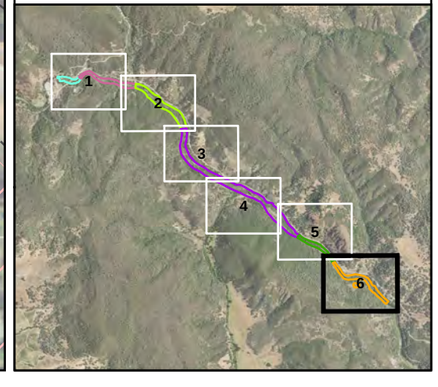
Parcel Boundary

Protected Lands

N

0 100 200 400

Feet



Invasive species occurence GPS data collected by Tuleyome on June 13, October 24-25, and November 1, 5 and 15, 2013 and May 6, May 24, and July 8, 2014
Tararisk treatment areas were mapped using Google Earth imagery from August 2014.

6.3 Management Unit A

This unit has a few large, contiguous strands of tamarisk covering approximately 0.4 acres, along 850 linear feet of Pope Creek (Figure 2a). The stream substrate is predominately gravel and cobble, with some large boulders.

Photo 5: Typical conditions in Management Unit A.

There is good access at the upstream end of the management unit for heavy equipment to enter the channel and mechanically remove tamarisk throughout much of the floodway. Stands which are inaccessible to heavy equipment will be removed using hand tools. Cut stump herbicide application (triclopyr or imazapyr) will immediately follow above ground biomass removal, or stumps will be re-cut if application is not immediate.

Himalayan blackberry is relatively abundant in this unit. This species will be controlled with a combination of mechanical removal and foliar herbicide application (triclopyr or glyphosate). Two years of follow-up with foliar spray herbicide application are needed to control regrowth and sprouting.

This section of Pope Creek is dynamic system, and recruitment of native vegetation is anticipated in areas where tamarisk and blackberry will be treated. As such, passive restoration is proposed in this reach.

6.4 Management Unit B

Unit B covers approximately 2,100 linear feet of stream (Figure 2b). Tamarisk invasion in this unit is spotty covering approximately 0.14 acres. Coarse substrate in this area may be limiting the establishment of tamarisk. Three blackberry clusters were mapped in this reach.

Due to the relatively low cover of invasive species in this unit, the control will consist of foliar herbicide application by hand (imazapyr for tamarisk, triclopyr or glyphosate for blackberry). Two years of follow-up with foliar herbicide application are needed to control regrowth and sprouting. Passive restoration is proposed in this reach; no active revegetation is proposed at this time.

6.5 Management Unit C

This unit contains dense, mature stands of tamarisk covering a relatively broad channel (Photos 6). Here, tamarisk covers almost the entire bottom of the channel for 2,285 linear feet, totaling 5.45 acres (Figure 2c). There are also some Himalayan blackberry clusters within this reach. Due to the extremely dense infestation, mechanical removal is cost-prohibitive.

Photo 6: Dense, 20-foot tall tamarisk stands. Person in white for scale

Aerial foliar herbicide application (imazapyr) from a helicopter would likely be the most effective control method from a cost and efficacy standpoint. Many of the plants are too tall and robust to effectively treat with ground-based foliar herbicide application.

If the tamarisk in this unit is treated with an aerial application of herbicide it would leave contiguous stands of dead plants. Natural disturbance would break down the remaining litter over time. Active revegetation is recommended in this unit to facilitate the recovery of the riparian vegetation community. Installation of willow pole cuttings is proposed in 10% of the treated areas.

6.6 Management Unit D

Unit D is the largest unit, encompassing approximately 1.1 river miles. The channel here is generally wider and drier condition than in other units. There are 8.13 acres of tamarisk in this reach, as well as many Himalayan blackberry plants. Tree of heaven and Arundo are also present in this unit. Tamarisk in this unit appeared to be dying back, possibly due to the drought conditions in recent years (Photo 7). However, tamarisk is drought tolerant and will generally resprout when wetter conditions return.

Photo 7: Drought-affected tamarisk

There is intermittent equipment access in this unit. Mechanical removal is proposed for 50% of the total area of tamarisk infestation in the unit. It is assumed that half of the mechanical removal can be accomplished using heavy machinery and half will require using hand tools. Cut stump herbicide application (triclopyr or imazapyr) will immediately follow biomass removal, or stumps will be re-cut if application is not immediate.

The tamarisk that is not mechanically removed will receive foliar application of herbicide (imazapyr). Blackberry will be controlled with a combination of mechanical removal and foliar herbicide application (triclopyr or glyphosate). Tree of heaven and will be controlled using mechanical removal followed by cut-stump herbicide application (glyphosate or triclopyr). Arundo will be controlled with either foliar spray (glyphosate or a mix of glyphosate and imazapyr) or mechanical removal followed by cut-stump herbicide application (mix of glyphosate and imazapyr). Two years of follow-up with foliar spray herbicide application are needed to control regrowth and sprouting.

Natural disturbance would break down the standing dead biomass that is not mechanically mulched or removed. Active revegetation is recommended in this unit to facilitate the

recovery of the riparian vegetation community. Installation of willow pole cuttings is proposed in 10% of the treated areas.

6.7 Management Unit E

In this unit, the valley narrows and Pope Creek becomes confined by the adjacent hillslopes (Photo 8). Land in this unit is part of the Cedar Roughs Wilderness Area, and as such carries the land use restrictions of a designated wilderness area (e.g., no use of motorized equipment)

Photo 8: Pope Creek is confined by adjacent hillslopes in Management Unit E. Consequently the riparian zone is narrower than in other management units.

This unit covers 1,560 linear feet of the creek. Tamarisk is relatively sparse in this area, and covers approximately 0.2 acres (Figure 2e). There are many Himalayan blackberry clusters in this unit as well. Along the trail to the south of Pope Creek there is an area with some mature tree of heaven, samplings and sprouts (Photo 9).

Photo 9: Tree of heaven in Management Unit E

Due to the landscape and the wilderness area restrictions, weed control will be limited to foliar application of herbicide (imazapyr for tamarisk, triclopyr or glyphosate for blackberry). Tree of heaven will be controlled with non-mechanized hand tools (e.g., saws and loppers), followed by cut-stump herbicide application (glyphosate or triclopyr). Two years of follow-up with foliar spray herbicide application are needed to control regrowth and sprouting for all species. Passive restoration is proposed in this reach; no active revegetation is proposed at this time.

6.8 Management Unit F

As the creek leaves the wilderness area, the valley and floodplain widen again. This unit contains 1.25 acres of tamarisk on 2,500 linear feet of Pope Creek (Figure 2f). Stands in this area are relatively large, but less dense than in Management Unit D. Vehicle access to the channel is limited in this area, so tamarisk will be controlled with hand tools followed by cut stump herbicide application (imazapyr or triclopyr). Two years of follow-up with foliar spray herbicide application (imazapyr) are needed to control regrowth and sprouting. Active revegetation is recommended in this unit to facilitate the recovery of the riparian vegetation community. Installation of willow

pole cuttings is proposed in 10% of the treated areas.

7.0 MONITORING, ADAPTIVE MANAGEMENT & KEY ISSUES TO BE RESOLVED

7.1 Maintenance & Monitoring

The first few years of monitoring following invasive species treatment would be completed by a plant ecologist, weed specialist, or other persons trained in the identification and treatment of the target species. During the summer, the trained professional will walk all treated management units and record the condition and status of invasive plants within each unit. This individual will record the locations of any invasive plant resprouts or seedlings using a GPS unit. They will also mark these plants with pin flags or surveyors tape for field identification. A licensed applicator will then retreat any marked invasive species with foliar herbicide spray. Small plants may also be removed by hand pulling or with hand tools. No heavy machinery will be used for follow-up treatment. The acreage to be treated in Years 2 and 3 is estimated to be 80-90% less than the initial treatment in Year 1. Recent aerial images may also be evaluated to quantify reduction in total cover by invasive species in the project reach.

Long-term monitoring and maintenance of these management units is anticipated in order for weed control and/or eradication within the project reach to be successful. After Year 3, volunteers will walk the treated management reaches annually to identify regrowth of target invasive species. They will record these locations using a GPS unit and also mark these plants with pin flags or surveyors tape. A licensed applicator will then re-treat any marked invasive species with foliar herbicide spray.

7.2 Adaptive Management

Adaptive management is likely to be necessary with an infestation this large and a stream that is highly dynamic. Adaptive management will include adjusting treatment techniques based on lessons learned from the success of initial control activities and adjusting to the distribution of invasive species. Revegetation and restoration of some treated areas may be needed if passive restoration methods do not result in recruitment of native species. During the Year 3 annual monitoring, the plant ecologist or weed expert should evaluate the state of native vegetation recovery in treated areas.

7.3 Key Issues to Be Resolved

There is great benefit in controlling invasive species (particularly tamarisk) in Pope Creek because it will preserve and restore its hydro-geomorphic functions and the values of the associated ecological communities. Invasive plants are a threat to these functions and values because tamarisk invasion appears to be modifying the morphology of the stream. Further information will help to inform the management planning and permitting process. Several key questions have been identified:

- How are birds and other wildlife using tamarisk/invasive plants compared to native habitats along the creek?
- What microhabitat conditions (e.g., sediment texture, water availability) are most favorable to invasive plants in Pope Creek? What areas are most vulnerable to infestation?

- How is tamarisk affecting channel form, sediment transport, floodplain roughness, and flood conditions?
- Does tamarisk invasion substantially affect water availability through changes in evapotranspiration or groundwater recharge?
- What is the status of drought-affected tamarisk stands in Management Unit D? Are they dead, or will they resprout under wetter conditions?

Answers to these questions will help guide planning and implementation of the WMP.

8.0 COSTS ESTIMATE

A cost estimate to implement the weed control strategy presented in this WMP is provided in Table 1. The cost estimate assumes a 10 year maintenance and monitoring period. The costs are based on hiring a professional land management company to perform the services. It may be possibly to complete some of the work with volunteer crews or organizations such as California Conservation Corps.

9.0 REGULATORY COMPLIANCE

9.1 CEQA/NEPA Compliance

With certain exceptions, the California Environmental Quality Act (CEQA) requires all state and local government agencies to consider the environmental consequences of projects over which they have discretionary authority before taking action on those projects. Implementing this WMP would be considered a "project" under the California Environmental Quality Act (CEQA) because it is likely to require discretionary approval(s) by one or more government agencies (e.g., CDFW). Based on experience with other projects and preliminary screening of the WMP, it is anticipated that an Initial Study/Mitigated Negative Declaration (IS/MND) would be the appropriate level of CEQA review for the project, i.e. all potentially significant impacts could be mitigated to a level that would be less than significant.

National Environmental Protection Act (NEPA) is the federal counterpart to CEQA. NEPA requires federal agencies to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. Section 102 requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach.

The project would require compliance with the NEPA if federal funds are used to implement the project or if there is a federal partner involved in the implementation (e.g., BLM). It is anticipated that an Environmental Assessment (EA) would be the appropriate level of NEPA review for the project.

9.2 Permits and Approvals

Several government agencies may have discretionary authority over some aspects of the WMP. A full screening of the applicable laws and codes would be conducted during CEQA/NEPA compliance. At minimum, it is expected that implementing the WMP, as described in this document, would require submitting notification to CDFW pursuant to Fish and Game Code Section 1600 *et seq.,* and compliance with the *Statewide General National Pollutant Discharge Elimination System (NPDES) Permit For Residual Aquatic Pesticide Discharges To Waters Of The United States From Algae And Aquatic Weed Control Applications.* In addition to NPDES, other sections of the federal Clean Water Act and state Porter-Cologne Water Quality Control Act may also be applicable to project activities.

Table 1.
Pope Creek Weed Management Plan
Estimate of Anticipated Implementation & Monitoring Costs
(December 2015)

All Units

Item No.	Description	Quantity	Unit	Unit Cost 1	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	2.4	AC	$58,760	$ 141,024
1b	Mechanical - Hand Tools	3.3	AC	$69,420	$ 231,169
1c	Chemical - Ground Application	10.1	AC	$6,045	$ 61,214
1d	Chemical - Aerial Spray	7.0	AC	$4,550	$ 31,850
2	**Other Invasive Species Control - Year 1**				
2a	Chemical - Ground Application	0.6	AC	$6,045	$ 3,627
3	**Year 2 - Follow-up Weed Abatement**	3.2	AC	$6,240	$ 20,218
4	**Year 3 - Follow-up Weed Abatement**	1.6	AC	$6,500	$ 10,660
5	**Long-Term Maintenance & Monitoring (after year 3)**	10	Year	$19,850	$ 198,500
6	**Revegetation/Restoration**	1.52	AC	$18,200	$ 27,664
	Subtotal				**$ 725,925**
	Contingency (10%)				$ 72,593
					$ 798,518

1. Unit costs assume California Prevailing Wage

Management Unit A

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	0.36	AC	$58,760	$ 21,154
1b	Mechanical - Hand Tools	0.04	AC	$69,420	$ 2,777
1c	Chemical - Ground Application	0.40	AC	$6,045	$ 2,418
2	**Other Invasive Species Control - Year 1**				
2a	Chemical - Ground Application	0.10	AC	$6,045	$ 605
3	**Year 2 -** Weed Abatement	0.10		$6,240	$ 624
4	**Year 3 -** Weed Abatement	0.05	AC	$6,500	$ 325
5	Long-Term Maintenance & Monitoring (after Year 3)	10	Year	$2,800	$ 28,000
6	Revegetation/Restoration	0	AC	$18,200	$ -
	Subtotal Management Unit A				**$ 55,902**

Management Unit B

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	0	AC	$58,760	$ -
1b	Mechanical - Hand Tools	0	AC	$69,420	$ -
1c	Chemical - Ground Application	0.14	AC	$6,045	$ 870
2	**Other Invasive Species Control - Year 1**		AC		
2a	Chemical - Ground Application	0.10	AC	$6,045	$ 605
3	**Year 2 -** Weed Abatement	0.05	AC	$6,240	$ 312
4	**Year 3 -** Weed Abatement	0.03	AC	$6,500	$ 195
5	Long-Term Maintenance & Monitoring (after Year 3)	10	Year	$1,750	$ 17,500
6	Revegetation/Restoration	0	AC	$18,200	$ -
	Subtotal Management Unit B				**$ 19,482**

Management Unit C

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	0	AC	$58,760	$ -
1b	Mechanical - Hand Tools	0	AC	$69,420	$ -
1c	Chemical - Ground Application	0	AC	$6,045	$ -
1d	Chemical - Aerial Spray	7.00	AC	$4,550	$ 31,850
2	**Other Invasive Species Control - Year 1**				
2a	Chemical - Ground Application	0.10	AC	$6,045	$ 605
3	**Year 2 -** Weed Abatement	1.11	AC	$6,240	$ 6,926
4	**Year 3 -** Weed Abatement	0.56	AC	$6,500	$ 3,640
5	Long-Term Maintenance & Monitoring (after Year 3)	10	Year	$6,400	$ 64,000
6	Revegetation/Restoration	0.56	AC	$18,200	$ 10,192
	Subtotal Management Unit C				**$ 117,213**

Management Unit D

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	2.04	AC	$58,760	$ 119,870
1b	Mechanical - Hand Tools	2.04	AC	$69,420	$ 141,617
1c	Chemical - Ground Application	8.13	AC	$6,045	$ 49,146
2	**Other Invasive Species Control - Year 1**				
2a	Chemical - Ground Application	0.10	AC	$6,045	$ 605
3	**Year 2 -** Weed Abatement	1.65	AC	$6,240	$ 10,296
4	**Year 3 -** Weed Abatement	0.83	AC	$6,500	$ 5,395
5	Long-Term Maintenance & Monitoring (after Year 3)	10	Year	$5,600	$ 56,000
6	Revegetation/Restoration	0.82	AC	$18,200	$ 14,924
	Subtotal Management Unit D				**$ 397,853**

Management Unit E

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	0	AC	$58,760	$ -
1b	Mechanical - Hand Tools	0	AC	$69,420	$ -
1c	Chemical - Ground Application	0.20	AC	$6,045	$ 1,223
2	**Other Invasive Species Control - Year 1**				
2a	Chemical - Ground Application	0.10	AC	$6,045	$ 605
3	**Year 2 -** Weed Abatement	0.06	AC	$6,240	$ 374
4	**Year 3 -** Weed Abatement	0.03	AC	$6,500	$ 195
5	Long-Term Maintenance & Monitoring (after Year 3)	10	Year	$1,400	$ 14,000
6	Revegetation/Restoration	0	AC	$18,200	$ -
	Subtotal Management Unit E				**$ 16,397**

Management Unit F

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	**Tamarisk Control - Year 1**				
1a	Mechanical - Heavy Machinery	0	AC	$58,760	$ -
1b	Mechanical - Hand Tools	1.25	AC	$69,420	$ 86,775
1c	Chemical - Ground Application	1.25	AC	$6,045	$ 7,556
2	**Other Invasive Species Control - Year 1**				
2a	Chemical - Ground Application	0.10	AC	$6,045	$ 605
3	**Year 2 -** Weed Abatement	0.27	AC	$6,240	$ 1,685
4	**Year 3 -** Weed Abatement	0.14	AC	$6,500	$ 910
5	Long-Term Maintenance & Monitoring (after Year 3)	10	Year	$1,900	$ 19,000
6	Revegetation/Restoration	0.14	AC	$18,200	$ 2,548
	Subtotal Management Unit F				**$ 119,079**

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Horizon
WATER and ENVIRONMENT

Appendix A

Technical Information on Target Invasive Species

Saltcedar

A non-native invasive plant in the western U.S

WRIC Leaflet #02-2
03/2002 (edited 02/2010)

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Saltcedar: what is it and why is it a problem?

Saltcedar, also called tamarisk, is a shrubby tree that was brought into the U.S. from the Old World in the latter part of the 19th century. Eight species of *Tamarix* were introduced to the western U.S. as ornamentals, for windbreaks, or for erosion control. Some of these species, principally *T. ramosissima*, but also *T. chinensis, T. gallica* and *T. parviflora*, have escaped from domesticated sites and invaded rivers and other riparian habitats throughout the west. These weedy species are called saltcedars because they have small, scaly, cedar-like leaves that exude salt brought up from the soil through the roots.

Foliage of athel tamarisk (left) and saltcedar (right)

Saltcedar leaves are gray-green in color, but turn yellow and drop in the winter. Another species, the athel tree (*Tamarix aphylla*) is common in the deserts of the southwest as a shade and windbreak tree. It tolerates the harsh desert environment without human assistance, but only occasionally escapes and is not regarded as a widespread problem.

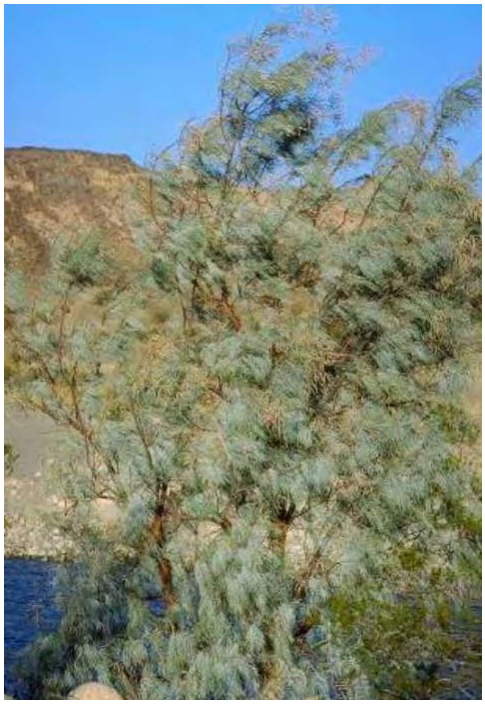
Smallflower tamarisk (*Tamarix parviflora*) flowering branches

Saltcedars produce thousands of flowers in spring and summer. Seed are very small and have a tuft of hairs on one end so they can disperse long distances on the wind or on water.

One mature plant is capable of producing 500,000 seed in one year. These seed are typically short-lived and must germinate within a few months after dispersal from the parent tree.

Saltcedar (*Tamarix ramosissima*) seedlings

Mature (*Tamarix ramosissima*) saltcedar
photo by Carl E. Bell



Athel tamarisk (*Tamarix aphylla*) along shoreline

Saltcedar grows rapidly from a seedling to a mature, flowering plant in one summer season. The root system is extensive, producing a taproot 10 feet deep to reach the water table, as well as secondary roots at the soil surface that readily soak up rainfall. Saltcedar tolerates drought, heat, cold, salinity, fire, and flooding.

In a little over 100 years, these species have come to occupy over one million acres of sensitive habitat ranging from northern Mexico to southern Canada. The southwestern states have become infested with dense stands of saltcedar along all major and minor river systems, including the Colorado, Gila, Sat, Pecos, and Rio Grande. In more recent years, saltcedar infestations have reached desert springs, water holes, and oases, especially in the southwestern deserts.

Where does it come from?

The genus *Tamarix* is common throughout the arid and semi-arid regions of the Old World. Weedy species in the western U.S. are native to Asia or the Mediterranean area. Athel tree was imported from India or Pakistan. Other *Tamarix* species are native to China, the Middle East, Africa, the Mediterranean, and even the Canary Islands in the Atlantic Ocean. There are no species native to the New World.

In the Old World, saltcedar can provide valuable shade, firewood or erosion control. Saltcedars have been purposely established in some areas of the Middle East to control wind-blown sand; the athel tree is used in the same way in the deserts of southern California. In its native range, saltcedar populations are restricted by

Smallflower tamarisk (*Tamarix parviflora*) in flower in riparian site

natural pests, such as insects and diseases. These pests did not accompany saltcedars to the U.S. Thus, weedy saltcedar species can expand their range anywhere the climate is suitable.

What effect does it have on natural habitat in the U.S.?

Effects on native vegetation

The most common native plants displaced by a saltcedar invasion are cottonwoods, mesquites, and willows growing along rivers and streams. The invasion of saltcedar is undoubtedly facilitated by human degradation of natural areas, such as areas where mesquite or cottonwood were over-harvested for firewood. Excessive groundwater pumping, dam building and flood control have also contributed to saltcedar establishment. Once saltcedar has invaded an area, it prevents native grasses, forbs and shrubs from recovering by exuding salts from its leaves, which increases the salinity of the surrounding soil beyond the tolerance of natives. Wildfires become more frequent and of higher intensity in saltcedar thickets, but saltcedar usually survives and regrows faster than natives.

Saltcedar (*Tamarix ramosissima*) infestation along a riparian site in the southwest

Effects on native wildlife

In the U.S., saltcedar is not commonly eaten by native herbivores, such as bighorn sheep or deer. Furthermore, saltcedar seed are too small to be a food source for birds or rodents. Some bird species, including the endangered Southwestern Willow Flycatcher, will nest or seek cover in saltcedar, but this plant is not a better home than the displaced native willow. The European honeybee will collect pollen and nectar from saltcedar, but the honey is reported to be of inferior quality.

Smallflower tamarisk (*Tamarix parviflora*) resprout from a stem fragment

Smallflower tamarisk (*Tamarix parviflora*) infestation

The invasion of a desert spring by saltcedar can negatively affect native wildlife. Bighorn sheep and deer avoid drinking from water holes where visibility is limited. A saltcedar thicket not only obstructs their view, but can provide cover for predators, such as mountain lions, and can physically impede their access to water. Equally important in the arid west, saltcedar uses large amounts of water and can dry up or lower the quality of a water source, which impacts aquatic organisms such as frogs, fish, and salamanders. This is especially significant in drought years, which occur regularly.

Effects on the physical environment

Not only does saltcedar increase surface soil salinity and fire potential, but also thickets created by dense infestations along rivers or streams increase soil erosion caused by floods. This occurs when saltcedar thickets decrease channel width and force flood water beyond the stream bank. Some remarkable changes have been observed following removal of saltcedar from a densely infested area. At Eagle Borax Works Spring in Death Valley, California, a historic one-acre pond disappeared when it was invaded by saltcedar. Eight weeks after the saltcedar stand was removed with a controlled burn, the pond reappeared. Similarly, at Spring Lake near Artesia, New Mexico, a 13-acre lake returned after eradication of saltcedar, verifying the impact of saltcedar on groundwater resources.

What can be done about it?

The critical things to do are to learn how to recognize saltcedar, to understand its negative impacts, and to know that it does not belong in our natural habitats. Control and eradication programs are being conducted throughout the western United States. Most of these efforts are on public lands, but restoration projects are also being conducted on privately owned nature reserves. The goal of most of these control programs is to preserve or recover sensitive areas, such as water holes or streams. In most cases, eliminating massive infestations along major rivers is not economically feasible at present.

Flowers of (left to right): saltcedar (*Tamarix ramosissima*)
athel tamarisk (*Tamarix aphylla*)
smallflower tamarisk (*Tamarix parviflora*)

With such a large and widespread infestation, biological control utilizing an imported insect pest of saltcedar is an optimal approach to long-term management. In 2001, the first biocontrol agent, the saltcedar leaf beetle (*Diorhabda elongata*), was released from caged sites throughout the southwest. Another insect, the manna mealybug (*Trabutina mannipara*) is being developed for release. Although the hope is that these insects will be successful in reducing the saltcedar problem, it is too soon to know how effective they will be.

Successful saltcedar control requires killing the root system. Some control methods that have been effective are foliar herbicide treatments, cutting the tree at the base and applying herbicide to the cut stump, applying a systemic herbicide to the base of uncut trees, ripping plants out by their roots with heavy equipment, or spraying regrowth with a systemic herbicide after a fire. When existing saltcedar plants are removed from an area, seedlings must be controlled for at least one year to prevent re-infestation. Sensitive riparian areas should be inspected at least once per year for new invasions of saltcedar. Small saltcedar plants growing from seed can be easily hand-pulled or sprayed with a systemic herbicide. This control effort is difficult, time consuming and expensive. For more information, or to make a contribution of your time and energy, please contact the **Bureau of Land Management** at a District Office, **California Invasive Plant Council** (Cal-IPC) or **The Nature Conservancy**.

A word about exotic pest plants

Saltcedar is one example of an exotic (i.e. non-native) pest plant causing large-scale ecological problems by taking over vital habitat for native plant and animal species. Estimates vary as to the number of exotic pest plant species that have made their way into the western U.S. since the arrival of Europeans, but there are probably thousands. Other examples are yellow mustards and brooms along the coast of California, giant reed (*Arundo donax*) clogging the rivers of coastal California, and yellow starthistle (*Centaurea solstitialis*), which infests 10-15 million acres of range and public lands in the state. Most of these have become so common they are mistaken for natives. The consequences of this invasion for the natural areas of the western states are grave.

Centaurea solstitialis **(yellow starthistle)**
photo by Carl E. Bell

Arundo donax **(giant reed)**

For further information on this subject or to see what you can do to help, visit the following websites:

California Invasive Plant Council
http://www.cal-ipc.org

U.S. Department of the Interior
http://www.invasivespecies.gov

University of California
Weed Research & Information Center
http://www.cal-ipc.org

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All photos by Joseph M. DiTomaso unless otherwise noted.

UC **WEED** Research & Information Center
UC Davis ■ Dept. of Plant Sciences ■ One Shields Avenue, MS4 ■ Davis, CA 95616
(530) 752-1748 ■ http://wric.ucdavis.edu ■ wric@ucdavis.edu

Weed of the Week

Tree-of-Heaven *Ailanthus altissima*

Common Names: tree-of-heaven, ailanthus, Chinese sumac, and stinking sumac, copal tree and varnish tree

Native Origin: Eastern and central China

Description: Tree-of-heaven is a rapidly growing, deciduous tree in the mostly tropical quassia family (Simaroubaceae). Mature trees can reach 80 feet or more in height. It has smooth stems with pale gray bark, twigs which are light chestnut brown and large compound leaves. Small yellow-green flowers have 5-6 petals and are borne in dense clusters near ends of upper stems. Pink to tan fruit is winged with a single seed in the middle. Roots have aggressive rhizomes. All parts of the tree, especially the flowers, have a strong, offensive odor similar to peanuts or cashews. Tree-of-heaven reproduces both sexually (seeds) and asexually (vegetative sprouts). Established trees also produce numerous suckers from the roots and re-sprout vigorously from cut stumps and root fragments.

Habitat: Disturbed soils, fields, roadsides, fencerows, woodland edges, forest openings, and rocky areas. It thrives in poor soils and tolerates pollution. It is not found in wetlands or shaded areas.

Distribution: This wide-spreading species is reported from states shaded on Plants Database map. It is reported invasive in AZ, CA, CT, DC, DE, FL, HI, IN, KY, LA, MA, MD, MI, MO, NC, NH, NJ, NM, NY, OH, OK, OR, PA, RI, SC, TN, VA, WA, WI, and WV.

Ecological Impacts: Tree-of-heaven is a prolific seed producer, grows rapidly, forms thickets, dense stands, and can overrun native vegetation. It colonizes by root sprouts and spreads by prolific wind- and water-dispersed seeds. Once established, it can quickly take over a site and form an impenetrable thicket. They produce toxins that prevent the establishment of other plant species.

Control and Management:

- **Manual-**Young seedlings may be pulled or dug up, preferably when soil is moist. Care must be taken to remove the entire plant including all roots and fragments. Cutting large seed producing female trees would at least temporarily reduce spread by this method.

- **Chemical-** It can be effectively controlled using any of several readily available general use herbicides such as triclopyr or imazapyr. Follow label and state requirements. The herbicides may be applied as a foliar (to the leaves), basal bark, cut stump, or hack and squirt treatment. Basal bark application is one of the easiest methods and does not require any cutting. It works best during late winter/early spring and in summer. The cut stump method is useful in areas where the trees need to be removed from the site and will be cut as part of the process. The hack-and-squirt or injection method is very effective and minimizes sprouting and suckering when applied during the summer.

- **Biocontrol -** A potential biological control for ailanthus may lie in several fungal pathogens, (*Verticillium dahliae* and *Fusarium oxysporum*) that have been isolated from dead and dying ailanthus trees in New York and in southern and western Virginia.

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Produced by the USDA Forest Service, Forest Health Staff, Newtown Square, PA. WOW 03-19-06
Invasive Plants website: http://www.na.fs.fed.us/fhp/invasive_plants

Arundo donax L.

Giant reed

Family: Poaceae
Range: Southern region of the U.S. In the west it can be found in California, Nevada, Utah, Arizona, New Mexico, and Texas.
Habitat: Riparian areas, floodplains, ditches, typically on sites with a low slope. Occurs in a wide range of soil types, but grows best in well-drained moist soils. Tolerates some salinity and extended periods of drought. Does not survive in areas with prolonged or regular periods of freezing temperatures.
Origin: Native to the Mediterranean region and tropical Asia. In California from the late 1700s to early 1800s, giant reed was often planted for erosion control in flood channels and as wind breaks. Since then it has been cultivated as an ornamental and to produce reeds for woodwind instruments. It is now a leading candidate for cellulosic biofuel production.
Impacts: Giant reed is primarily a problem in riparian corridors. It develops dense stands which often displace native vegetation, diminish wildlife habitat, and increase flooding and siltation in natural areas. Giant reed is also adapted to a periodic fire regime. The canes are readily flammable throughout much of the year, and the presence of giant reed increases the susceptibility of riparian corridors to fire. Large stands of giant reed can increase water loss from underground aquifers in semi-arid regions due to a high evapotranspiration rate. The rate of water loss is estimated at roughly three times more than that of the native riparian vegetation. It is also an alternate host for beet western yellows virus, sugarcane mosaic virus, and maize dwarf mosaic virus.
Western states listed as Noxious Weed: California
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Giant reed is a bamboo-like perennial to 25 ft tall, with thick, well-developed rhizomes. Although plants are typically terrestrial, they can tolerate periodic flooding. The canes are erect, semi-woody, and about 1 to 2 inches thick. First year green canes have unbranched stems the same diameter as older canes, but more pliable. Older canes are often branched, sometimes with leaves only on the branches. The blades are less than 3 ft long and 1 to 3 inches wide. The ligules consist of a short, even, minutely fringed membrane about 1 to 2 mm long. The auricles and collar region are distinctly pale yellowish-green. The rhizomes are creeping, thick, scaly, often forming a dense network, firm and knotty at the stem bases. Rhizome and stem fragments with a node can develop into a new plant under suitable conditions.

Inflorescences consist of large terminal plume-like panicles, 1 to 2 ft long, and silvery cream-colored to purplish or brown. Giant reed does not appear to produce viable seed in North America, although some Asian populations produce viable seed. Plants reproduce only vegetatively from rhizomes and rhizome and stem fragments; and stem and rhizome fragments generally disperse with water, mud, and human activities.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Minor infestations can be eradicated by manual methods, especially where sensitive native plants and wildlife might be damaged by other methods. Plants less than 6 ft in height and arising from a new stem or rhizome fragment can be hand pulled. This may be most effective in loose soils and after rains have loosened the substrate. Giant reed can also be dug using hand tools, particularly when used in combination with cutting near the base of the plant. Chopping, cutting or mowing (rotary brush cutter, chainsaw, or tractor-mounted mower) can also be used to reduce giant reed infestations, although the fibrous nature of giant reed makes using these techniques difficult. Such methods usually require tractor-mounted equipment, but on rough or rocky soils scythes can be used for smaller patches. These methods generally cause less soil disturbance compared to heavy

	equipment. However, they are nonselective and may damage other desirable species or open up new niches for weedy invasions. These methods usually require several cuttings before the underground parts exhaust their reserve food supply, and larger giant reed patches will have enough reserves to resprout even after years of treatment. The best timing for cutting is when the plants begin to flower, as this is when the reserve energy supply in the rhizomes is lowest. Mechanical methods using mechanized equipment (e.g., backhoe) to remove above-ground vegetation is a common non-chemical control method for giant reed. However, such equipment is also nonselective and can only be used on accessible terrain. Most mechanical equipment is not safe to operate on slopes over 30%. It is also of limited use where soils are highly susceptible to compaction or erosion or where excessive soil moisture is present. Site obstacles such as rocks, stumps or logs also reduce efficiency. Mechanical eradication of giant reed is extremely difficult, even with the use of a backhoe, as rhizomes buried under 3 to 10 ft of alluvium readily resprout. Regardless of the mechanical removal method employed, it is critical to remove the entire rhizome root mass. If any of the rhizome mass is left in the ground it will resprout. In addition, stems and roots should be removed, chipped or burned on site to prevent resprouting.
Cultural	Giant reed is not very palatable to cattle, but they will feed on it during the drier months. Sheep also have potential for the management of giant reed and have been shown to survive for extended periods on a strict diet of the perennial grass. However, sheep must be properly managed to prevent soil compaction problems particularly in wet areas. The most successful grazers are goats, particularly Angora and Spanish goats. Goats can have several advantages over mechanical and chemical control methods; they are less costly and can negotiate slopes too steep to manage with machines. Angoras are preferred over Spanish goats because of their smaller size and ease of transport. Since goats will trample or browse virtually any vegetation within a fenced area, any desirable trees or shrubs must be protected. A flame thrower or weed burner device can be used as a spot treatment to heat-girdle the stems at the base of giant reed plants. This technique is less costly than basal and stem herbicide treatments and is suitable for use during wet weather when the wildfire hazard is low. Its effectiveness is comparable to manual cutting. Large infestations may be burned to remove standing mature plants. This may be accomplished with or without a pre-spray of herbicides to kill and desiccate plants. When burning is used alone it will not prevent resprouting from the rhizomes. Burning is best followed by herbicide treatment of resprouting plants.
Biological	Little is known about the effects of various pathogens and insects on the growth and reproduction of *Arundo donax*. However, numerous insects are known to feed on this species. In recent work, the eurytomid wasp, *Tetramesa romana*, was evaluated as a potential biological control agent in North America. The wasp was found to be specific to *Arundo* and thus unlikely to harm native or cultivated plants in the Americas. Undoubtedly, many more years will be required before this species or any other potential biological control agents are identified and released.

CHEMICAL CONTROL

The following specific use information is based on reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II, Rodeo, Aquamaster*, and others	**Rate:** Broadcast foliar treatment: 2 to 4 qt product (*Roundup ProMax*)/acre (2.25 to 4.5 lb a.e./acre) or 2 to 4 qt product (*Rodeo* or *Aquamaster*)/acre (2 to 4 lb a.e./acre) around aquatic sites. Spot treatment: 2% v/v solution. However, the *Rodeo* product label allows up to an 8% v/v solution, depending on the equipment being used. **Timing:** Postemergence. Mid-summer to fall application after flowering and before dormancy is the best timing to kill plants and protect injury on many natives. Follow-up application in subsequent spring to control germinating seedlings may be necessary. **Remarks:** Glyphosate is considered the best option for control in pure stands. Two to three years of treatment are necessary. Herbicide treatment can be used after repeated mowing to reduce necessity for spring treatment to kill seedlings. Dense stands of giant reed (> 80% canopy cover) are most efficiently treated by aerial application, usually by helicopter. Helicopter application can treat at least 124 acres per day.

	Undiluted glyphosate can be applied as a cut stump treatment with a paint brush within 1 to 2 minutes after stem cutting. Results have shown that glyphosate used in a cut stem treatments, regardless of time of application (May, July, or September), provided excellent control with no resprouting. Another method of treatment includes cutting or burning plants followed by foliar treatment of glyphosate to cane regrowth to about 6 to 8 ft in height.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapyr *Habitat*	**Rate:** 1 to 2 qt product/acre (0.5 to 1 lb a.e./acre) **Timing:** Postemergence fall application timing is most effective, similar to glyphosate. **Remarks:** Imazapyr has soil residual activity and may impact restoration efforts.
Imazapyr + glyphosate	**Rate:** 1 pt imazapyr (*Habitat*) + 1 qt glyphosate product/ acre (0.25 + 1 lb a.e./acre, respectively) **Timing:** Postemergence fall application timing is most effective. **Remarks:** The combination of the two herbicides prevents the synthesis of six amino acids, as each herbicide inhibits three amino acids. This combination is thought to provide better control at lower rates of each herbicide, thus it is more affordable compared to imazapyr alone.

RECOMMENDED CITATION: DiTomaso, J.M., G.B. Kyser et al. 2013. *Weed Control in Natural Areas in the Western United States.* Weed Research and Information Center, University of California. 544 pp.

WILD BLACKBERRIES

Integrated Pest Management for Home Gardeners and Landscape Professionals

Of the 11 species of *Rubus* in California, four were introduced primarily from Eurasia. Most species of wild blackberry, also called brambles, provide important sources of food and cover for many birds and mammals.

Four species, however, are considered weeds. Two of these are non-natives, cutleaf blackberry (*R. laciniatus*) (Fig. 1) and Himalaya blackberry (*R. discolor* [formerly known as *R. procerus*]) (Fig. 2). In addition, two native species also can be weeds under certain conditions. For example, thimbleberry (*R. parviflorus*) (Fig. 3) competes with conifers during establishment in reforested areas, and California blackberry (*R. ursinus* [formerly known as *R. vitifolius*]) (Fig. 4) can infest areas adjacent to streams and ditches. Of these weedy species, the most common, vigorous, and troublesome is Himalaya blackberry.

IDENTIFICATION

Of the four weedy wild blackberries, thimbleberry is the only nonvining species. It also lacks prickly stems and has a simple leaf with no leaflets. Both Himalaya and cutleaf blackberry have five-angled stems whereas thimbleberry is rounded in cross section, but Himalaya blackberry is easily distinguishable from the other wild blackberries by its five distinct leaflets, each one toothed and usually oval. By comparison, cutleaf blackberry has five very deeply lobed leaflets, and California blackberry has only three leaflets. Not all wild blackberry leaves are deciduous; many remain evergreen. This is an important feature for chemical control in late fall and winter.

Himalaya blackberry has showy flowers that form in large clusters at the end of shoots. Each flower is about 1 inch across with five white or pink petals. The fruits are black and tasty when ripe. New canes are produced each year from the crown (the base of the plant), replacing those that die naturally. New plants start from crown regrowth, rhizomes (horizontal, underground shoots), and seeds that germinate in fall and spring. Reproduction is similar for the other three species.

IMPACT

The scrambling habit of Himalaya and the other vining wild blackberries smothers existing plant growth. In addition, the tangled mass of thorny stems blocks access of humans, livestock, equipment, and vehicles to pastures and waterways. In addition, it can host Pierce's disease and serve as a vector to movement of the pathogen to other agricultural and nonagricultural areas, including riparian sites.

In forest areas, timber-logging operations create large open areas that wild blackberries often invade. When grazed, the thorny stems can injure the nasal passages of livestock. Another undesirable aspect of vining blackberry plants is they are a good source of food and shelter for rats.

BIOLOGY

Many animal species feed on wild blackberries; consequently, seeds spread easily from one area to another in animal droppings. Wild blackberry seeds have a hard seed coat and can remain dormant for an extended period. Once seeds germinate and grow and the plants become established, expansion of the thicket is almost entirely a result of vegetative growth from rhizomes. Over time a single plant can cover a very large area.

Figure 1. Cutleaf blackberry.

Figure 2. Himalaya blackberry.

Figure 3. Thimbleberry.

Figure 4. California blackberry.

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Wild blackberry plants can live for 25 years or longer. They produce vines that arise from a central crown or from buds that form along rhizomes (Fig. 5). First-year canes don't produce flowers. In the second year, the canes fruit and die. Tips of first-year canes that contact the ground form roots at the nodes, contributing to the lateral expansion of the plant.

Bumblebees and honey bees are the primary pollinators of wild blackberry flowers. The flowers can be self-pollinated, but cross pollination increases fruit set.

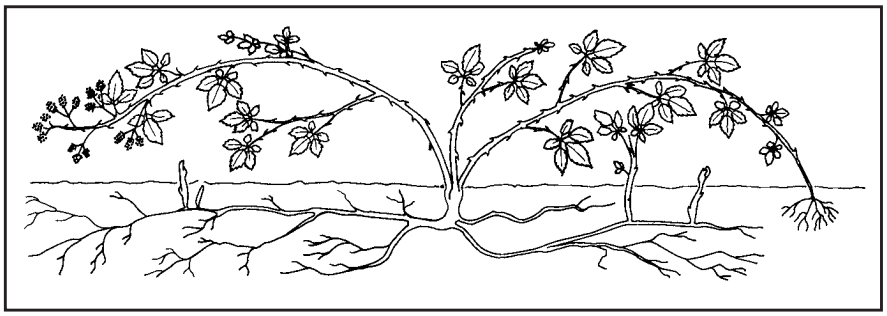

Figure 5. Vegetative growth of a blackberry plant from a central crown.

MANAGEMENT

Wild blackberries are able to regenerate from the crown or rhizomes following mowing, burning, or herbicide treatment. This makes them difficult to control, and control measures often require follow-up treatment. Land managers often rely on a combination of mechanical and chemical control methods followed by a prescribed burn to dispose of vegetative material.

Because of the extensive underground root system, digging out the plants in a home landscape is a difficult undertaking. Home gardeners generally must rely on foliage-applied herbicide treatments to control an infestation of wild blackberries. One nonchemical option in the home landscape is the use of a rototiller to till the ground several times after the canes have been removed.

Mechanical Control

Because **repeated tillage** easily controls wild blackberries, they aren't a problem in cultivated agricultural systems. A single cultivation, however, can fragment the rhizomes and spread the weed. **Bulldozing** also can cause resprouting and can spread the weed by fragmenting roots and stems.

Mowing isn't an effective method for controlling wild blackberries. In many cases it stimulates the formation of suckers from lateral roots and induces branching. Despite the lack of long-term control, mowing or chopping can provide short-term canopy reduction that will encourage the growth of grasses and broadleaf plants.

Burning, like mowing, isn't an effective long-term strategy, because wild blackberry plants vigorously resprout from rhizomes. However, like mowing, it also provides short-term canopy reduction.

Biological Control

Because many *Rubus* species are native or of economic importance, biocontrol isn't a practical control method in California. In Australia, however, blackberry leaf rust (*Phragmidium violaceum*) has been released for control of the weed. Thus far this program has not been successful, because the rust hasn't caused significant damage to its host. The rust was discovered in Oregon in the early 2000s and appeared to cause some damage to Himalaya blackberry populations. However, it has not maintained that level of injury and hasn't become widespread in California.

Chemical Control

Blackberry plants usually regrow following herbicide application; thus, repeated treatments might be necessary for effective long-term control.

Herbicides applied to the soil. In noncrop areas, tebuthiuron (Spike) is registered for use by licensed applicators for brush control. Tebuthiuron is a nonselective urea herbicide that is used for total control (i.e., it eliminates other vegetation in the treatment area) of shrubs, trees, and other weeds. It can be applied in a pelleted formulation at the base of the plant to provide long-term control of wild blackberries.

Herbicides applied to the plant. Herbicides can be used in rangeland, pastures, noncrop areas, along roadsides, and in right-of-ways to control actively growing wild blackberry plants.

To effectively control blackberries during the growing season, an herbicide must be transported within the plant to the rhizomes and new growing points. For this to occur, the herbicide must move in the phloem with the plant sugars produced through photosynthesis. In early summer during the rapid extension of canes and expansion of foliar tissue, sugars are transported within the plant from the underground storage tissues to the shoots. After midsummer, new growth is reduced in wild blackberry first-year canes (nonflowering shoots), because these shoots are actively transporting sugars to the rhizomes. These sugars are stored for the following year's growth. In the flowering shoots (second-year canes), movement of sugars from the shoots to the rhizomes occurs later in the season than it does for first-year canes and is most active after completion of fruiting.

Time a foliar herbicide application so that it coincides with the maximum rate of sugar movement to the root system. This will depend upon whether the plants are primarily first-year canes or a combination of both first- and second-year canes. In a situation where only first-year canes are present (for example when plants have been burned or mowed), the most effective time for

optimal herbicide transport to the root system is in late summer. Herbicide application at this time reduces the likelihood of regrowth in subsequent years. Where the bramble infestation consists primarily of second-year canes or a combination of first- and second-year canes, apply an herbicide in early fall, before plants become dormant. Herbicides applied too early generally result in good kill of the top growth but very little movement of the chemical to the root system. Consequently, the plant regrows.

Plants stressed from drought or grazing don't translocate sugars as rapidly as do actively growing plants. Thus, chemical control of wild blackberry plants under stress is difficult and not recommended.

Foliar-applied herbicides. Herbicides used to control wild blackberry during the growing season include glyphosate, dicamba, dicamba/2,4-D combinations, and triclopyr. Of these, glyphosate (Roundup and other products containing glyphosate) and triclopyr (Brush-B-Gon, Blackberry and Brush Killer) are registered for use by home gardeners.

- Glyphosate formulated into a product with 41% active ingredient (a.i.) can provide good to excellent control of wild blackberries when applied in a 0.5 to 1.5% solution (i.e., about 0.6 to 2 ounces of product per gallon of water). One product available for use in the home landscape with this concentration of active ingredient is Roundup Super Concentrate. In natural areas, Roundup Pro is commonly used, and in riparian sites near water, the formulations Aquamaster and Rodeo are registered. Glyphosate products that have a lower concentration of active ingredient, such as Roundup Concentrate (18% a.i.), will require a 1.5 to 3.5% solution (i.e., about 2 to 4.5 ounces per gallon of water) for effective control. Late summer or early fall treatments give better control than treatments before or during flowering. To obtain good control, however, complete foliage coverage (spray-to-wet) is essential; spray the plant until it is thoroughly wet but not to the point of runoff. Burning or mowing 40 to 60 days after spraying with glyphosate increases the level of control and also contributes to good pasture establishment by removing stem debris. Shoots recovering from sublethal glyphosate treatment tend to die more quickly when subjected to heavy grazing. Be sure to wait at least two weeks before grazing after treatment if less than 10% of the area was treated. If more than 10% of the area was treated, animals can't be grazed on the land until eight weeks following treatment.
- Dicamba alone (Banvel, Vanquish) or plus 2,4-D applied in late summer gives good control of wild blackberries. However, 2,4-D alone provides only fair control and will result in resprouting.
- Triclopyr is available to licensed applicators for commercial use in either amine (Garlon 3A) or ester (Garlon 4) formulations. Triclopyr ester (0.75 to 1% solution) is the most effective formulation of triclopyr on thimbleberry and the other three species of wild blackberries. Absorption of the herbicide into the foliage isn't as good with the amine form. Nevertheless, it also provides good control when applied at a 1% solution. The best time to apply either form of the herbicide is midsummer. When air temperatures are higher than 80°F, it is best to use the amine formulation, because the ester form is subject to vaporization. The timing for control of wild blackberries with triclopyr is somewhat earlier than that recommended for glyphosate. Like glyphosate, apply triclopyr spray-to-wet on the foliage. Sometimes glyphosate and triclopyr (1% solution each) are used in combination to achieve better control. Triclopyr is available in retail stores for use in the home landscape in products formulated at a lower concentration than those available to licensed applicators. Carefully read and follow the label of these products (Brush-B-Gon Concentrate, Blackberry and Brush Killer) to apply the correct amount to plants.

Basal bark treatment. Concentrated forms of triclopyr (often mixed with commercially available seed oils for better penetration) can be applied to basal regions of wild blackberries with a backpack sprayer using a solid cone, flat fan, or a straight-stream spray nozzle. Thoroughly cover a 6- to 12- inch basal section of the stem with spray but not to the point of runoff. Basal bark applications can be made almost any time of the year, even after leaves have senesced (aged, dried, and fallen from plant). In areas where people frequently harvest the fruit of wild blackberries, a midfall basal bark treatment might be desirable to avoid human contact with the chemical.

Dormant stem and leaf treatment. As an alternative to basal bark treatments, a 1% solution of triclopyr ester can be applied to dormant leaves and stems in late fall and winter in a 3% crop oil concentrate mixture; see product labels for the rate to use to obtain the desired concentration. As with other herbicide applications, spray the plant until it is thoroughly wet but not to the point of runoff. Like basal bark treatments, the timing of this technique prevents human contact with the herbicide during berry-picking season.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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