PROJECT MANUAL

Volume III: Technical Provisions

Huff's Corner Off-Site Mitigation Project

ITB-2026-0005

County of Yolo
Department of General Services

April 2, 2026

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Attachments:

A. Riparian Restoration Plan (March 2026, prepared by ECORP Consulting, Inc.)

B. CDFW Streambed Alteration Agreement (EPIMS Notification No. YOL-13602-R2)

1. GENERAL

1.1 Work includes site preparation (e.g., invasive species control and soil amendments), installation of native plantings and irrigation systems, and protection and documentation of plantings. The Contractor shall provide ongoing maintenance, monitoring, and reporting during the warranty period, including replacement of failed plantings as necessary to meet specified performance standards. Optional post-warranty maintenance and monitoring may be required to support long-term establishment of the restoration areas.

1.2 The work will take place on two County-owned properties, referred to as the "Cache Creek Nature Preserve Restoration Site" and the "Woodland Reiff and Haller/Muller Restoration Site." These sites are collectively referred to as the "Restoration Sites." Maps are provided in Attachment A.

1.3 The Contractor shall prepare a Stormwater Pollution Prevention Plan (SWPPP), if required.

1.4 The Contractor shall adhere to all applicable conditions in the California Department of Fish and Wildlife (CDFW) Streambed Alteration Agreement (Notification No. YOL-13602-R2).

1.5 The Contractor shall perform all activities in accordance with the CDFW-approved Riparian Restoration Plan (March 2026).

1.6 The Contractor shall perform all activities in accordance with the applicable conditions of the Project Partnership Agreement Between the State of California Department of Water Resources and the County of Yolo for the Huff's Corner Levee Raise & Channel Reconfiguration – Phase II (DWR Agreement No. 4600015709).

2. SITE PREPARATION

2.1 The Contractor shall provide a description of how the Restoration Sites will be prepared for planting, including the removal of non-native plant species, if applicable. Any earthmoving activities during site preparation shall be limited to those necessary to install the plants and irrigation system (e.g., digging, planting holes, trenching for irrigation, or grading small areas for proper plant placement). Existing non-native understory vegetation shall be cleared using mowers and handheld equipment or by chemical means.

2.2 The Contractor shall provide an assessment of invasive plants in the Restoration Sites prior to the planting effort and include methods for controlling the invasive species. This assessment shall focus on invasive riparian species listed as *High*, *Moderate*, or

Watch on the California Invasive Plant Inventory (CIPI; https://www.cal-ipc.org/plants/inventory/) maintained by the California Invasive Plant Council (Cal-IPC). All invasive species present within the Restoration Sites shall be mapped. It will be the responsibility of the Contractor to manage invasive plants within the Restoration Sites during the Warranty Period.

2.3 Soil amendments (e.g., incorporating organic material into the soil) may be required to ensure planting survivability. The Contractor shall notify the County prior to performing any soil amendment activities.

3. PLANTINGS

3.1 The Contractor shall provide a timeline for implementation. All restoration plantings shall be completed either in the Spring Planting Season (generally defined as April 1 through June 15) or the Fall Planting Season (generally defined as September 15 through November 30). Any plantings outside these general timeframes shall be approved by the County.

3.2 The Contractor shall provide a detailed planting plan which includes: the number of units of species of trees, shrubs, and any other container stock to be planted; a native seed mix; a description of the spacing of container stock; and a map showing the proposed planting arrangements and designated photo points. The County will provide the final planting design to CDFW prior to implementation. Under no circumstances shall the Contractor begin planting before CDFW approval of the planting plan has been received.

3.3 The Contractor shall plant the following quantities per species at the identified locations:

Common Name	Scientific Name	Qty	Location
Fremont Cottonwood	*Populus fremontii*	165	Cache Creek Nature Preserve Restoration Site
Willow	*Salix* sp.	69	Cache Creek Nature Preserve Restoration Site
Valley Oak	*Quercus lobata*	40	Woodland Reiff and Haller/Muller Restoration Site
Black Walnut	*Juglans hindsii*	10	Woodland Reiff and Haller/Muller Restoration Site

3.4 The Contractor shall provide an irrigation plan and install all irrigation infrastructure. Flood and/or drip irrigation is expected to be provided to the restoration plantings for the first three years of growth, as needed, based on precipitation.

3.5 Trees shall be planted in adherence to current recognized Best Management Practices as outlined by the International Society of Arboriculture and the current edition of the American Standards Institute (ANSI) A300 Tree Care Standards.

3.6 The Contractor shall adhere to all applicable requirements of Yolo County Code §10-3.4115(A)(7) pertaining to the source of native seeds, plants, and cuttings used for the project. A copy of the applicable code section is available at: https://codelibrary.amlegal.com/codes/yolocounty/latest/yolo/0-0-0-17210.

3.7 If nursery stock of any species is unavailable and a substitute species is required, the Contractor shall coordinate with the County to submit the proposed replacement species and quantities for written approval from CDFW prior to implementation.

3.8 The Contractor shall protect the restoration plantings using browse protection cages.

3.9 The Contractor shall give each plant a unique identifier and collect the location of each planting via a Global Positioning System unit. The corresponding data shall be delivered to the County in a GIS-compatible format no later than one (1) month following completion of planting activities.

3.10 The Contractor shall photograph each planting immediately after installation to document its initial condition. All photographs shall be in JPG, PNG, or GIF format and shall be delivered to the County no later than one (1) month following completion of planting activities.

3.11 Photo points within the Restoration Sites shall be established after the plantings are installed. The locations of the photo points shall be submitted to the County in a GIS-compatible format no later than one (1) month following completion of planting activities.

3.12 A native seed mix shall be applied to all disturbed areas following planting activities to prevent erosion and inhibit the establishment of invasive species. The Contractor shall submit the proposed seed mix to the County for approval prior to implementation.

4. QUALITY ASSURANCE

4.1 Substantial Completion Acceptance – acceptance of the work prior to the start of the Warranty Period:

4.1.1 Once the Contractor completes the installation of all items in this section, the County will observe all work for Substantial Completion Acceptance upon

written request of the Contractor. The request shall be received at least ten calendar days before the anticipated date of the observation.

4.1.2 Substantial Compliance Acceptance by the County shall be for general conformance to specified size, character, and quality and not relieve the Contractor of responsibility for full conformance to the Contract documents, including correct species.

4.1.3 Any plantings that are deemed defective as defined under the provisions below shall not be accepted.

4.1.4 The Contractor shall replace defective work and plantings. All replacements shall be like-for-like. If a like-for-like replacement is infeasible, the Contractor shall obtain County approval prior to installing a different species. The County shall make the final determination as to whether the plantings meet the specifications or are defective.

4.2 The County will provide the Contractor with written acknowledgement of the date of Substantial Completion Acceptance and the beginning of the Warranty Period.

4.3 The Contractor shall be solely responsible for quality control of the work.

5. WARRANTY PERIOD

5.1 Plantings shall be warrantied for a minimum of one (1) year after Substantial Completion Acceptance is issued. Plantings installed in the Fall shall be alive and in satisfactory growth as of November 30 of the first year after planting (e.g., plantings in Fall 2026 shall be warrantied until November 30, 2027). Plantings installed in the Spring shall be alive and in satisfactory growth as of June 15 of the first year after planting (e.g., plantings in Spring 2027 shall be warrantied until June 15, 2028).

5.2 During the Warranty Period, any plantings that are rated as "*Poor*" or "*Dead*" (as further defined in Section 6.5) or otherwise deemed damaged, unsightly, or unhealthy, shall be promptly removed and replaced by the Contractor, as directed by the County. Any vandalized plantings shall be reported to the County.

5.3 Replacement plantings shall conform to the requirements of the specifications and shall be performed as often as necessary to ensure the establishment of healthy plants. Each replacement shall be maintained and guaranteed for one (1) year from the date of replacement in accordance with the terms of the Warranty Period, unless terminated early by the County.

5.4 The Contractor shall be responsible for all labor, equipment, and materials costs associated with the procurement, delivery, and installation of replacement plantings.

Upon such determination, the Contractor shall not be entitled to any additional compensation for the installation of replacement plantings beyond the payment provided for the original plant installation.

5.5 The County may, at its sole discretion, require the Contractor to address tree planting-related issues as they arise.

5.6 The Contractor shall notify the County immediately, in writing, of any plant mortality occurring during the Warranty Period. Dead plantings shall be removed promptly, regardless of cause, at no additional cost to the County. Replacement plantings shall occur during the appropriate planting season. If removal occurs outside the planting season, replacement shall be performed at the start of the next applicable planting season. For species identified as fall hazards, replacement shall occur during the subsequent spring planting season.

6. WARRANTY PERIOD MAINTENANCE & MONITORING

6.1 During the Warranty Period, the Contractor shall provide all maintenance for all plantings. Maintenance shall commence immediately following installation and continue throughout the Warranty Period to ensure the plantings remain in a healthy condition and the planting areas are maintained in a clean and orderly manner until final acceptance. Regular maintenance activities shall include, but not be limited to, the following:

- Maintenance, repair, and replacement of the irrigation system, as needed, to ensure proper functioning.
- Management of invasive species within the Restoration Sites.
- Maintenance, repair, and replacement for plant protection materials (e.g., cages/fences) to prevent damage due to wildlife.
- Removal of any trash accumulated.
- Implementation of signage and public outreach, as needed, to prevent human intrusion into the Restoration Sites while the plantings are being established.

6.2 During the Warranty Period, irrigation shall be applied at a minimum frequency of once per week during dry periods.

6.3 The Contractor shall be solely responsible for securing a water source for the Restoration Sites.

6.4 While performing the maintenance activities, a qualitative assessment shall be conducted by walking meandering paths through the Restoration Sites and recording

observations on the general condition of the plantings. The qualitative monitoring will be used to inform maintenance activities, and adaptive management measures should they need to be implemented. Qualitative assessments shall note the following:

- Areas where planted species are failing to establish and the cause of failure to establish, if apparent.
- Condition of irrigation system and frequency of watering.
- Any problematic non-native invasive plants.
- Signs of damage due to animals (e.g., beaver, rodent, deer herbivory).
- Adequacy of fencing and signage and signs of human intrusion/disturbance.
- Presence of trash or vandalism.
- Other potential threats to restoration plantings (e.g., disease, drought conditions, erosion, excessive flooding).
- Wildlife observed onsite including wildlife signs such as scat, pellets, or bones.

6.5 Condition of the plantings shall be evaluated between June and July. Plant condition shall be ranked accordingly by the following scale:

- *Good* – healthy foliage and vigorous growth
- *Fair* – healthy foliage, but minimal apical growth
- *Poor* – few green leaves present and no apparent apical growth
- *Dead* (including those unable to be located and assumed dead)

6.6 The percentage of plantings that are alive and dead shall be calculated for each species planted. Of the living plantings, the proportion that are in good, fair, or poor condition shall be calculated.

6.7 Invasive Species Management:

6.7.1 Invasive species management shall occur on a regular basis to prevent establishment and spread of invasive plants within the Restoration Sites.

6.7.2 The top priority shall be to manage invasive species ranked as *High*, *Moderate*, or *Watch* by the Cal-IPC. Management guides for the main species of concern for the Restoration Sites are provided in Appendix D to the Riparian Restoration Plan.

6.7.3 Implementation of weed control should be limited to hand removal, mowing or cutting, and the use of herbicides as necessary. Targeted herbicide application methods should be used if herbicides are required. Should herbicides be used, the Contractor shall provide a list of the herbicides used and Safety Data Sheets to the County with the other materials required by Section 6.8.

6.7.4 Plantings and native vegetation shall be protected by a spray shield or similar devices to avoid plant damages caused by spray drift.

6.7.5 Any discrete patches of invasive species shall be mapped to prioritize weed removal efforts, and the approximate cover of diffusely distributed species shall be noted. Any other invasive species noted to be affecting the success of the plantings shall also be noted and prioritized for removal.

6.8 The Contractor shall maintain detailed records of all maintenance activities, including the types of tasks performed, date of performance, types and quantities of materials and products used, irrigation frequency and volume, and crew size. The Contractor shall review these records with the County upon request and shall submit copies to the County on a monthly basis, no later than the 10th of each month.

6.9 The Contractor shall notify the County in writing if maintenance, including irrigation, is insufficient to maintain plant health. Such notification shall be provided in a timely manner to allow the County to take corrective action. The notification shall identify specific maintenance deficiencies and include recommended corrective measures. Failure of the Contractor to adequately monitor the Restoration Sites or to provide timely written notice of maintenance needs shall not relieve the Contractor of its obligations under this Warranty.

6.10 The Contractor shall meet with the County every two (2) months during the Warranty Period to inspect the plantings, identify potential issues, and implement corrective actions as necessary.

7. FINAL WARRANTY PERIOD INSPECTION & ACCEPTANCE

7.1 At the end of the Warranty Period, the Contractor and the County shall jointly inspect the plantings to determine acceptability. To be accepted, the work shall be in a condition comparable to new installation. Each planting shall exhibit a form typical of its species and maintain at least seventy-five percent (75%) of its original canopy in a viable condition. Any planting that has lost its central leader shall be deemed unacceptable.

7.2 If the work is deemed unsatisfactory, the maintenance period will continue at no additional expense to the County until the work has been completed, observed, and approved by the County.

7.3 Following the inspection, the County shall prepare a punch list of deficiencies. Upon satisfactory correction of all identified deficiencies, the County shall issue written Notice of Final Acceptance and completion of the Warranty Period.

7.4 Defective work shall be corrected promptly upon discovery, weather and seasonal conditions permitting.

7.5 Should the County decide not to exercise any of the "Post-Warranty Maintenance" Contract options, the Contractor shall attend a handover meeting with the County to formally transfer maintenance responsibilities. The Contractor shall provide all records of past maintenance activities, including complete maintenance logs, and a list of anticipated critical maintenance tasks for the subsequent twelve (12) months. The Contractor shall make its Supervisor available for a period of twelve (12) months following the conclusion of the Warranty Period to respond to reasonable inquiries regarding past maintenance.

7.6 The irrigation infrastructure shall be fully functional upon transfer of the maintenance obligations to the County.

8. POST-WARRANTY PERIOD MAINTENANCE & MONITORING

8.1 In the event the County elects to exercise any "Post-Warranty Maintenance & Monitoring" Contract options, the Contractor shall continue to perform site maintenance and monitoring in accordance with the Contract requirements.

8.2 During the Post-Warranty Maintenance & Monitoring Period, the irrigation application schedule shall be, at a minimum, once every two (2) weeks during dry periods in Year 2 post-planting, and once per month in Year 3 post-planting. Irrigation is not anticipated for Years 4 and 5 post-planting; however, the County reserves the right to require irrigation during these years if deemed necessary.

8.3 The Contractor shall be solely responsible for securing a water source for the Restoration Sites.

9. ANNUAL MONITORING REPORTS

9.1 An annual monitoring report must be submitted to CDFW by January 31 of each year following each monitoring year. The County will take the lead in preparing the report; however, the Contractor shall make appropriate staff available to coordinate with and support the County, including providing data, information, and other materials as reasonably requested by the County.

9.2 The reports will include an assessment of the interim performance standards for Years 1 through 4 and an analysis of the final performance standards in Year 5, as further detailed in Section 10.

9.3 Each report will discuss the cause(s) of failure to meet any unmet performance standards and will describe any adaptive management measures taken or planned.

9.4 The reports will also include photographs from the designated photo points, a summary of invasive species control activities (if needed), methods used to remove non-native plants, and a list of wildlife observed on-site.

10. PERFORMANCE STANDARDS

10.1 The plantings shall be subject to the Interim Performance Standards and Final Performance Standards described below.

10.1.1 Interim Performance Standards. The goal of interim performance standards is to evaluate the condition of plantings and restoration areas, determine whether they are on track to meet final standards, identify causes of poor plant health or mortality, and guide adaptive management actions to address those issues. The interim performance standards, as outlined in the Riparian Restoration Plan, are:

Category	Standards
Plantings	1. Each species planted will have an 80-percent or higher survival rate relative to the required plantings (i.e., 206 plantings out of 258 required plantings) will have survived at the end of the monitoring period. Mortality of plantings in excess of the 258 required plantings (e.g., contingency plantings) will be excluded from the survival rate. New volunteer native riparian species may also be included in calculations. 2. 70 percent or more of the living woody container plantings will have a ranking of Good or Fair condition within each planting type.
Invasive Species	1. Area (ac.) (for discrete populations) and percent cover (for diffuse populations) of invasive species rated as *High* or *Moderate* by the CIPI will be equal to or lower than baseline levels.

10.1.2 Final Performance Standards. The goal of final performance standards is to determine that the mitigation requirements per the SAA have been met. The final performance standards are:

Category	Standards
Plantings	70 percent or more of the required plantings (i.e., 180 plantings out of 258 required plantings) will have survived at the end of the monitoring period. Mortality of plantings in excess of the 258 required plantings (e.g., contingency plantings) will be excluded from the survival. New volunteer native riparian species may also be included in calculations.
Invasive Species	Area (ac.) of discrete populations of invasive species rated as *High* or *Moderate* by the CIPI will be equal to or lower than baseline levels.

11. PAYMENT

11.1 Mobilization/Demobilization

11.1.1 The contract lump sum price for Mobilization/Demobilization shall not exceed five percent (5%) of the Base Bid and shall include full compensation for obtaining all bonds, permits, licenses, and for furnishing all labor, materials, tools, equipment, and incidentals necessary to complete the work. Payment for Mobilization/Demobilization will be prorated as follows:

- When the Monthly Progress Payment (excluding Mobilization/Demobilization) is five percent (5%) or more of the Original Contract Amount, fifty percent (50%) of the contract item price for Mobilization/Demobilization will be paid.
- When the Monthly Progress Payment (excluding Mobilization/Demobilization) is twenty-five percent (25%) or more of the Original Contract Amount, seventy-five percent (75%) of the contract item price for Mobilization/Demobilization will be paid.
- When the Monthly Progress Payment (excluding Mobilization/Demobilization) is fifty percent (50%) or more of the Original Contract Amount, eighty-five percent (85%) of the contract item price for Mobilization/Demobilization will be paid.

- The remaining fifteen percent (15%) will be paid upon completion of all Contract Work, removal of all equipment from the site, final cleanup of the Project, and final acceptance.

11.1.2 Payment will be made at the contract lump sum price for Mobilization/Demobilization. This price and payment shall be full compensation for all costs associated with this item.

11.2 Develop Planting Design

11.2.1 Payment for "Develop Planting Design," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for the development of the planting plan, including any revisions required for approval by CDFW.

11.3 Site Preparation of Restoration Sites

11.3.1 Payment for "Site Preparation of Restoration Sites," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, materials, and incidentals required to prepare the Restoration Areas for planting. Work shall include, but is not limited to, invasive weed management, mowing, soil amendments, and other related activities necessary to prepare the sites.

11.4 Fremont Cottonwood (*Populus fremontii*) Trees

11.4.1 Payment for "Fremont Cottonwood (*Populus fremontii*) Trees," measured as specified, will be made at the contract unit price per tree. Such payment shall constitute full compensation for procurement, delivery, planting, and warranty of the specified tree species.

11.5 Willow (*Salix* sp.) Trees

11.5.1 Payment for "Willow (*Salix* sp.) Trees," measured as specified, will be made at the contract unit price per tree. Such payment shall constitute full compensation for procurement, delivery, planting, and warranty of the specified tree species.

11.6 Valley Oak (*Quercus lobata*) Trees

11.6.1 Payment for "Valley Oak (*Quercus lobata*) Trees," measured as specified, will be made at the contract unit price per tree. Such payment shall constitute full compensation for procurement, delivery, planting, and warranty of the specified tree species.

11.7 Black Walnut (*Juglans hindsii*) Trees

11.7.1 Payment for "Black Walnut (*Juglans hindsii*) Trees," measured as specified, will be made at the contract unit price per tree. Such payment shall constitute full compensation for procurement, delivery, planting, and warranty of the specified tree species.

11.8 Irrigation Installation at Restoration Sites

11.8.1 Payment for "Irrigation Installation at Restoration Sites," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, materials, equipment, and incidentals required to install, test, and make operational the irrigation system at the Restoration Sites, in accordance with the Contract specifications.

11.9 Warranty Period Maintenance and Monitoring

11.9.1 Payment for "Warranty-Period Maintenance and Monitoring," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, materials, and incidentals required to perform maintenance and monitoring during the Warranty Period.

11.10 Post-Warranty Maintenance and Monitoring (Year 2) [Optional]

11.10.1 Payment for "Post-Warranty Maintenance and Irrigation (Year 2)," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, materials, incidentals required to perform maintenance and monitoring during Year 2 post-planting.

11.11 Post-Warranty Maintenance and Monitoring (Year 3) [Optional]

11.11.1 Payment for "Post-Warranty Maintenance and Irrigation (Year 3)," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, materials, and incidentals required to perform maintenance and monitoring during Year 3 post-planting.

11.12 Post-Warranty Maintenance and Monitoring (Year 4) [Optional]

11.12.1 Payment for "Post-Warranty Maintenance and Irrigation (Year 4)," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, materials, and incidentals required to perform maintenance and monitoring during Year 4 post-planting.

11.13 Post-Warranty Maintenance and Monitoring (Year 5) [Optional]

11.13.1 Payment for "Post-Warranty Maintenance and Irrigation (Year 5)," measured as specified, will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, equipment, materials, and incidentals required to perform maintenance and monitoring during Year 5 post-planting.

*****END OF VOLUME III*****

ATTACHMENT A

Riparian Restoration Plan

Prepared by ECORP Consulting, Inc., March 2026

Riparian Restoration Plan
for the
Huff's Corner Levee Raise and Channel Reconfiguration Project

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Yolo County, California

Prepared For:

County of Yolo

Prepared By:

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ENVIRONMENTAL CONSULTANTS
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March 2026

SUPERSEDED February 2024 and November 2024

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Appendix B – Project Area

Appendix C – Representative Photographs of the Mitigation Site

Appendix D – Invasive Species Management Guides

LIST OF ACRONYMS AND ABBREVIATIONS

Term	Definition
Cal-IPC	California Invasive Plant Council
CCNP	Cache Creek Nature Preserve
CDFW	California Department of Fish and Wildlife
CIPI	California Invasive Plant Inventory
DBH	diameter at breast height
ECORP	ECORP Consulting, Inc.
HUC	Hydrologic Unit Code
NRCS	Natural Resources Conservation Service
OHWM	Ordinary High Water Mark
Plan	Riparian Restoration Plan
Project	Huff's Corner Levee Raise and Channel Reconfiguration Project
SAA	Streambed Alteration Agreement
Teichert	Teichert Land Company
Triangle	Triangle Properties
USGS	U.S. Geological Survey

1.0 RESPONSIBLE PARTIES

1.1 Applicant

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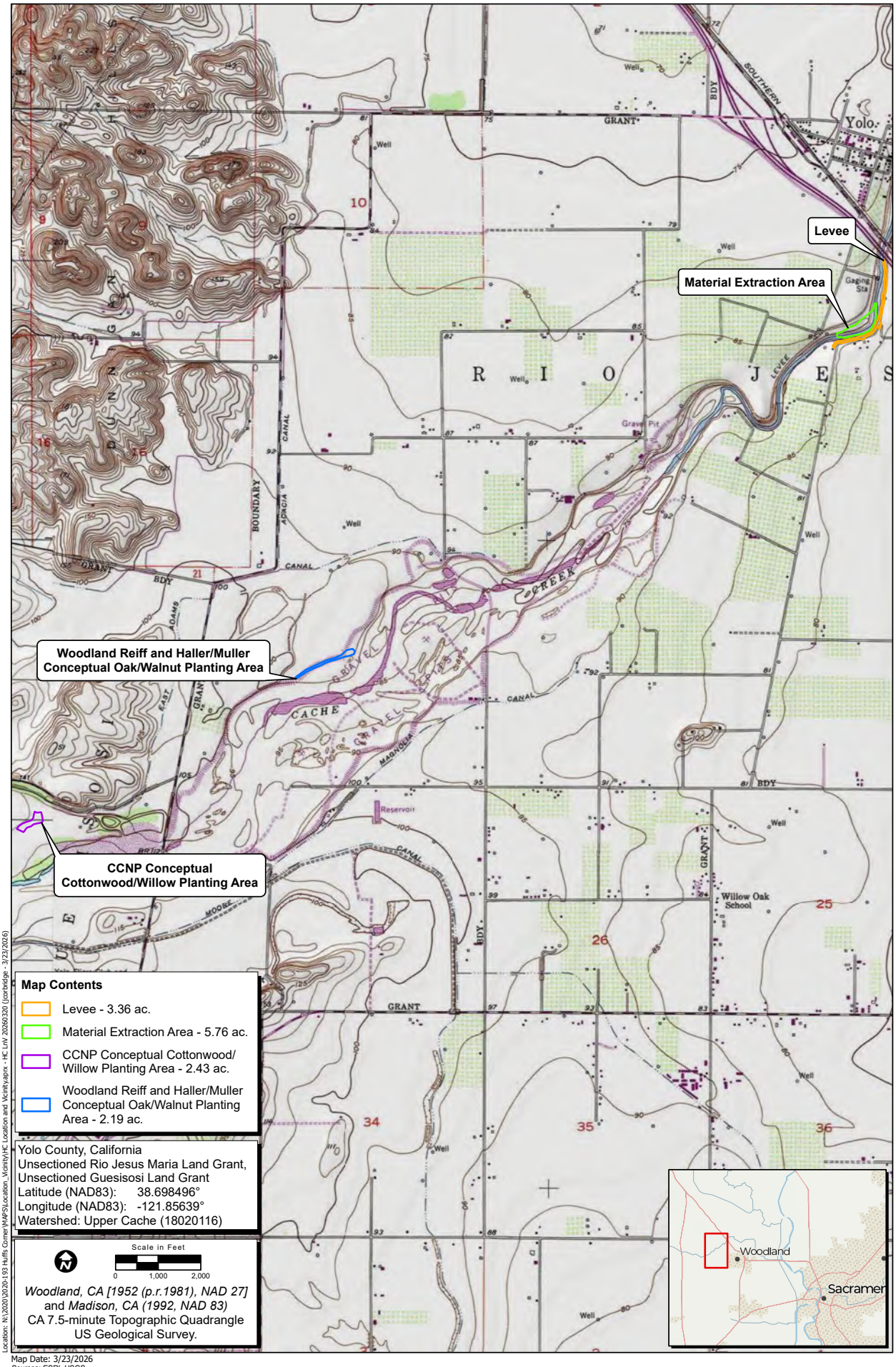
2.0 PROJECT INFORMATION

2.1 Project Location

The Huff's Corner Levee Raise and Channel Reconfiguration Project (Project) Area is located on Cache Creek in unincorporated Yolo County, north of the City of Woodland, Yolo County, California (Figure 1). The site corresponds to an unsectioned portion of the Rio Jesus Maria Landgrant of the "Woodland, California," 7.5-minute quadrangle (U.S. Geological Survey 1981). The approximate center of the Project Area is located at 38.721875° latitude and -121.808903° longitude within the Upper Cache Watershed (Hydrologic Unit Code [HUC] 18020116; Natural Resources Conservation Service [NRCS] et al. 2016).

2.2 Project Overview and Impacts

The Project consists of two distinct components. The first is the levee "raise," which is more accurately described as a rehabilitation action to return the levee to the original design height. The second component is the Cache Creek channel reconfiguration. Descriptions of each Project component are provided below. The Project will temporarily disturb/remove vegetation from 5.75 acres within the channel and riparian corridor of Cache Creek and will include the removal of 86 trees with diameters at breast height (DBH) over 4 inches.



Map Date: 3/23/2026
Sources: ESRI, USGS

ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

Figure 1. Project Location and Vicinity

2020-193 Huffs Corner

2.2.1 Channel Reconfiguration

The south bank of Cache Creek at Huff's Corner had approximately 100 linear feet of near-vertical bank, 30 to 50 feet high, which was undercut into the levee slope. The root cause of the erosion was identified as an abrupt, near 90-degree bend of Cache Creek at the site of the worst erosion. Significant point bar deposition occurred on the inside edge of the bend opposite the eroded scarp. A vegetated island also existed in the channel at this location which, along with the point bar, constrained the river flow and pushed it against the eroding scarp. The Project repaired this erosion site and reconfigured the channel to reduce future erosion.

The Project used a three-pronged approach to address these issues. First, sediment was removed and off-hauled from the north-side secondary channel. Second, some of the vegetation currently stabilizing the mid-channel island was removed. Finally, a sacrificial terrace was constructed along the south bank that will serve to reduce flow velocity against the bank and direct flow more towards the center of the channel. Additionally, boulders were imported and placed along the south bank.

Major construction activities for the erosion control/channel reconfiguration included excavation and export of sediment; removal and export of vegetation; installing deterrents for motorized vehicle access; and placement of boulders along the south bank.

This Riparian Restoration Plan (Plan) was created to address mitigation required for the riparian vegetation removed as part of the Project activities.

2.2.2 Levee Rehabilitation

The existing 2,700-foot-long reach of the levee at Huff's Corner has been identified as being freeboard deficient (i.e., below the design height). The Project will raise the entire reach approximately 4 to 6 feet to meet the 1957 design profile, which includes 3 feet of freeboard (levee that is not under water during a particular water level to which it is designed). County Road 18 is located on the levee crown over the western 1,100 feet of the proposed levee raise; the Project includes removal and replacement of the affected section of County Road 18.

To accommodate the required elevation, the land side base of the levee will be widened by approximately 12 to 15 feet. In addition, the portion of the levee that extends northward from the hairpin turn of County Road 18 to Interstate 5 will be completely graded down to level earth and a new levee will be built in the same location.

Major construction activities for the levee raise will include clearing, grubbing, and stripping of the widened levee footprint; degradation of the existing levee; construction of approximately 2,700 linear feet of reconfigured levee; restoration of the final levee embankment and staging/laydown areas; installation of erosion control vegetation on the embankment slopes and toe access corridors as appropriate;

replacement of County Road 18, including signage and road markings; and installation/replacement of gates, fences, and other similar features.

2.3 Regulatory Context

The purpose of this Plan is to satisfy Measure 3.4 of the Project's California Department of Fish and Wildlife (CDFW) Streambed Alteration Agreement (SAA; Notification No. EPIMS-YOL-3602-R2), which requires a Riparian Restoration Plan to be prepared.

Measure 3.2 of the Project's SAA requires the replacement of all native woody trees and shrubs with a DBH of 4 inches or more with the same species at a ratio of 3:1 or greater at the impact site or an offsite location. Trees impacted by Project activities are described in Appendix A and Table 1. The minimum planting requirements for each tree species removed are shown in Table 1.

Table 1. Tree Impacts and Mitigation Requirements

Tree Species	Number of Native Trees Removed	Minimum Number of Trees to be Planted (3:1)
Northern California black walnut (*Juglans hindsii*)	3	9
Fremont's cottonwood (*Populus fremontii*)	50	150
Valley oak (*Quercus lobata*)	12	36
Willow (*Salix* sp.)	21	63
Total Minimum Tree Plantings Required:	**86**	**258**

Per Measure 3.2, the restored area shall be monitored for a minimum of 5 years; success of all plantings shall be a minimum of 70-percent survival at the end of 5 years, including at least 2 years without supplemental irrigation. If restoration is not successful, replacement planting shall occur including additional watering, weeding, invasive exotic eradication, or any other practice to achieve said requirements. Replacement plants shall be monitored with the same survival and growth requirements for an additional 5 years post-planting.

3.0 EXISTING SITE CONDITIONS

Preconstruction conditions of the Project Area are described below. Impacts to riparian trees are described in Appendix A and the Project Area is shown on the figure in Appendix B.

3.1 Vegetation and Land Cover

The creek bed is largely unvegetated with a substrate of sand and gravel. A narrow band of riparian vegetation is found near the Ordinary High Water Mark (OHWM) of the creek and includes Fremont's cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), sandbar willow (*Salix exigua*), and Goodding's black willow (*Salix gooddingii*). The upland shelves above the OHWM are made up of scattered patches of herbaceous weedy grassland, riparian woodland/scrub, and barren (highly disturbed) areas. Herbaceous grassland portions of the Project are dominated by a variety of weedy grasses and forbs such as ripgut brome (*Bromus diandrus*), wild oats (*Avena fatua*), and rough cocklebur (*Xanthium strumarium*).

The levee portion of the Project includes developed roads, barren levee surfaces, and ruderal roadsides.

3.2 Aquatic Resources

An Aquatic Resources Delineation was conducted for the Project in October 2021 (ECORP Consulting, Inc. 2022) to identify potential Waters of the U.S./State and was subsequently verified by the U.S. Army Corps of Engineers. Cache Creek (intermittent creek) lies within the Project Area. The reach of Cache Creek within the Project is intermittent and typically dry during the dry season. The creek supports an OHWM and a defined bed and bank.

3.3 Soils and Topography

According to the Soil Survey Geographic database for Yolo County, California (NRCS 2023a), two soil units, or types, have been mapped within the Project (Figure 2):

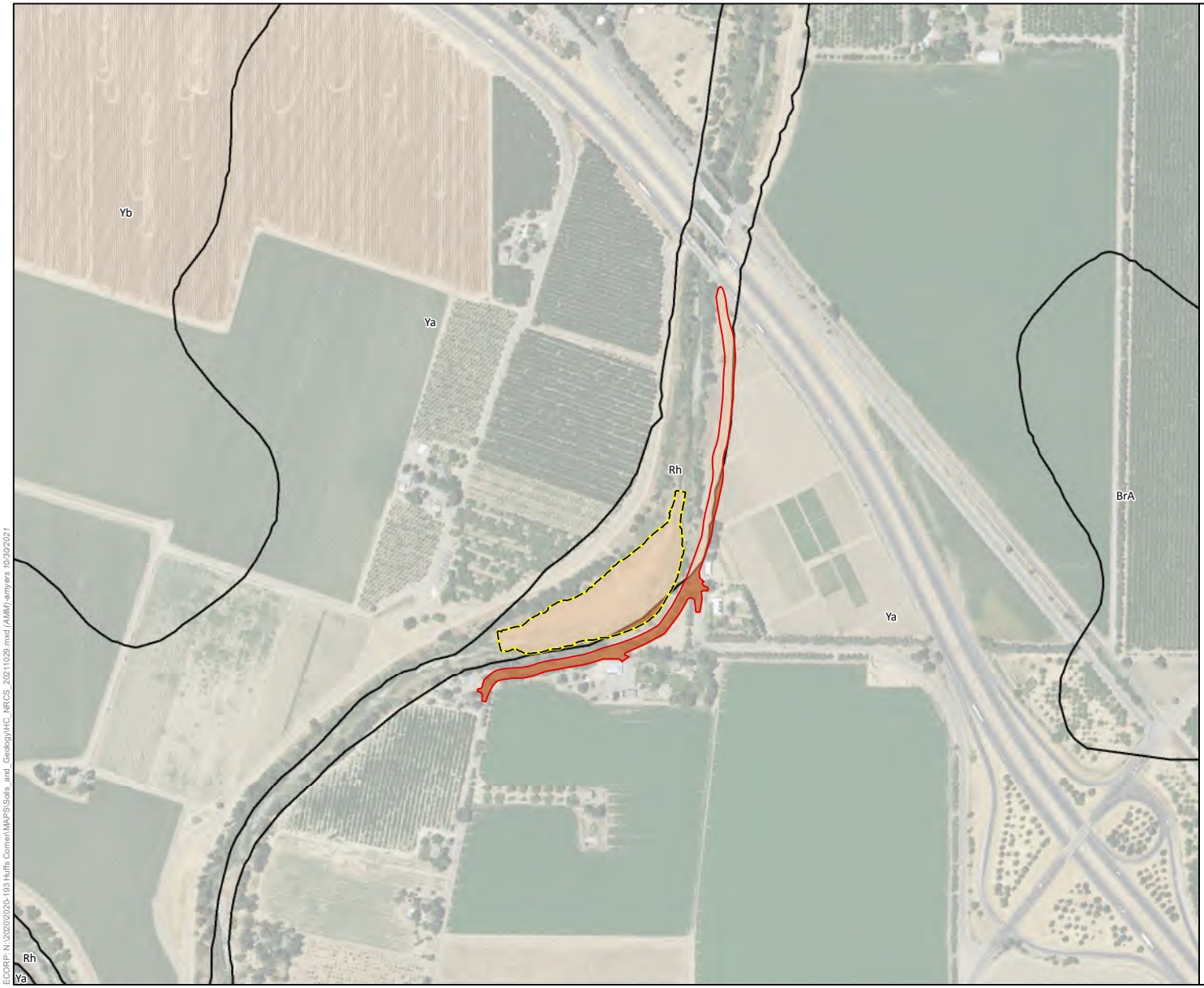
- Rh – Riverwash
- Ya – Yolo silt loam, 0 to 2 percent slopes, Major Land Resource Area 17

3.3.1 Riverwash

Riverwash (Rh) consists of excessively drained, sandy, gravelly, or stony stream and river deposits (NRCS 2023b). Riverwash (Rh) contains Riverwash hydric components in channels and streams (NRCS 2023c).

3.3.2 Yolo Series

The Yolo series consists of very deep, well-drained soils that formed in alluvium from mixed rocks. Yolo soils are on alluvial fans and flood plains (NRCS 2023b). Yolo silt loam (Ya) contains Sycamore hydric components in alluvial fans (NRCS 2023c).



Map Features

- Levee - 3.36 acres
- Material Extraction Area - 5.76 acres

Series Designation - Series Description

- Rh - Riverwash
- Ya - Yolo silt loam, 0 to 2 percent slopes, MLRA 17

Natural Resources Conservation Service (NRCS) Soil Survey Geographic (gSSURGO) Database for Yolo County, CA

Photo Source: NAIP 2020



ECORP N:\2020\2020-193 Huffs Corner\MAPS\Soils_and_Geology\HC_NRCS_20211028.mxd (AMM) amyers 10/30/2021

Map Date: 10/30/2021

ECORP Consulting, Inc.
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Scale in Feet
0 250 500

Figure 2. Natural Resources Conservation Service Soil Types

2024-181.01 Huff's Corner Levee Raise and Channel Reconfiguration Project

4.0 MITIGATION OF IMPACTS

As there is no suitable area for restoration of riparian vegetation onsite, riparian plantings will be conducted at two offsite locations owned in fee by the County. Oak and walnut plantings will be planted at the Woodland Reiff and Haller/Muller Restoration Site. Cottonwood and willow plantings will be planted within the Cache Creek Nature Preserve (CCNP). These two areas are jointly referred to as the Restoration Sites. Representative photographs of the Restoration Sites are provided as Appendix C.

4.1 Restoration Site Locations

The Woodland Reiff and Haller/Muller Restoration Site is located along Cache Creek south of the Muller Pit, approximately 2.8 miles upstream of the Project Area (Figure 1). The Haller/Muller In-Channel Restoration Site is located within the Upper Cache Watershed (HUC 18020116), the same watershed as the Project. The center of the Woodland Reiff and Haller/Muller Restoration Site is located at approximately 38.700258° latitude and -121.852358° longitude.

The CCNP Restoration Site is located within the CCNP along Cache Creek, approximately 4.3 miles upstream of the Project Area (Figure 1). The CCNP Restoration Site is located within the Upper Cache Watershed (HUC 18020116), the same watershed as the Project. The center of the CCNP Restoration Site is located at approximately 38.690451° latitude and -121.876607° longitude.

4.2 Existing Conditions at Restoration Site

4.2.1 Woodland Reiff and Haller/Muller Restoration Site

The Woodland Reiff and Haller/Muller Restoration Site is located adjacent to an existing riparian restoration test plot implemented by Triangle Properties (Triangle) in 2020. The site lies within a low area separated from Cache Creek by a berm. The site becomes inundated by flows from Cache Creek approximately one to two times per year (Barry Baba, personal communication 1.4.24). Existing vegetation consists primarily of herbaceous vegetation. If present within the site, riparian trees and shrubs will be avoided during implementation of mitigation (site preparation and planting) at the site. Work by Triangle during implementation of the test plot indicated that the soil consists of 4 to 5 feet of alluvial sediment overlaying gravel. Soil types within the site are shown in Figure 3. There is one soil type within the site: Rh – Riverwash.



Map Features

Woodland Reiff and Haller/Muller Conceptual Oak/Walnut Planting Area - 2.19 ac.

NRCS Soil Type

Rh - Riverwash

Sources: ESRI, NHD, USDA NRCS SSURGO (2019), Yolo County



Location: N:\2020\2020-193 Huffs Corner\MAPS\Soils_and_Geology\HC Soils and Geology.aprx - HC Offsite Mitigation Soils 20260320 (jcorbridge - 3/23/2026)

Map Date: 3/23/2026

ECORP Consulting, Inc.
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Scale in Feet
0 500

Figure 3. Offsite Mitigation Natural Resources Conservation Service Soil Types
2020-193 Huff's Corner Project

4.2.2 CCNP Restoration Site

The CCNP Restoration Site is located in an area of the CCNP that was previously prepared for willow plantings; however, past plantings did not survive due to severe drought conditions. Trenches were previously cut to allow irrigation of the willow planting area. Cottonwoods are planned to be planted along the lower portion of the western slope of the edge of the CCNP, which will benefit the CCNP by acting as a visual barrier to the adjacent farm. The site is currently dominated by Bermuda grass (*Cynodon dactylon*) with scattered willows (*Salix* spp.) and coyote brush (*Baccharis pilularis*). Adjacent wetlands are dominated by cattails (*Typha* spp.) and bulrushes (e.g., *Schoenoplectus* spp.). Existing native riparian vegetation will be avoided during planting of riparian vegetation per this Plan. Soil types within the site are shown in Figure 4. There is one soil type within the site, Ya - Yolo silt loam, 0 to 2 percent slopes.

4.3 Site Preparation

The construction contractor will determine exact site preparation methods. No earthmoving will be performed during site preparation. Existing non-native understory vegetation will be cleared using mowers and handheld equipment.

4.4 Restoration Plantings

Figures 5 and 6 show the conceptual planting areas. Willow and cottonwood plantings will be planted within the CCNP Restoration Site, and oak and walnut plantings will be planted in the Woodland Reiff and Haller/Muller Restoration Site. Final planting design will be provided to CDFW prior to implementation.

Plants are anticipated to be planted at a greater than 3:1 ratio to account for potential mortality. Planting numbers shown below are based on a 10 percent increase (contingency amount) relative to the required number of plantings shown in Table 1. Table 2 provides the number of each species to be planted, recommended spacing, and habitat requirements. All plantings will be obtained from locally sourced nursery stock. Exact planting type will be determined by availability of nursery stock at the time of planting.



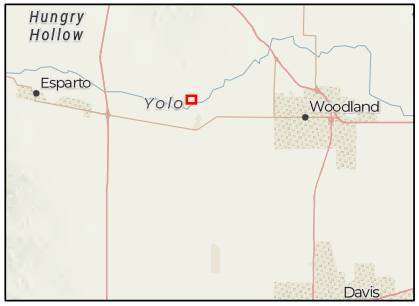
Map Features

CCNP Conceptual Cottonwood/Willow Planting Area - 2.43 ac.

NRCS Soil Type

Ya - Yolo silt loam, 0 to 2 percent slopes, MLRA 17

Sources: ESRI, NHD, USDA NRCS SSURGO (2019), Yolo County



Location: N:\2020\2020-193 Huffs Corner\MAPS\Soils_and_Geology\HC Soils and Geology.aprx - HC CCNP Offsite Mitigation Soils 20241112 (welsh - 11/12/2024)

Map Date: 11/12/2024

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Scale in Feet
0 100 200

Figure 4. Cache Creek Nature Preserve Conceptual Offsite Mitigation
Natural Resources Conservation Service Soil Types
2024-181.01 Huff's Corner Levee Raise and Channel Reconfiguration Project



Map Features

Woodland Reiff and Haller/Muller Conceptual Oak/Walnut Planting Area - 2.19 ac.

Sources: ESRI, NHD, Yolo County



Location: N:\2020\2020-193 Huffs Corner\MAPS\Mitigation\Huffs Corner Mitigation.aprx - HC Mitigation Planting Area 20260320 (jcorbridge - 3/23/2026)

Map Date: 3/20/2026

ECORP Consulting, Inc.
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Scale in Feet
0 500

Figure 5. Woodland Reiff and Haller/Muller Conceptual Mitigation Planting Area

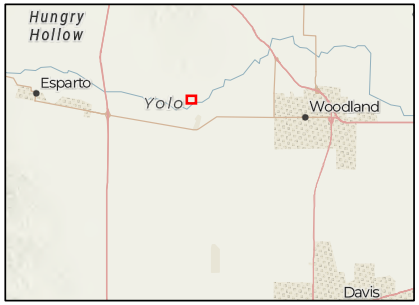
2020-193 Huff's Corner Project



Map Features

- Conceptual Cottonwood Planting Area - 1.64 ac.
- Conceptual Willow Planting Area - 0.79 ac.

Sources: ESRI, NHD, Yolo County



Location: N:\2020\2020-193 Huffs Corner\MAPS\Mitigation\Huffs Corner Mitigation.aprx - HC CCNP Offsite Mitigation Planting Area 20241111 (jwelsh - 11/12/2024)

Map Date: 11/12/2024

ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

Scale in Feet
0 100 200

Figure 6. Cache Creek Nature Preserve Conceptual Offsite Mitigation Planting Area
2024-181.01 Huff's Corner Levee Raise and Channel Reconfiguration Project

Table 2. Riparian Restoration Plantings				
Common Name	**Scientific Name**	**Number of Plantings with 10 Percent Contingency**	**Approximate Spacing (feet)**	**Habitat Requirements**
Fremont Cottonwood	*Populus fremontii*	165	4-6	High Moisture Level
Willow	*Salix* sp.	69	4-6	High Moisture Level
Valley Oak	*Quercus lobata*	40	10-12	Low Moisture Level
Black Walnut	*Juglans hindsii*	10	8-10	Moderate Moisture Level
Total Number of Plantings		**284**		

4.4.1 Planting Protection

Plantings will be protected using browse protection cages.

4.4.2 Irrigation

Flood and/or drip irrigation will be provided to the plantings for the first 3 years of growth as needed based on precipitation. During the first year, irrigation will be provided on a weekly basis during dry periods. During the second year, irrigation will be provided every 2 weeks during dry periods. During the third year, irrigation will be provided once per month during dry periods. It is anticipated that irrigation will be discontinued after the third dry season post-restoration.

4.5 Restoration Schedule

Table 3 provides a proposed restoration schedule.

Table 3. Restoration Schedule	
Year 0 (2026):	• Site preparation conducted Summer/Fall 2026
Year 1 (2027)	• Plantings are anticipated to occur during fall or winter of 2026 • Irrigation will be applied upon planting, and once per week during dry periods
Year 2 (2028):	• Maintenance of the restoration areas as needed • Irrigation will be applied once every two weeks during dry periods • Annual performance standard monitoring of restoration areas will be conducted in late spring or early summer • Annual report will be submitted to CDFW by January 31

Table 3. Restoration Schedule	
Year 3 (2029):	• Maintenance of the restoration areas as needed • Irrigation will be applied once per month during dry periods • Annual performance standard monitoring of restoration areas will be conducted in late spring or early summer • Annual report will be submitted to CDFW by January 31
Year 4 (2030):	• Maintenance of the restoration areas as needed • No irrigation is anticipated • Annual performance standard monitoring of restoration areas will be conducted in late spring or early summer • Annual report will be submitted to CDFW by January 31
Year 5 (2031):	• Maintenance of the restoration areas as needed • No irrigation is anticipated • Final performance standard monitoring of restoration areas will be conducted in late spring or early summer • Final annual report will be submitted to CDFW by January 31

Notes: CDFW = California Department of Fish and Wildlife

5.0 MONITORING OF RESTORATION PLANTINGS

5.1 Monitoring Schedule

Performance standard monitoring of the plantings will be completed for a minimum of 5 years following planting or until CDFW determines the mitigation requirements have been fulfilled. Monitoring methods described in Section 5.2 will be implemented for each monitoring year (Years 1 through 5) during summer (June/July). Quantitative monitoring of plantings will occur once per year.

In Years 1 through 4, interim performance standards will be used to assess the plantings to determine if plantings are on track to meeting final performance standards or if remedial measures are needed, and to address any potential issues early on. Final performance standards will be applied beginning in Year 5 to determine whether plantings have met the requirements of the SAA.

5.2 Monitoring Methods

5.2.1 Plantings

After installation and during the first monitoring year, each planting will be given a unique identifier and the location of each planting will be collected via a Global Positioning System unit. Any deviations from the Plan will be noted. In subsequent monitoring years, each planting will be assessed to determine overall success of plantings.

Condition of plantings will be evaluated annually in the summer. Plant condition will be ranked according to the following scale:

- Good – healthy foliage and vigorous growth;
- Fair – healthy foliage, but minimal apical growth;
- Poor – few green leaves present and no apparent apical growth; or
- Dead (including those unable to be located and assumed dead).

The percentage of plantings that are alive and dead will be calculated for each species planted. Of the living plants, the proportion of plantings that are in good, fair, or poor condition will be calculated.

5.2.2 Invasive Species

Invasive plants known to be problematic in Cache Creek riparian areas that are a priority for eradication include edible fig (*Ficus carica*), smallflower tamarisk (*Tamarix parviflora*), tree of heaven (*Ailanthus altissima*), tree tobacco (*Nicotiana glauca*), giant reed (*Arundo donax*), barbed goatgrass (*Aegilops triuncialis*), wild teasel (*Dipsacus fullonum*), fennel (*Foeniculum vulgare*), Himalayan blackberry (*Rubus armeniacus*), medusahead (*Elymus caput-medusae*), perennial pepperweed (*Lepidium latifolium*), poison hemlock (*Conium maculatum*), purple loosestrife (*Lythrum salicaria*), stinkwort (*Dittrichia graveolens*), Italian thistle (*Carduus pycnocephalus*), milk thistle (*Silybum marianum*), yellowflag iris (*Iris pseudacorus*), and yellow star-thistle (*Centaurea solstitialis*) (Yolo County 2019).

The California Invasive Plant Inventory (CIPI; https://www.cal-ipc.org/plants/inventory/), maintained by the California Invasive Plant Council (Cal-IPC 2023), rates invasive species according to their impacts on habitat and physical processes. During planting effort, baseline levels of invasive riparian species listed as *High*, *Moderate,* or *Watch* on the CIPI will be assessed. During each monitoring year, any discrete patches of these species will be mapped to prioritize weed removal efforts, and approximate percent cover of diffusely distributed species will be noted. Any other invasive species noted to be affecting success of the plantings should also be noted and prioritized for removal.

Levels of *High*, *Moderate,* or *Watch* rated invasive species within the Restoration Sites will be compared to baseline levels on an annual basis, and invasives within the Restoration Sites will be managed to ensure new or expanded populations are managed to baseline levels.

5.2.3 Qualitative Monitoring

A qualitative assessment will be conducted by walking meandering paths through the Restoration Sites and recording observations on the general condition, concurrent with monitoring tasks described in Sections 5.2.1 and 5.2.2.

Qualitative assessments will note the following:

- Areas where planted species are failing to establish and the cause of failure to establish, if apparent.
- Condition of irrigation system and frequency of watering.
- Any problematic nonnative invasive plants (Section 5.2.2).
- Signs of damage due to animals (e.g., beaver, rodent, deer herbivory).
- Adequacy of fencing and signage and signs of human intrusion/disturbance.
- Presence of trash or vandalism.
- Other potential threats to restoration plantings (e.g., disease, drought conditions, erosion, excessive flooding).
- Wildlife observed onsite including wildlife signs such as scat, pellets, or bones.

Qualitative monitoring will be used to inform maintenance activities, and adaptive management measures should they need to be implemented.

5.2.4 Photo Documentation

Photo points within the Restoration Sites will be established during the first monitoring year and photographs of the restoration areas will be taken on an annual basis during qualitative monitoring to document site conditions. The compass angle and position of all photographs will be recorded.

5.3 Interim Performance Standards

The goal of interim performance standards is to assess the condition of plantings and general restoration areas, to assess whether plantings are on track to meet final performance standards, to identify any issues causing poor plant health/mortality, and to identify potential adaptive management measures to address those issues. Interim performance standards are not intended to be used in order to determine if mitigation obligations have been met; final performance standards are used for that purpose.

Interim performance standards are described in Table 4 (monitoring methods are described in Section 5.2). If interim performance standards are not met for any given year, adaptive management methods may be implemented as described in Section 8.3.

Table 4. Interim Performance Standards	
Plantings	1. Each species planted will have an 80-percent or higher survival rate relative to the required plantings (i.e., 206 plantings out of 258 required plantings) will have survived at the end of the monitoring period. Mortality of plantings in excess of the 258 required plantings (e.g., contingency plantings) will be excluded from the survival rate. New volunteer native riparian species may also be included in calculations. 2. 70 percent or more of the living woody container plantings will have a ranking of Good or Fair condition within each planting type.
Invasive species	1. Acreage (for discrete populations) and cover (for diffuse populations) of invasive species rated as *High* or *Moderate* by CIPI will be equal to or lower than baseline levels.

Notes: CIPI = California Invasive Plant Inventory

5.4 Final Performance Standards

The goal of final performance standards is to determine if the mitigation requirements per the SAA have been met. Final performance standards are described in Table 5.

Table 5. Final Performance Standards	
Plantings	70 percent or more of the required plantings (i.e., 180 plantings out of 258 required plantings) will have survived at the end of the monitoring period. Mortality of plantings in excess of the 258 required plantings (e.g., contingency plantings) will be excluded from the survival rate. New volunteer native riparian species may also be included in calculations.
Invasive species	Acreage of discrete populations of invasive species rated as *High* or *Moderate* by CIPI will be equal to or lower than baseline levels.

Notes: CIPI = California Invasive Plant Inventory

6.0 MAINTENANCE DURING THE MONITORING PERIOD

6.1 Maintenance Activities

Qualitative assessments described in Section 5.2.3 will help identify maintenance activities that may be needed during the 5-year monitoring period and ensure that they are completed in a timely manner. Regular maintenance activities will include the following:

- Maintenance, repair, and replacement of the irrigation system as needed to ensure proper functioning;
- Maintenance, repair, and replacement of plant protection materials (e.g., cages/fences) to prevent damage due to wildlife;
- Removal of any trash accumulated; and

- Implementation of signage and public outreach as needed to prevent human intrusion into the restoration areas while plants are establishing (note that long-term signage and outreach is not a requirement of this Plan).

6.2 Management of Invasive Species

Invasive species management is recommended to occur on a regular basis to prevent establishment and spread of invasive plants within the Restoration Sites. The top priority will be to manage invasive species ranked as *High, Moderate,* or *Watch* by the CIPI to levels lower than adjacent reference areas.

Management guides for the main species of concern within the site are provided as Appendix D. Additional guidance is available online at Cal-IPC (www.cal-ipc.org) and the University of California Weed Research and Information Center website (https://wric.ucdavis.edu). Implementation of weed control should be limited to hand removal, mowing, or cutting, and use of herbicides as necessary. Targeted herbicide application methods should be used if herbicides are required. Plantings and native vegetation must be protected by a spray shield or similar devices to avoid plant damages caused by spray drift.

6.3 Adaptive Management

Adaptive management methods will be implemented if interim performance standards are not met for a given year. Adaptive management is an approach to natural resource management in which changes to management practices are informed by observations on the ground in a continuous cycle. Adaptive management may be applied to activities necessary to address shortfalls in meeting established performance standards, effects of unanticipated disturbances, and/or larger scale trends and events such as climate change, fire, flood, or other natural events (i.e., force majeure). Adaptive management methods will be determined in consultation with CDFW.

The steps taken to implement adaptive management for restoration projects are generally as follows:

1. Plan restoration action;
2. Implement restoration action;
3. Conduct monitoring of restoration action;
4. Evaluate outcome of restoration action; and
5. Incorporate new knowledge obtained into plans for next steps, and return to #1.

Examples of adaptive management responses to typical restoration issues are provided in Table 6.

Table 6. Example Adaptive Management Responses to Potential Issues	
Issue	**Potential Adaptive Management Response**
Damage to plantings	Identify cause of damage and target plant protection toward cause of damage (i.e., herbivory by deer, small mammals, or beaver damage would be treated differently).
Failure/poor health of certain species	Failure of certain species or in certain areas may be due to easily remedied issues (e.g., broken irrigation equipment), or complex soil or hydrological conditions that are difficult to remedy. Identify the potential causes of failure if possible. If cause cannot be remedied, replace failed plantings with other native species that are performing well in those areas.
Competition between plantings and other species	If plantings are being outcompeted by invasive plant species, implement invasive plant control methods. However, if plantings are being outcompeted by locally native plants (volunteers), preference should be given to allowing the volunteers to survive, and volunteers may be counted toward performance standards.
Disturbance due to unauthorized public access	Additional signage, fencing, and public outreach may be needed to make the public aware of the restoration. Pedestrian trails may need to be removed to stop continuing unauthorized access. Additional plantings of native blackberries or poison oak (*Toxicodendron* sp.) also discourage public access to sensitive areas.

7.0 REPORTING

7.1 Annual Reports

Monitoring reports will be submitted to CDFW by January 31 following each monitoring year (a minimum of 5 years). The report will present an assessment of the interim performance standards in Years 1 through 4. The report will include an analysis of the final performance standards in Year 5. Each report will discuss the cause(s) of failure to meet any unmet performance standards and will describe any adaptive management measures taken or planned. The report will also include photographs from designated photo points, a summary of invasive species control activities if needed, methods used to remove nonnative plants, and a list of wildlife observed onsite.

8.0 CONTINGENCY

8.1 Initiating Procedures

Each annual report will include an analysis of the cause(s) of failure to meet any unmet performance standards and discuss any adaptive management measures taken or planned. If the restored areas have not met the final performance standards in Year 5, the Applicant's maintenance and monitoring obligations will continue until CDFW provides final confirmation that mitigation obligations have been met.

8.2 Mitigation Contingency

If the early results of monitoring indicate that the restoration areas are not on track to meet performance criteria, remedial actions will be taken based on the analysis of cause(s) of failure and monitoring will

continue until the CDFW gives final confirmation. Section 6.3 provides more information on adaptive management methods.

Alternatively, and at the discretion of CDFW, the Applicant may propose purchase mitigation credits at a CDFW-approved mitigation bank if the restoration is not successful. Should that be the case, the final mitigation report shall identify any success criteria shortfall and propose the type and quantity of mitigation credits to be purchased to close out the Project.

9.0 COMPLETION OF MITIGATION

9.1 Notification of Completion

The Applicant will notify CDFW when submitting the final annual report when the monitoring period is complete and the Applicant believes that the final performance standards have been met. CDFW may require a site visit following receipt of the final annual report to confirm the completion of the mitigation requirements. Monitoring will cease if the restored areas are found by CDFW to be in compliance with established final performance standards. Monitoring will be extended beyond the 5-year period only for those restoration areas that are not meeting the final performance standards.

10.0 FUNDING SOURCE

Restoration work is anticipated to be funded through a Project Partnership Agreement between the California Department of Water Resources and Yolo County (Agreement No. 4600015709) under the State's Flood System Repair Program. Local match will be provided by Yolo County through funds procured from the Gravel Mining Fee Ordinance for implementation of the Cache Creek Resource Management Plan (Yolo County 2019).

11.0 LONG-TERM MANAGEMENT

Long-term management of the area will be the responsibility of the Applicant (Yolo County), who is the landowner of both Restoration Sites.

12.0 REFERENCES

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APPENDIX A

Tree Impact Data

Common Name	Scientific Name	DBH (inches)	Individual Stem Sizes (if multi-stemmed)
Northern California black walnut	*Juglans hindsii*	13	10,3
Northern California black walnut	*Juglans hindsii*	15.5	7,8.5
Northern California black walnut	*Juglans hindsii*	10	–
Fremont's cottonwood	*Populus fremontii*	40.6	21.1,19.5
Fremont's cottonwood	*Populus fremontii*	26.8	21.3,5.5
Fremont's cottonwood	*Populus fremontii*	17.3	15.1,2.2
Fremont's cottonwood	*Populus fremontii*	18	–
Fremont's cottonwood	*Populus fremontii*	20	–
Fremont's cottonwood	*Populus fremontii*	6	–
Fremont's cottonwood	*Populus fremontii*	6	–
Fremont's cottonwood	*Populus fremontii*	4.8	–
Fremont's cottonwood	*Populus fremontii*	8	–
Fremont's cottonwood	*Populus fremontii*	6	–
Fremont's cottonwood	*Populus fremontii*	12	–
Fremont's cottonwood	*Populus fremontii*	10	–
Fremont's cottonwood	*Populus fremontii*	15	–
Fremont's cottonwood	*Populus fremontii*	12	–
Fremont's cottonwood	*Populus fremontii*	12	–
Fremont's cottonwood	*Populus fremontii*	4.5	–
Fremont's cottonwood	*Populus fremontii*	4.2	–
Fremont's cottonwood	*Populus fremontii*	4.4	–
Fremont's cottonwood	*Populus fremontii*	5	–
Fremont's cottonwood	*Populus fremontii*	6.2	4.6,1.6
Fremont's cottonwood	*Populus fremontii*	5.7	–
Fremont's cottonwood	*Populus fremontii*	4.1	–
Fremont's cottonwood	*Populus fremontii*	4.4	–
Fremont's cottonwood	*Populus fremontii*	4.3	–
Fremont's cottonwood	*Populus fremontii*	7.1	2.4,4.7
Fremont's cottonwood	*Populus fremontii*	6	–
Fremont's cottonwood	*Populus fremontii*	22.5	10.5,12
Fremont's cottonwood	*Populus fremontii*	8	–
Fremont's cottonwood	*Populus fremontii*	9	–
Fremont's cottonwood	*Populus fremontii*	8	–

Common Name	Scientific Name	DBH (inches)	Individual Stem Sizes (if multi-stemmed)
Fremont's cottonwood	*Populus fremontii*	14	7,7
Fremont's cottonwood	*Populus fremontii*	29	–
Fremont's cottonwood	*Populus fremontii*	4	–
Fremont's cottonwood	*Populus fremontii*	38.6	20,18.6
Fremont's cottonwood	*Populus fremontii*	19.8	–
Fremont's cottonwood	*Populus fremontii*	9.1	3.2,1.8,1.7,1.4,1
Fremont's cottonwood	*Populus fremontii*	23.4	–
Fremont's cottonwood	*Populus fremontii*	4.4	2.4,2
Fremont's cottonwood	*Populus fremontii*	4	–
Fremont's cottonwood	*Populus fremontii*	5.9	–
Fremont's cottonwood	*Populus fremontii*	6.8	–
Fremont's cottonwood	*Populus fremontii*	5	–
Fremont's cottonwood	*Populus fremontii*	6.2	–
Fremont's cottonwood	*Populus fremontii*	6.2	3.9,2.3
Fremont's cottonwood	*Populus fremontii*	5	–
Fremont's cottonwood	*Populus fremontii*	5	2.4,2.6
Fremont's cottonwood	*Populus fremontii*	9.6	2.6,2.9,4.1
Fremont's cottonwood	*Populus fremontii*	30.0	–
Fremont's cottonwood	*Populus fremontii*	30.0	–
Fremont's cottonwood	*Populus fremontii*	30.0	–
Valley oak	*Quercus lobata*	5.5	–
Valley oak	*Quercus lobata*	4	–
Valley oak	*Quercus lobata*	4.4	–
Valley oak	*Quercus lobata*	4.6	–
Valley oak	*Quercus lobata*	15.0	–
Valley oak	*Quercus lobata*	20.0	–
Valley oak	*Quercus lobata*	30.0	–
Valley oak	*Quercus lobata*	30.0	–
Valley oak	*Quercus lobata*	35.0	–
Valley oak	*Quercus lobata*	25.0	–
Valley oak	*Quercus lobata*	28.0	–
Valley oak	*Quercus lobata*	26.0	–
Willow	*Salix* sp.	7	1,1,1,2,1,1

Common Name	Scientific Name	DBH (inches)	Individual Stem Sizes (if multi-stemmed)
Willow	*Salix* sp.	6	1,1,2,1,1
Willow	*Salix* sp.	4	2,2
Willow	*Salix* sp.	6.5	1,1,1,1,2.5
Willow	*Salix* sp.	4	2,2
Willow	*Salix* sp.	7	4,3
Willow	*Salix* sp.	7	3,4
Willow	*Salix* sp.	5	–
Willow	*Salix* sp.	4	–
Willow	*Salix* sp.	4	–
Willow	*Salix* sp.	7	–
Willow	*Salix* sp.	5.3	–
Willow	*Salix* sp.	4.1	–
Willow	*Salix* sp.	10.9	–
Willow	*Salix* sp.	4	–
Willow	*Salix* sp.	11.1	4.9,6.2
Willow	*Salix* sp.	11	–
Willow	*Salix* sp.	6.7	–
Willow	*Salix* sp.	5	–
Willow	*Salix* sp.	5	–
Willow	*Salix* sp.	5	–

APPENDIX B

Project Area

Exhibit B: Project Areas

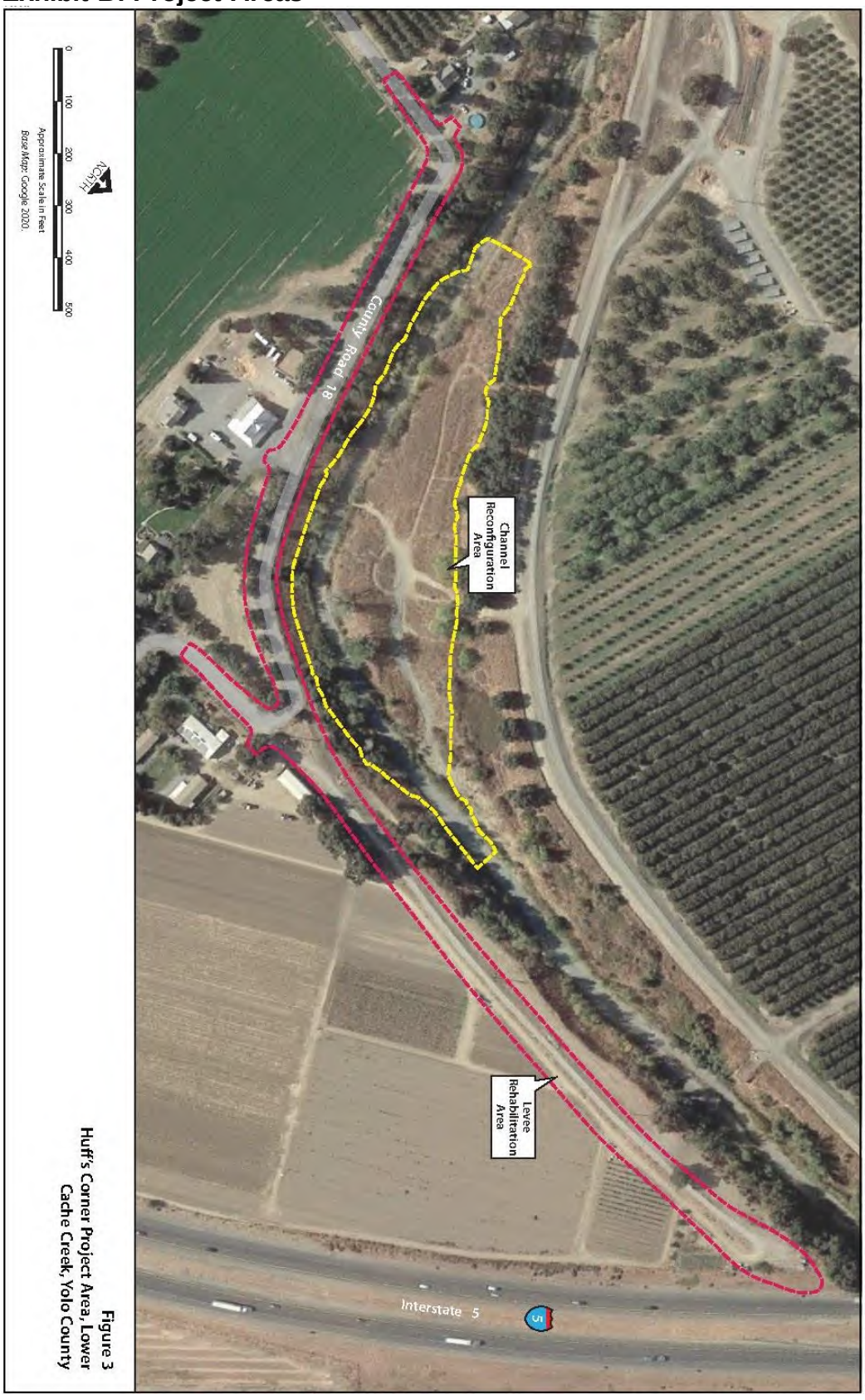


Figure 3
Huff's Corner Project Area, Lower Cache Creek, Yolo County

APPENDIX C

Representative Photographs of the Mitigation Site



View of the CCNP Restoration Area, facing southwest. Photo taken November 11, 2024.



View of the CCNP Restoration Area, facing southeast. Photo taken November 11, 2024.



View of the Woodland Reiff and Haller/Muller Restoration Site, facing east from bridge. Photo taken March 11, 2026.



View of the Woodland Reiff and Haller/Muller Restoration Site, facing west toward bridge. Photo taken March 11, 2026.

APPENDIX D

Invasive Species Management Guides

This WEED REPORT does not constitute a formal recommendation. When using herbicides always read the label, and when in doubt consult your farm advisor or county agent.

This WEED REPORT is an excerpt from the book *Weed Control in Natural Areas in the Western United States* **and is available wholesale through the UC Weed Research & Information Center (wric.ucdavis.edu) or retail through the Western Society of Weed Science (wsweedscience.org) or the California Invasive Species Council (cal-ipc.org).**

Aegilops cylindrica Host.; jointed goatgrass
Aegilops triuncialis L.; barb goatgrass

Jointed goatgrass and barb goatgrass


Aegilops triuncialis

Family: Poaceae
Range: Jointed goatgrass is found in all western states. Barb goatgrass is found only in California and Oregon, primarily in northern California, especially the Central Valley foothills northward to southern Oregon. Both are expanding their distribution.
Habitat: Disturbed and undisturbed grasslands, oak woodlands, fields, rangelands, pastures, and roadsides. Barb goatgrass tolerates serpentine and hard, shallow, dry, gravelly soils but usually is not found in chaparral. Jointed goatgrass also infests grain fields, especially winter wheat.
Origin: Both species are native to Mediterranean Europe and western Asia.
Impacts: Plants have high silica content, resulting in a persistent thatch that can suppress other species. Barb goatgrass is late-maturing and drought-tolerant, enabling it to occupy and form monocultures in marginal environments. Tough seedheads with long barbed awns are inconvenient for humans and can injure livestock, even fatally. Jointed goatgrass joints are difficult to separate from wheat grains, and contaminated wheat harvests are reduced in quality and value.
Western states listed as Noxious Weed: *A. cylindrica*, Arizona, California, Colorado, Idaho, New Mexico, Oregon, Washington; *A. triuncialis*, California, Oregon
California Invasive Plant Council (Cal-IPC) Inventory: *A. triuncialis*, High Invasiveness

Jointed goatgrass and barb goatgrass are late-maturing winter annual grasses with spikes that resemble those of winter wheat. Both species can hybridize with wheat. Unlike wheat, goatgrass spikes break apart into hardened sections called joints.

Goatgrass plants grow up to 20 inches tall. Jointed goatgrass foliage looks similar to winter wheat, but blades, auricles, ligules, and leaf sheaths have evenly spaced, fine hairs along the margins. Barb goatgrass has gray-green foliage, spreading to erect, usually sparsely covered with fine hairs.

Goatgrass seedheads have spikelets arranged alternately along a zigzag rachis. The spikelets are large, hard, and cylindrical to cone-shaped, with long awns. Barb goatgrass, in particular, has stiff, barbed awns; mature seedheads break off whole and can work their way into fur or clothing. The goatgrasses go to seed later than most annual grasses, usually in late spring to early summer. Jointed goatgrass seedheads are 1 to 5 inches long, and barb goatgrass seedheads are 1 to 2.5 inches long. At maturity, heads turn reddish to purple and then dry to a straw color. Eventually the seedheads break apart into joints (spikelets attached to a piece of rachis). Once on the ground, the joints often can survive field burns because of their hard coat. The spikes and joints disperse by attaching to animals, humans, equipment or vehicles.

Seeds germinate in fall and winter, sometimes while still attached to the joints. In fact, joints often remain attached to the lower shoot of dug-up seedlings. Barb goatgrass seeds can remain viable for 2 years or more on the soil, while jointed goatgrass seeds can remain viable for 3 to 5 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling or hoeing small infestations is effective, if the roots are pulled and air-dried. Mowing can reduce seed production, but timing is critical. Mowing should occur after flowering, but before goatgrass seeds reach the soft boot stage. Early mowing will result in new tiller growth, and late mowing will only spread viable seed. Tillage may be used in certain situations. In agricultural fields, sweep tillage or V-blade tillage may be used during fallow periods. Conventional deep plowing will bury goatgrass seed beyond emergence depth. However, buried seed may be viable for up to 5 years, and secondary tillage may bring goatgrass seed back up to a successful

	emergence depth (< 5 in).
Cultural	Heavy grazing throughout the growing season and high intensity/short duration grazing periodically during the growing season appear to increase plant density. Both species mature later than most rangeland annual grasses, providing a window for controlling goatgrass seed production. It is important to burn before the joints disarticulate, to ensure seed kill. Burning will not effectively control seed on the soil surface. Goatgrass germination may increase the year after burning due to increased fertility and light penetration. Therefore, a second year management strategy must be incorporated, and the population should be monitored for several years. In rangeland, burning the first year followed by herbicide and spring seeding the second year may improve barb goatgrass control. For jointed goatgrass in winter wheat, burning fields after harvest can reduce germination of joints at the surface by 90% or more.
Biological	Naturally occurring bacterial strains that infect annual brome and jointed goatgrass, but have no effect on wheat, have been isolated in Kansas and Washington. These bacteria may soon be used in a bio-herbicidal approach for jointed goatgrass control in winter wheat. However, their utility in rangelands has not been explored.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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*, and others	**Rate:** 1 qt product (*Roundup ProMax*)/acre for young plants < 6" tall (1.1 lb a.e./acre); 1.5 to 4 qt product (*Roundup ProMax*)/acre (1.7 to 4.5 lb a.e./acre) for larger plants or plants under stress. **Timing:** Postemergence in late winter to early spring. Apply to rapidly growing, non-stressed plants before flowering. If possible, apply before desirable perennials have emerged. According to label recommendations, seedling goatgrass can be selectively suppressed in pasture with 5 to 11 oz *Roundup ProMax* (or other trade name)/acre. **Remarks:** Glyphosate has no soil activity and is nonselective, so may kill desirable competitors. Its effectiveness is increased by addition of ammonium sulfate.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapic *Plateau*	**Rate:** 4 to 6 oz product/acre (1 to 1.5 oz a.e./acre) **Timing:** Preemergence in fall or postemergence in early spring. **Remarks:** Mixed selectivity, tending to favor Asteraceae and some grasses. Safe for most native grasses, but higher rates may suppress seed of some cool-season grasses. Use lower rates for dry climates and low leaf litter and higher rates as moisture increases and/or leaf litter increases. Use methylated seed oil surfactant. Imazapic has long soil residual activity. Imazapic is not registered for use in California.
Propoxycarbazone-sodium *Canter R+P*	**Rate:** 1.2 oz product/acre (0.84 oz a.i./acre) **Timing:** Postemergence from the 2-leaf to 2-tiller stage when plants are growing rapidly. **Remarks:** Propoxycarbazone is a broad-spectrum herbicide that will control many species. It will provide only partial control of jointed goatgrass and perhaps barb goatgrass. Perennial grass species vary in tolerance. A non-ionic surfactant should be added at 0.25 to 0.5% v/v solution.
Sulfometuron *Oust* and others	**Rate:** 1.33 to 2 oz product/acre (1 to 1.5 oz a.i./acre) **Timing:** Preemergence or early postemergence in fall or in late winter after emergence but before goatgrass is 3 inches tall. **Remarks:** Sulfometuron has mixed selectivity. It is fairly safe on native perennial grasses, especially wheatgrass. Other desirable grasses may be stunted, stressed, or injured. Good for revegetation use. Should be used with a surfactant for early postemergence treatments. Sulfometuron has fairly long soil residual activity. Do not let spray drift onto sensitive crops. May move long distances in dry light windblown soils.
Sulfometuron + chlorsulfuron *Landmark XP*	**Rate:** 1.5 oz product/acre **Timing:** Preemergence, in fall or after soil thaws in spring. **Remarks:** See sulfometuron.

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.

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Ailanthus altissima (Mill.) Swingle

Tree-of-heaven



Family: Simaroubaceae
Range: Throughout the United States except Montana, North Dakota, South Dakota, and Wyoming.
Habitat: Disturbed places, roadsides, urban waste areas, landscaped sites, and many natural communities, including riparian areas, grassland, and woodland. Tolerates shade, many types of pollution, and harsh soil conditions, including acidic soils of mine spoils and phosphorus-poor soils. It can grow in most environments, including pavement cracks.
Origin: Native to China and introduced to North America as a landscape ornamental, as a food plant for a certain type of silkworm, and as a culturally important medicinal plant of Chinese immigrants.
Impacts: Forms dense thickets that compete with native vegetation and reduce wildlife habitat, particularly in riparian areas. Often considered a tree-fall hazard around homes and buildings, and the roots can damage pavement, roads, and foundations. May have allelopathic properties that inhibit the germination of other plants. Although not considered toxic, handling tree-of-heaven foliage can cause contact dermatitis in sensitive individuals, and the pollen is a common allergen.
Western states listed as Noxious Weed: California
California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness

Tree-of-heaven is a fast-growing deciduous tree to nearly 70 ft tall, with large, pinnate-compound leaves. The leaves have an unpleasant skunky odor, especially when crushed. The tree produces a long, deep taproot with many creeping roots that sucker freely. Creeping roots may extend to about 50 ft in all directions.

Trees are dioecious (male or female), with females producing a winged fruit called a samara. Fruits mature in late summer and disperse from fall through the following spring with wind, water, and possibly birds. Most seeds probably fall close to the parent plant. Female trees typically begin to produce fruits at several years of age. One tree can produce 325,000 seeds or more annually, a large proportion of which are viable. Seeds generally survive about 1 year under field conditions and usually do not develop a persistent seed bank. Seedlings typically do not survive in shaded understory conditions. In addition to seed, plants reproduce vegetatively from creeping roots. Root sprouts tolerate shade better than seedlings, and new trees more often develop from the roots of established trees. New shoots can sprout up to 50 ft away from the parent tree and often grow more than 3 ft per year under favorable conditions. Individual trees typically have a life span of 30 to 50 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling can remove seedlings, but once underground creeping roots have developed, this technique is generally not effective. For saplings or small trees, a weed wrench or other woody weed extractor can be used. Care must be taken to extract the entire root or stump sprouting will occur. Best results are achieved when soil is moist.
Cultural	A heavily shaded environment will reduce the establishment of tree-of-heaven.
Biological	No biological control agents have been released for the control of tree-of-heaven.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product (*Perspective*)/acre **Timing:** Postemergent to foliage of young trees in summer to early fall. **Remarks:** *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Triclopyr *Garlon 3A, Garlon 4 Ultra, Pathfinder II* Aminopyralid + triclopyr *Capstone*	**Rate:** Foliar spot treatment: 1 to 2% v/v solution of *Garlon 4 Ultra* or 1 to 1.5% v/v *Capstone* and water plus 0.5% v/v non-ionic surfactant to thoroughly wet all leaves. Basal cut stump treatment: 20 to 25% *Garlon 4 Ultra* in 80% oil carrier. Cut stump treatment: 20 to 25% *Garlon 3A* in water. Basal bark treatment: 20 to 30% *Garlon 4 Ultra* in 70 to 80% oil carrier, or *Pathfinder II* as a ready-to-use formulation. Stem injection treatment: one cut per every 3 inches of stem diameter, and 1 ml of undiluted *Garlon 3A* added to each cut. For clumps, one hack per every 6 inches of total stem diameter. Treat largest stems. **Timing:** Foliar treatments best when leaves are fully expanded. Cut stump, basal cut stump, basal bark and stem injection treatments can be used anytime, but are best when used in late summer or early fall. **Remarks:** Triclopyr is a selective herbicide for broadleaf species and will not damage desirable grasses growing nearby. Foliar treatment should only be made on small trees, saplings, or seedlings. For cut stump treatments, cut stems horizontally at or near ground level, then immediately apply herbicide solution to cover the outer 20% of the stump face. Coppicing and root suckering typically occur after cutting, but the treatment should control most resprouts. Others have found that stem injection, then cut stump treatment can completely kill tree. Basal bark treatment: spray the lower trunk, including the root collar, to a height of 12 to 15 inches from the ground; the spray should thoroughly wet the lower stem but not to the point of runoff. For stem injection treatments, be sure that each cut goes well into or below the cambium layer. Trees should not be cut for at least 4 months after basal bark and stem injection treatments. A dye can be added to either product. Triclopyr can be applied as a premix with aminopyralid (*Capstone*) at 8 to 9 pt product/acre. Triclopyr can also be mixed with picloram or imazapyr for basal bark treatments (20% *Garlon 4 Ultra* + 5% *Tordon 22K* or 3% *Stalker*). Basal bark applications are made as described for triclopyr. Trees should not be cut for at least one month after treatment. Picloram is not registered for use in California.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** Foliar spot treatment: 2 to 4% solution of glyphosate (*Roundup ProMax* or similar product) and water plus 0.5% v/v non-ionic surfactant to thoroughly wet all leaves. Stem injection treatment: one cut per every 3 inches of stem diameter, and 1 ml of undiluted herbicide added to each cut. For clumps, one hack per every 6 inches of total stem diameter. Treat largest stems. **Timing:** Foliar treatments best when leaves are fully expanded. For stem injection treatments, root injury is increased when applied mid-June to mid-September (fall color). **Remarks:** A nonselective systemic herbicide. Can also be mixed with dicamba to achieve good control with foliar applications. Stem injection and cut stump applications are made as described for triclopyr. Like triclopyr, there is extensive coppicing with a cut stump treatment. Others have found that stem injection with glyphosate, then cut stump treatment can completely kill tree.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapyr *Arsenal, Habitat, Stalker, Chopper, Polaris*	**Rate:** Cut stump treatment: 20% *Stalker* or *Chopper* formulation v/v in 80% oil carrier or 20% *Arsenal* or *Habitat* v/v in 80% water carrier. Stem injection treatment: one cut per every 3 inches of stem diameter, and 1 ml of undiluted herbicide (*Arsenal* or *Habitat*) added to each cut. For clumps, one hack per every 6 inches of total stem diameter. Treat largest stems. Basal bark treatment: 20% *Stalker* or *Chopper* formulation v/v in 80% oil carrier.

	Timing: Best when used in late summer to early fall, but before leaf drop. **Remarks:** Soil residual herbicide. May result in bare ground around trees for some time after treatment. Applications are made as described for triclopyr. Imazapyr is the most consistent and best stem treatment for tree-of-heaven.
Metsulfuron *Escort*	**Rate:** 2 oz product/acre for foliar application (1.2 oz a.i./acre) **Timing:** Treatments best when leaves are fully expanded. **Remarks:** Can be tank mixed with glyphosate or triclopyr. Not registered for use in California.

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.

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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.

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Carduus acanthoides L.; plumeless thistle
Carduus nutans L.; musk thistle
Carduus pycnocephalus L.; Italian thistle
Carduus tenuiflorus Curtis; slenderflower thistle

Plumeless, musk, Italian, and slenderflower thistle



Family: Asteraceae
Range: Musk thistle is found in all western states. Plumeless thistle is found in most western states, except Oregon, Nevada, Utah and Arizona. Italian and slenderflower thistle are most common in west coast states, Washington, Oregon and California. Italian thistle is also found in Idaho.
Habitat: Disturbed open sites, roadsides, pastures, annual grasslands, and waste areas. These thistles can tolerate a relatively wide range of soil types but prefer fertile, well-drained soils.
Origin: All species are native to Europe and the Mediterranean region.
Impacts: These thistles can dominate sites and crowd out native species and forage plants. The spines inhibit grazing and discourage livestock and wildlife from entering infested areas.
Western states listed as Noxious Weed: *C. acanthoides*, Arizona, California, Colorado, Oregon, South Dakota, Washington, Wyoming; *C. nutans*, California, Colorado, Idaho, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming; *C. pycnocephalus*, California, Oregon, Washington; *C. tenuiflorus*, California, Oregon, Washington
California Invasive Plant Council (Cal-IPC) Inventory: *C. acanthoides* and *C. tenuiflorus*, Limited Invasiveness; *C. nutans* and *C. pycnocephalus*, Moderate Invasiveness

The weedy *Carduus* thistles are winter annuals or biennials with prickly leaves and stems with prickly wings. Plumeless thistle and musk thistle grow to 5 ft tall. They are closely related and may hybridize. Italian thistle and slenderflower thistle are also closely related and can grow to 6.5 ft tall. All these thistles form deep taproots. Plants may grow as a biennial, germinating in winter to early spring and existing as a rosette until flower stems develop in spring to summer of the following year. After bolting, stems branch near the top. Stem leaves taper down the stem as spiny wings.

All these thistles produce purple to pink, rarely white, flowers in summer. Plumeless and musk thistle have typical hemispherical thistle flowers, while Italian and slenderflower thistle flowers are more cylindrical in shape. Musk thistle flowers are often nodding on long stalks. Reproduction in all these species is only by seed. Seeds typically fall near the parent plant or are disperse to greater distances with wind. Seeds that germinate in late summer to fall often behave as winter annuals and flower in the following summer. Seeds rarely persist in the soil seedbank for more than a few years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	These thistles can be cultivated or manually removed when small. To control by cutting, use a sharpened shovel at the top of the root crown. Grubbing hoes must cut the plants 2 to 4 inches below ground level to prevent resprouting from dormant axillary buds.

	Mowing the plant during flowering can greatly reduce seed production, though a single mowing is seldom sufficient due to the wide differences in the maturity of plants in a natural population. For mowing, wait till plants bolt and are about to flower. This may require repeated visits at weekly intervals over the 4 to 7 week blooming period, because not all plants bloom simultaneously. Plants will regrow if mowed before they are fully bolted. Plants cut 4 days after the first flowers open can produce viable seed.
Cultural	Large livestock tend to avoid grazing on thistles, although horses and cattle have been known to eat the flowerheads. Sheep will eat the rosettes. Goats like the flowerheads and are able to digest the seed. Depending on timing, the soil seedbank, the plant community, and other factors, fire may help control thistles or may promote their invasion. Grass fires may not be hot enough to kill the root crown of thistle rosettes, but a flamer can be used to kill individual plants. In general, thistles compete poorly with healthy established grasses and other vegetation. Establishment of selected, aggressive grasses can be an effective cultural control of thistles.
Biological	The thistle head weevil (*Rhinocyllus conicus*) is an introduced biocontrol agent that attacks *Carduus* species and several other thistles. It is established in much of the northwestern and north central United States. The weevil gives effective control of musk thistle in parts of Montana, less so in other areas. The crown weevil (*Trichosirocalus horridus*) and thistle crown fly (*Cheilosia corydon*) also are locally established. The fungus musk thistle rust (*Puccinia carduorum*) may soon be approved as a biocontrol agent.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 2 qt product/acre (0.95 to 1.9 lb a.e./acre) **Timing:** Postemergence in the rosette stage. **Remarks:** 2,4-D is broadleaf-selective and has no soil activity. It may require repeat application. It is not the most effective treatment, but is widely used because of low cost. Do not apply ester formulations when outside temperatures exceed 80°F.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 3 to 4.5 oz product/acre **Timing:** Postemergence in spring up to flowering, or in fall rosette stage. **Remarks:** *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid *Milestone*	**Rate:** 4 to 5 oz product/acre (1 to 1.25 oz a.e./acre) **Timing:** Preemergence in winter to early spring and postemergence to seedling treatments in spring up to flower bud stage. Can be applied in fall in cold-winter areas. Apply when plants are at the late bolt through early flowering stages. For late applications starting at the late bud stage, 2,4-D at 1 lb ae/acre should be tank-mixed with *Milestone*. **Remarks:** Aminopyralid is one of the most effective herbicides for thistles. It is a broadleaf herbicide like picloram, but more selective and with a shorter soil residual activity. Aminopyralid is generally safe on grasses. It has longer soil residual and higher activity than clopyralid.
Aminopyralid + 2,4-D, *Forefront HL*; Aminopyralid + metsulfuron, *Opensight*; Aminopyralid + triclopyr, *Capstone*	**Rate:** 1.5 to 2 pt *Forefront HL*/acre; 1 to 3 oz *Opensight*/acre; 4 to 6 pt *Capstone*/acre **Timing:** Postemergence in rosette to bolting stages. **Remarks:** These combinations are broadleaf-selective. *Opensight* is not registered for use in California.
Clopyralid	**Rate:** 0.25 to 1.33 pt product/acre (1.5 to 8 oz a.e./acre)

Transline	**Timing:** Postemergence in spring, up to the flower bud stage. **Remarks:** Clopyralid is a broadleaf herbicide that is more selective to some broadleaf plants than picloram. It is very safe on grasses.
Clopyralid + 2,4-D *Curtail*	**Rate:** 2 to 4 qt product/acre (use higher rate if plants are drought-stressed) **Timing:** Postemergence to rapidly growing weeds from full rosette to early flower bud. **Remarks:** The combination is broadleaf-selective with a wide range of susceptible species.
Dicamba *Banvel*, *Clarity*	**Rate:** 0.5 to 2 pt product/acre (0.25 to 1 lb a.e./acre); 8 to 16 oz product/acre for rosettes, up to 2 pt product/acre for bolting plants **Timing:** Postemergence to rapidly growing plants up to bolting. Application to smaller plants gives better control. **Remarks:** Dicamba is a broadleaf-selective herbicide often combined with other active ingredients. It is effective earlier in the season than 2,4-D. It is also effective when tank-mixed with 2,4-D (0.75 lb a.e./acre 2,4-D + 0.25 lb a.e./acre dicamba). Dicamba has very limited soil residual. Avoid drift to sensitive crops. Do not apply when outside temperatures exceed 80°F. Dicamba is available mixed with diflufenzopyr in a formulation called *Overdrive*. The combination is broadleaf-selective, but safe on most grasses. This has been reported to be effective on plumeless and musk thistle, and may have a similar effect on other members of the genus *Carduus*. Diflufenzopyr is an auxin transport inhibitor which causes dicamba to accumulate in shoot and root meristems, increasing its activity. *Overdrive* is applied postemergence at 4 to 8 oz product/acre on rapidly growing plants. Higher rates should be used on large annuals and biennials or when treating perennial weeds. Add a non-ionic surfactant to the treatment solution at 0.25% v/v or a methylated seed oil at 1% v/v solution.
Fluroxypyr *Vista XRT*	**Rate:** 22 oz product/acre (7.7 oz a.e./acre) **Timing:** Postemergence to rapidly growing weeds. **Remarks:** Fluroxypyr is broadleaf-selective and safe on most grasses.
Picloram *Tordon 22K*	**Rate:** 0.67 to 1 qt product/acre (0.33 to 0.5 lb a.e./acre) **Timing:** Postemergence from flower bud stage to senescence. Most effective in fall treatments. **Remarks:** Picloram is one of the most effective herbicides for this weed and can provide 2 years of control. Most broadleaf plants are susceptible, but it is relatively safe on established grasses. It can injure young or germinating grasses. Picloram is also effective when mixed with dicamba or 2,4-D. It has long soil residual activity. Picloram can be used in a premix with 2,4-D (*Grazon P+D*) or fluroxypyr (*Surmount*) for the control of *Carduus* species. Picloram is a restricted use herbicide. Picloram and its formulations are not registered for use in California.
Triclopyr *Garlon 3A, Garlon 4 Ultra*	**Rate:** 1.33 to 2.66 qt *Garlon 3A*/acre or 1 to 2 qt *Garlon 4 Ultra*/acre (1 to 2 lb a.e./acre) **Timing:** Postemergence to rapidly growing weeds. **Remarks:** Triclopyr is broadleaf-selective and safe on most grasses. It is most effective on smaller plants. *Garlon 4 Ultra* is formulated as a low volatile ester. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage. Rates are based on those reported for Canada thistle.
Triclopyr + 2,4-D *Crossbow*	**Rate:** 2 to 4 qt product/acre **Timing:** Postemergence during the rosette stage. **Remarks:** Include non-ionic surfactant at 1 qt/100 gal water (0.25% v/v).
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** 1.33 to 2.67 qt product (*Roundup ProMax*)/acre (1.5 to 3 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants in bud stage. **Remarks:** Glyphosate has no soil activity and is nonselective. Repeat applications may be necessary. It is more effective with the addition of ammonium sulfate.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1 to 2.6 oz product/acre (0.75 to 1.95 oz a.i./acre) **Timing:** Postemergence in fall to new rosettes, or to rosettes in spring before bolting. Chlorsulfuron

	or metsulfuron applied from the bolting through very early bud stage eliminated viable achene development. **Remarks:** Chlorsulfuron has mixed selectivity, but is generally safe on grasses. Use a surfactant. It can be used in late season applications to reduce seed production and has fairly long soil residual activity. Fall application may injure desirable bromes.
Imazapic *Plateau*	**Rate:** 8 to 12 oz product/acre (2 to 3 oz a.e./acre) **Timing:** Preemergence or early postemergence. Only suppression of musk thistle when applied preemergence. **Remarks:** Imazapic has mixed selectivity and some soil residual activity. Although the label indicates that musk thistle can be controlled with imazapic, it generally tends to favor members of the Asteraceae and some grasses. Use a methylated seed oil surfactant at 0.25% v/v. Not registered for use in California.
Imazapyr *Arsenal*, *Habitat*, *Stalker*, *Chopper*, *Polaris*	**Rate:** 3 to 4 pt product/acre (0.75 to 1 lb a.e./acre) **Timing:** Preemergence or postemergence. **Remarks:** Imazapyr is a nonselective herbicide. Rates are based on those reported for bull thistle.
Metsulfuron *Escort*	**Rate:** 0.5 to 1 oz product/acre (0.3 to 0.6 oz a.i./acre) **Timing:** Postemergence to young, rapidly growing weeds in spring before flowering, or in fall to new rosettes. Chlorsulfuron or metsulfuron applied from the bolting through very early bud stage eliminated viable achene development. Metsulfuron seemed to work a bit better than chlorsulfuron. **Remarks:** Metsulfuron has mixed selectivity and is generally safe on grasses. Use a surfactant. It can be tank-mixed with aminopyralid (*Opensight*), 2,4-D and/or dicamba. Metsulfuron has some soil residual activity. It is not registered for use in California.
Metsulfuron + chlorsulfuron *Cimarron X-tra*	**Rate:** 0.5 oz product/acre **Timing:** Postemergence before flowering. **Remarks:** It is not registered for use in California.
Sulfometuron *Oust* and others	**Rate:** 6 to 8 oz product/acre (4.5 to 6 oz a.i./acre) **Timing:** Preemergence or early postemergence, during the rainy season when weeds are germinating or rapidly growing. **Remarks:** Sulfometuron has mixed selectivity, but is fairly safe on native perennial grasses, especially wheatgrass. This rate is very high and may not be the best option. Desirable grasses may be stunted, stressed, or injured. Sulfometuron has fairly long soil residual activity.
PHOTOSYNTHETIC INHIBITORS	
Hexazinone *Velpar L*	**Rate:** 4 to 6 pt product/acre (1 to 1.5 lb a.e./acre) **Timing:** Preemergence before weeds emerge or postemergence to young plants. **Remarks:** Hexazinone has both foliar and soil activity. In soil applications, rates will vary with soil texture and soil organic matter; best results when applied to moist soil. Use rates will also vary depending on the weed species to be controlled. Hardwood trees near application site can absorb this chemical through the roots and may be injured or killed. Do not spray near the root zone of desirable hardwood trees or shrubs. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.

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Centaurea solstitialis L.

Yellow starthistle



Family: Asteraceae
Range: Most contiguous states, except a few southern and northeastern states.
Habitat: Open disturbed sites, open hillsides, grassland, rangeland, open woodlands, fields, pastures, roadsides, waste places. May also inhabit cultivated fields. Does not tolerate low light areas or shading.
Origin: Southern Europe. Accidentally introduced as a seed contaminant in alfalfa. It has spread rapidly since its introduction into California in the mid-1800s.
Impacts: Plants are highly competitive and typically develop dense, impenetrable stands that displace desirable vegetation in natural areas, rangelands, roadsides and other places. Yellow starthistle is considered one of the most serious rangeland weeds in the western U.S. Yellow starthistle is sometimes problematic in grain fields, where the seeds can contaminate the grain harvest and lower its quality and value. Yellow starthistle contains an unidentified compound that causes nigropallidal encephalomalacia or chewing disease in horses.
Western states listed as Noxious Weed: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Yellow starthistle is a simple to bushy winter annual, occasionally biennial, with spiny yellow-flowered heads and stiff wiry stems to 6 ft tall. Plants form a basal rosette of leaves until mid-spring. Stem leaves are alternate and mature foliage is grayish- to bluish-green, densely covered with fine white cottony hairs. Its leaf bases form wings along the stems. Rosette leaves typically wither by flowering time. The taproot can extend deep into the soil (> 6 ft) allowing plants to utilize deep soil moisture not available to other annual species, particularly grasses.

The flowerheads are solitary on stem tips, and consist of numerous yellow disk flowers. The phyllaries are densely to sparsely covered with cottony hairs or with patches of hairs at the bases of the spines. The central spine of the main phyllaries is 10 to 25 mm long, stiff, yellowish to straw-colored throughout. Yellow starthistle reproduces only by seed and develops two types of achenes. The outer ring of achenes is a dull dark brown, often speckled with tan, lacking pappus bristles, and often remaining in heads. The inner achenes are glossy, gray or tan to mottled cream-colored and tan, with slender white pappus bristles 2 to 5 mm long. Most seeds fall near the parent plant. Some seed is viable 8 days after flower initiation. Large flushes of seeds typically germinate after the first fall rains, but smaller germination flushes can occur during winter and early spring. Seeds can survive for up to about 10 years in the field under certain environmental conditions, but it appears that few seeds survive beyond 4 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand removal, mowing, or cultivation, when used to prevent seed production over 2 to 3 years or more (the soil life of the seeds), can reduce or eliminate an infestation. Manual removal of yellow starthistle is most effective with small patches or in maintenance programs where plants are sporadically located in the grassland system. This usually occurs with a new infestation or in the third year or later in a long-term management program. These methods can also be important in steep or uneven terrain where other mechanical tools (e.g., mowing) are impossible to use. To ensure that

	plants do not recover it is important to detach all above-ground stem material. Leaving even a 2-inch piece of the stem can result in recovery if leaves and buds are still attached to the base of the plant. The best timing for manual removal is after plants have bolted but before they produce viable seed (i.e. early flowering). At this time, plants are easy to recognize, and some or most of the lower leaves have senesced. If hand removal is conducted after plants begin to produce seeds, it may be necessary to put pulled plants in bags and remove them from the site. Hand removal is particularly easy in areas with competing vegetation. Under this condition, yellow starthistle will develop a more erect slender stem with few basal leaves. These plants are relatively brittle and easy to remove. In addition, they usually lack leaves at the base and, consequently, rarely recover even when a portion of the stem is left intact. Hand removal options for yellow starthistle typically include hand pulling, hoeing, or string trimming. Systematic surveys and repeated removal should be conducted every 2 to 4 weeks throughout the growing season. Mowing is most effective when 2 to 5% of the total population of seedheads is in bloom. Mowing too early can result in higher seed production. Plants should be cut below the height of the lowest branches. It will require multiple years of continuous mowing to successfully manage yellow starthistle. Mowing is best used in an integrated approach. Since it is a late season management tool, it is best employed in the later years of a long-term management program or in a lightly infested area. Mowing is not feasible in many locations due to rocks and steep terrain. Mowing is not always successful and can decrease the reproductive efforts of insect biocontrol agents, injure late growing native forb species, and reduce fall and winter forage for wildlife and livestock. The success of mowing depends on proper timing and the growth form of the plant. Mowing too early (before seedheads reach spiny stage) or too late (after seed set) will usually increase the yellow starthistle problem. Mowing too early in the season can remove competitive grass cover and promote vigorous yellow starthistle regrowth. If done too late, mowing scatters yellow starthistle seed. Best results were obtained by mowing once at the early flowering stage, and again 4 to 6 weeks later to cut regrowth during the floral bud stage. A dense spring canopy of desirable vegetation optimizes yellow starthistle control. Yellow starthistle plants with an erect, high-branching growth form are effectively controlled by a single mowing at the early flowering stage, while sprawling low-branching plants cannot be controlled even with repeated mowing. Despite its limitations, mowing conducted at the early flowering stage, before viable seed production, can be very effective for yellow starthistle control. Anecdotal information also indicates that mowing the standing skeletons in fall, before the first rains, can form a mulch that blocks light and suppresses subsequent germination of yellow starthistle. A flail mower is considered best. The yellow starthistle litter layer may be less suppressive to grass germination, as it is not as light dependent as yellow starthistle. Tillage is effective, and is occasionally used on roadsides. It is also often used in agricultural lands, which is probably why yellow starthistle is not a significant cropland weed. In wildlands and rangelands, tillage is usually not appropriate because it can damage important desirable species, increase erosion, alter soil structure, and expose the soil for rapid reinfestation if subsequent rainfall occurs. Any tillage operation that severs the roots below the soil surface can effectively control yellow starthistle. Early summer tillage, before viable seeds are set, and repeated tillage following rainfall/germination events will rapidly deplete the yellow starthistle seed bank, but may also have the same effect on the seed bank of desirable species.
Cultural	High-intensity short-duration grazing by sheep, goats, or cattle should be implemented during the period when yellow starthistle plants have bolted to just before they produce spiny heads. Cattle and sheep avoid yellow starthistle once the buds produce spines, whereas goats continue to browse plants even in the flowering stage. For this reason, goats have become a more popular method for controlling yellow starthistle in relatively small infestations. Grazing the weed during the bolting stage can provide palatable high protein forage (8 to 14%). This can be particularly useful in late spring and early summer when other annual species have senesced. Grazing alone will not provide long-term management or eradication of yellow starthistle, but can be a valuable tool in an integrated management program. This prescription must be continued for at least 3 years in a severe infestation to reduce the yellow starthistle seed bank. Prescribed burns can provide control if conducted at the proper timing. Burning should be timed to coincide with the very early yellow starthistle flowering stage. At this time yellow starthistle has yet to produce viable seed, whereas seeds of most desirable species have dispersed and grasses have dried to provide adequate fuel. Fire has little if any impact on seeds in the soil. Burning at other times may enhance yellow starthistle survival by removing the thatch and encouraging seed germination in fall. The ability to use repeated burning depends on climatic and environmental conditions. In areas where

	resources are ample and total plant biomass is abundant, 2 or 3 consecutive years of burning may be practical. However, in other situations, fuel loads may not be sufficient to allow multiple year burns. Consequently, prescribed burning may be more appropriate as part of an integrated approach. Air quality issues can be significant when burns are conducted adjacent to urban areas. A major risk of prescribed burning is the potential of fire escapes. This risk is greatest when burns are conducted during the summer months. In some areas, burning can lead to rapid invasion by other undesirable species with wind-dispersed seeds, particularly members of the sunflower family. In addition to summer burning, yellow starthistle seedlings have been controlled using winter or early spring flaming. This technique is somewhat nonselective, and control of yellow starthistle is inconsistent. When spring drought follows a flaming treatment, control of yellow starthistle can be excellent. In contrast, a wet spring can lead to complete failure and increased yellow starthistle infestation, particularly since competing species may be dramatically suppressed.
Biological	Six insects have become established for the control of yellow starthistle in the western United States. These include three species of weevils (seed-head weevil [*Bangasternus orientalis*], flower weevil [*Larinus curtus*], and the hairy weevil [*Eustenopus villosus*]), and three species of flies (seed-head fly [*Urophora sirunaseva*], peacock fly [*Chaetorellia australis*], and the false peacock fly [*Chaetorellia succinea*]). All six insects attack the flower heads of yellow starthistle and produce larvae that develop and feed within the seedhead. Of these, only four have become well established. Of these, only two, *Eustenopus villosus* and *Chaetorellia succinea*, have any significant impact on reproduction. The combination of these two insects reduces seed production by 43 to 76%. Although this level of suppression is not sufficient to provide long-term yellow starthistle management, the use of biological control agents can be an important component of an integrated management approach. A more successful biological control program will likely require the introduction of plant pathogens or other insects which attack roots, stems, or foliage. A new potential biological control agent is a root-feeding weevil, *Ceratapion basicorne*, that has shown promise under greenhouse conditions. It has yet to be approved, but is expected to be released in the next couple of years. The most widely studied pathogen for yellow starthistle control is the Mediterranean rust fungus *Puccinia jaceae*. It can attack the leaves and stem of yellow starthistle, causing enough stress to reduce flowerhead and seed production. Although it has been released it does not seem to have much impact on yellow starthistle populations.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 1.5 pt product/acre (0.48 to 0.72 lb a.e./acre) for small rosettes, 2 to 4 pt product/acre (0.95 to 1.9 lb a.e./acre) for larger plants up to bolting **Timing:** Postemergence from rosette to beginning of bolting, but before flowering. **Remarks:** 2,4-D controls larger plants well, but is not considered as effective as other growth regulator herbicides for season-long control. It is broadleaf-selective and may injure other non-target species, particularly crop plants. 2,4-D has no soil activity. Do not apply ester formulation when outside temperatures exceed 80°F. Amine forms are as effective as ester forms for small rosettes, and amine forms reduce the chance of off-target movement from volatility.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 3 to 5 oz product (*Perspective*)/acre **Timing:** Postemergence and preemergence. Postemergence applications are most effective when applied to plants from the seedling to the mid-rosette stage. **Remarks:** Aminocyclopyrachlor gives control of yellow starthistle similar to aminopyralid. *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for

	use in California and some counties of Colorado (San Luis Valley).
Aminopyralid *Milestone*	**Rate:** 3 to 5 oz product/acre (0.75 to 1.25 oz a.e./acre). Use higher rates when weeds are larger. **Timing:** Postemergence and preemergence. Postemergence applications are most effective when applied to plants from the seedling to the mid-rosette stage. Earlier applications (i.e., in fall) may not provide full-season control, and later applications (bolting to early spiny stage) will require higher rates. **Remarks:** Aminopyralid is one of the most effective herbicides for the control of yellow starthistle. It is safe on grasses, although preemergence application at high rates can greatly suppress invasive annual grasses, such as medusahead. Aminopyralid has a longer residual and higher activity than clopyralid. Other members of the Asteraceae and Fabaceae are very sensitive to aminopyralid. For postemergence applications, a non-ionic surfactant (0.25 to 0.5% v/v spray solution) enhances control under adverse environmental conditions; however, this is not normally necessary. Other premix formulations of aminopyralid can also be used for yellow starthistle control. These include *Opensight* (aminopyralid + metsulfuron; 1.5 to 2 oz product/acre) and *Forefront HL* (aminopyralid + 2,4-D; 2 to 2.6 pt product/acre), both applied at the rosette to bolting stages.
Clopyralid *Transline*	**Rate:** 0.25 to 0.67 pt product/acre (1.5 to 4 oz a.e./acre). Seedlings and rosettes can be treated at the lower rate, but bolted plants should be treated at higher rates. **Timing:** Postemergence and preemergence. For postemergence application, apply to plants from seedling to mid-bolting stage. However, since clopyralid has a shorter soil residual compared to aminopyralid, optimal timing is at the later rosette stages, but before bolting. Earlier applications (i.e., in fall) may not provide full-season control, and later applications (bolting to early spiny stage) will require higher rates and may not give sufficient control. **Remarks:** Clopyralid gives excellent control of yellow starthistle. While it is very safe on grasses, it will injure many members of the Asteraceae, particularly thistles, and can also injure legumes, including clovers. Most other broadleaf species and all grasses are not injured. When clopyralid is used to control seedlings a surfactant is not necessary. However, when treating older plants or plants exposed to moderate levels of drought stress, surfactants can enhance the activity of the herbicide.
Clopyralid + 2,4-D *Curtail*	**Rate:** 2 to 4 qt *Curtail*/acre **Timing:** Same as for clopyralid. **Remarks:** Add a non-ionic surfactant.
Dicamba *Banvel*, *Clarity*	**Rate:** 0.5 pt product/acre (0.25 lb a.e./acre) for seedlings, 1 to 1.5 pt product/acre (0.5 to 0.75 lb a.e./acre) for larger plants up to bolting. **Timing:** Postemergence to plants from rosette to beginning of bolting. **Remarks:** Dicamba is a broadleaf-selective herbicide often combined with other active ingredients. It is not typically used alone to control yellow starthistle. Dicamba is available mixed with diflufenzopyr in a formulation called *Overdrive*. This has been reported to be effective on yellow starthistle. Diflufenzopyr is an auxin transport inhibitor which causes dicamba to accumulate in shoot and root meristems, increasing its activity. *Overdrive* is applied postemergence at 4 to 8 oz product/acre to rapidly growing plants. Higher rates should be used on large annuals. Add a non-ionic surfactant to the treatment solution at 0.25% v/v or a methylated seed oil at 1% v/v solution.
Picloram *Tordon 22K*	**Rate:** 1 to 1.5 pt product/acre (4 to 6 oz a.e./acre) **Timing:** Postemergence and preemergence. Postemergence applications should be made to plants from rosette to bud formation stage. Apply when there is adequate soil moisture and weeds are growing rapidly. **Remarks:** Picloram acts much like aminopyralid, aminocyclopyrachlor, and clopyralid, but gives a broader spectrum of control and has much longer soil residual activity. It can provide about 2 to 3 years of control. Most broadleaf plants are susceptible. Although well-developed grasses are not usually injured by labeled use rates, some applicators have noted that young grass seedlings with fewer than four leaves may be killed. Do not apply near trees. *Tordon 22K* is a federally restricted use pesticide. Picloram is not registered for use in California.

Triclopyr *Garlon 3A, Garlon 4 Ultra*	**Rate:** 1 pt *Garlon 4 Ultra* or 1.33 pt *Garlon 3A*/acre (0.5 lb a.e./acre) for seedlings, up to 3 pt *Garlon 4 Ultra* or 4 pt *Garlon 3A*/acre (1.5 lb a.e./acre) for larger plants. **Timing:** Postemergence from seedling to bolting stage. **Remarks:** Triclopyr has little to no residual activity. It is broadleaf-selective and typically does not harm grasses. *Garlon 4 Ultra* is formulated as a low volatile ester. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** Broadcast foliar treatment: 1.33 to 2.67 qt product (*Roundup ProMax*)/acre (1.5 to 3 lb a.e./acre). Spot treatment: 1% to 2% v/v solution **Timing:** Postemergence to plants from bolting to beginning of flowering. **Remarks:** Glyphosate is the most effective herbicide for late season control. Good coverage, clean water, and rapidly growing yellow starthistle plants are all essential for adequate control. It has no soil activity and is nonselective. To achieve selectivity, it can be applied using a wiper or spot treatment to control current year's plants.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1.33 to 2.6 oz product/acre (1 to 1.95 oz a.i./acre) **Timing:** Preemergence activity only. Chlorsulfuron does not have postemergence activity on yellow starthistle and must be used in combination with 2,4-D, dicamba, or triclopyr to provide effective control. **Remarks:** Chlorsulfuron has mixed selectivity on both broadleaf and grass species but is generally safe on grasses. It has fairly long soil residual activity. Herbicide solution requires constant agitation during application.
Imazapyr *Arsenal*, *Habitat*, *Stalker*, *Chopper*, *Polaris*	Not often used for yellow starthistle control but has been shown to be somewhat effective at 3 to 4 pt product/acre. It has preemergence and some postemergence activity, and a long soil residual.
Sulfometuron *Oust* and others	Not often used for yellow starthistle control but has been shown to be somewhat effective at 1 to 2 oz product/acre. It has preemergence activity only, and a long soil residual.
PHOTOSYNTHETIC INHIBITORS	
Hexazinone *Velpar L*	Not often used for yellow starthistle control but has been shown to be somewhat effective at 1 to 2.5 gal product/acre. It has preemergence activity only, and a long soil residual. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.

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.

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Conium maculatum L.

Poison-hemlock



Family: Apiaceae
Range: Throughout the contiguous U.S., including every western state.
Habitat: Moist soil along hedgerows, along the banks of streams and rivers, roadsides and wastelands, woodlands, meadows, and pastures.
Origin: Native to Europe.
Impact: Produces piperidine alkaloids which are highly toxic to humans and animals. Domestic animals such as swine, cattle, goats, horses, and sheep can be poisoned by the toxin coniine after ingesting any portion of the plant. Poison-hemlock is the most toxic to cattle. Symptoms can include vomiting, nausea, trembling, rapid respiration, joint and movement problems, slow, weak and rapid pulse, increased salivation and urination, convulsions, paralysis, coma, and death from respiratory paralysis. Ingestion during fetal development can result in severe birth defects.
States listed as Noxious Weed: Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, Washington
California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness

Poison-hemlock is a tall branching biennial to 4 to 6 ft tall. The stem is erect, hollow, smooth, bright green with a distinctive mottled appearance and irregular purple splotches. The long-stalked leaves are glabrous, up to 2 ft long, bright green, alternate, and tripinnately compound (divided into leaflets which are again divided and subdivided). Its root is a long, forked, fleshy taproot, pale yellow in color, with numerous lateral roots.

The inflorescence is a compound umbel with 12 to 16 rays, and numerous small white flowers located at the terminal positions. Each flower produces two gray-brown seeds with five wavy longitudinal ridges. The seeds have the highest concentration of coniine. Poison hemlock smells like mouse urine when crushed, a characteristic of the poisonous alkaloids. Plants reproduce only by seed. Most seeds fall near the parent plant. Seed dispersal is prolonged and occurs from late summer through winter. Most seeds germinate almost immediately if conditions are favorable, but a small proportion remains dormant. Dormant seeds require a period of high summer and/or low winter temperatures before they can germinate. Seeds survive up to about 3 years under field conditions.

NON-CHEMICAL CONTROL

Mechanical (mowing, plowing, and cultivation)	Hand removal is recommended for small infestations. When pulling the plants, dig down and remove the entire taproot. Wear gloves and wash hands after working with poison-hemlock. Manual control efforts can be successful, but can cause soil disturbance encouraging further germination of seeds. Solid carpets of hemlock seedlings are not uncommon following soil disturbance. Cutting is ineffective; the plants send up new seed stalks in the same season the cutting occurs. Establishment of populations can be prevented with repeated cultivation and plowing.
Cultural	Due to the plant's toxicity, grazing is not recommended for control. Even dried plant parts are not safe as the toxins take several years to dissipate. Use certified weed-free hay to prevent the poisoning of livestock. Do not burn, as toxins can be released into the air through the smoke.
Biological	There are no known biological controls. Since its introduction to North America, only a few native insects have been able to overcome its toxic defenses. These attack the seedhead, but do very little damage to the rest of the plant.

CHEMICAL CONTROL

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GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 4 pt product/acre (0.48 to 1.9 lb a.e./acre) **Timing:** Postemergence in seedling to rosette stage. **Remarks:** Broadleaf-selective, most effective when applied soon after plants emerge. Adding a wetting agent may enhance control. Also effective tank mixed with dicamba.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product/acre **Timing:** Postemergence in seedling to rosette stage. **Remarks:** Broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid + metsulfuron *Opensight*	**Rate:** 2.5 to 3.3 oz product/acre **Timing:** Preemergence in fall, or postemergence in the seedling to rosette stage. **Remarks:** Not registered for use in California.
Triclopyr *Garlon 4 Ultra*, *Remedy Ultra*	**Rate:** 5 to 8 pt product/acre (2.5 to 4 lb a.e./acre) **Timing:** Postemergence in seedling to rosette stage. **Remarks:** Broadleaf-selective, safe on most grasses. Most effective on smaller plants. *Garlon 4 Ultra* and *Remedy Ultra* are low volatile esters. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage. Also effective in a premix with 2,4-D (*Crossbow*) or tank mixed with clopyralid (*Transline*).
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** Broadcast treatment: 1.33 to 2.67 qt product (*Roundup ProMax*)/acre (1.5 to 3 lb a.e./acre). Spot treatment: 1 to 1.5% v/v solution **Timing:** Best when applied postemergence to rapidly growing plants before bolting. However, higher rates can control plants at the bud to full bloom stage. **Remarks:** Glyphosate is a nonselective herbicide that has no soil activity. Add a non-ionic surfactant.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1 to 2.6 oz product/acre (0.75 to 1.95 oz a.i./acre) **Timing:** Postemergence to rapidly growing plants. **Remarks:** Desirable grasses should be well established before application.
Imazapic *Plateau*	**Rate:** 8 to 12 oz product/acre (2 to 3 oz a.e./acre) **Timing:** Preemergence. **Remarks:** Mixed selectivity, favors members of the Asteraceae and some grasses. Some soil residual activity. In postemergence applications, use methylated seed oil at 1.5 to 2 pt/acre. Not registered for use in California.
Imazapyr *Arsenal AC*, *Habitat*, *Stalker*, *Chopper*, *Polaris*	**Rate:** 2 pt product (*Arsenal AC*)/acre (1 lb a.e./acre); 4 pt product (*Habitat*)/acre (1 lb a.e./acre) + 1 qt/acre methylated seed oil **Timing:** Preemergence or early postemergence in the rosette stage. **Remarks:** Nonselective. Long soil residual, leaves more bare ground than other treatments, even a year after application. Do not apply more than 3 qt product/acre. *Habitat* is an aquatic registered formulation for use close to water.
Metsulfuron *Escort*	**Rate:** 1 oz product/acre (0.6 oz a.i./acre) **Timing:** Postemergence to rapidly growing plants. **Remarks:** Use a non-ionic surfactant or silicone surfactant. Prevent drift to sensitive plants. Apply only to pastures, rangeland, and non-crop sites. Metsulfuron can also be used in a premix with dicamba + 2,4-D (*Cimarron Max*). Metsulfuron and its formulations are not registered in California.

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.

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Dittrichia graveolens (L.) Greuter

Stinkwort





Family: Asteraceae
Range: In the western United States, stinkwort is only found in California. It is also found in a few northeastern states.
Habitat: Disturbed soils of roadsides, wasteland, gravel areas, levees, and washes; sometimes in pastures, fields, riparian woodlands, and margins of tidal marshes or vernal pools. Grows best on well-drained, sandy or gravelly soils. Thrives in areas with hot, dry summers, but does not require them. Can grow on serpentine, saline, and metal-contaminated soils.
Origin: Native to southern Europe.
Impacts: Stinkwort is rapidly expanding its range. Often found in disturbed sites on the urban fringe, where its sticky, smelly foliage interferes with human activity. In Australia, where stinkwort has been for 150 years, it has naturalized in many habitats. It causes allergic contact dermatitis in humans; it also has been implicated in livestock deaths by enteritis owing to the barbed pappus bristles puncturing the small intestine. Its impact in natural areas is not known, but it is just beginning to invade open riparian or grazing areas.
California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness (Alert)

Stinkwort is an erect, fall-flowering annual growing up to 3 ft tall. A recent introduction to the west coast, stinkwort was first reported in California in the mid-1980s. Its sticky, glandular-hairy foliage is intensely aromatic. The oils on the foliage, especially on mature plants, make it difficult to control with postemergence herbicides. Stinkwort germinates during winter but remains small until spring. During late spring and summer, it develops into a shrubby, pyramid- or sphere-shaped plant which superficially resembles Russian-thistle or kochia. Stinkwort is a member of the Inuleae tribe and is related to the cudweeds (*Gnaphalium* spp.), but more closely resembles native tarweeds (*Holocarpha*, *Hemizonia*). Its leaves are linear to lance-shaped, typically 0.5 to 1 inch long by only 1 to 3 mm wide.

Unlike most annual, and particularly winter annual weeds, it flowers from September to December, producing small yellow flowerheads around 0.25 inch diameter. The flowerheads turn reddish as they age. Its seeds are tiny, with a barbed pappus, and are readily distributed by wind, water, or by sticking to fur or clothing. The seeds reportedly have a short life in the soil, probably less than 3 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Stinkwort has a relatively shallow root system, so it can be controlled by hoeing or pulling. When doing any kind of mechanical control of stinkwort, wear appropriate protective clothing (long sleeves, long pants, gloves) to minimize exposure to the irritating oils. Once stinkwort goes into flower, plants should be bagged and taken off site, because seeds may ripen on the cut plants. Mowing can give partial control, but this plant often has low branches below the level of most mowers, so it may regrow. Mowing a second time, especially in mid- to late summer after the soil has dried out, may give improved control.
Cultural	There is no information available on grazing for the control of stinkwort. It is likely that the plant is not very

	palatable to livestock. Burning alone is not likely to be a good control for stinkwort. It usually grows in locations without enough grasses for dry fuel. Even so, if a burn was successful in controlling the current year's plants, this would likely just clear off the site for a subsequent flush of stinkwort the following winter. Potentially, this could be followed with herbicide treatment as part of an integrated management strategy as with yellow starthistle. Stinkwort establishes and thrives in open, disturbed sites. To limit its chances for establishing, minimize disturbances such as overgrazing and soil manipulation. Pastures should be managed for dense, competitive stands; aim for maximum ground cover in spring, when stinkwort seedlings are trying to establish.
Biological	No biocontrol agents are presently known for this species.

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.

Because of stinkwort's sticky foliar oils, many sources recommend using ester formulations of growth regulator herbicides (2,4-D, MCPA, triclopyr, etc.)

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 2 to 4 pt product/acre (0.95 to 1.9 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants. Smaller plants are easier to control. **Remarks:** 2,4-D is a broadleaf-selective herbicide with no soil activity. Ester formulations appear better at cutting through the oils on the foliage, but do not apply ester formulations when outside temperatures exceed 80°F. A related chemical, MCPA, is commonly used for control of stinkwort in Australia at rates of 25 oz product/acre (0.75 lb a.e./acre). Timing and remarks are similar to 2,4-D.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product/acre **Timing:** In spring either preemergence or postemergence. For postemergence applications, treat until bolting. **Remarks:** Controls many broadleaf species. Although generally safe to grasses, it may suppress some annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. Not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid + 2,4-D, *Forefront HL*; Aminopyralid + metsulfuron, *Opensight*; Aminopyralid + triclopyr, *Capstone*	**Rate:** 1.5 to 2.1 pt *Forefront HL*/acre; 2.5 to 3.3 oz *Opensight*/acre; 4 to 6 pt *Capstone*/acre **Timing:** Postemergence to plants in the rosette to bolting stages. **Remarks:** These combinations are broadleaf-selective. Recommended rates based on those reported for knapweeds or perennial thistles. *Opensight* is not registered for use in California.
Dicamba *Banvel*, *Clarity*	**Rate:** 2 to 4 pt product/acre (1 to 2 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants. **Remarks:** Broadleaf-selective herbicide often combined with other active ingredients. Also effective tank-mixed with 2,4-D. It will kill above-ground parts of the plant, but new rosettes will regenerate from the root system. Its use may require repeat applications. Avoid drift to sensitive crops. Do not apply when outside temperatures exceed 80°F. Dicamba + MCPA (3 to 5 oz dicamba product plus 14 to 20 oz MCPA product) is a standard treatment for stinkwort in Australia.
Triclopyr *Garlon 4 Ultra*	**Rate:** 2 to 4 pt product/acre (0.75 to 1.5 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants before flowering. Smaller plants are easier to

	control. **Remarks:** Broadleaf-selective, generally safe on established grasses. It has little to no soil activity. *Garlon 4 Ultra* is formulated as a low volatile ester. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** 2 to 4 pt product (*Roundup ProMax*)/acre (1.1 to 2.25 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants in late spring to early summer, after desirable competitors have senesced. **Remarks:** Nonselective, no soil activity. Effectiveness may be increased by adding ammonium sulfate.

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Foeniculum vulgare Mill.

Fennel



Family: Apiaceae
Range: Particularly a problem in California, but found throughout many western states including Washington, Oregon, Arizona, Nevada, Utah, New Mexico and Texas.
Habitat: Fennel prefers open disturbed areas and has invaded roadsides, slopes, fields, grasslands, coastal scrub, riparian and wetland areas, and other natural communities, particularly in coastal regions.
Origin: Native to southern Europe. Birds and rodents consume the seeds, and feral pigs relish the roots.
Impacts: Established plants are competitive, and soil disturbance facilitates the development of dense stands, which can exclude native vegetation in some areas. Unlike the weedy form, cultivated varieties are seldom invasive. Fennel is also rated as a noxious weed in some regions of Australia.
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Fennel is an aromatic perennial with a deep thick taproot. Plants can grow to 10 ft tall, with finely dissected leaves divided into numerous thread-like segments. Foliage and seeds have a strong licorice or anise scent, especially when crushed. Different varieties are cultivated as a spice or vegetable, for an essential oil used to flavor foods, and in some countries, for medicinal purposes.

The inflorescence consists of several flat-topped compound umbels of small yellow flowers. Fruits separate into two halves (mericarps) at maturity. Plants reproduce by seed and sometimes vegetatively from root or crown fragments. Seeds are dispersed with water, soil movement, animals, human activities, and as a seed contaminant. Seeds appear to survive several years under field conditions. Fragmentation of roots and crowns may occur during flooding events, mudslides, or agricultural operations. New shoots grow from the crown and lower portions of overwintering stems in mid-winter to early spring.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand chop small infestations (large fennel plants have a very substantial root, so this labor intensive). Slashing just before flowering may kill the plants, or repeat slashing of regrowth may be needed. Even if plants recover, slashing the stems at flowering will prevent seed set. The use of a mattock to remove the plant can also be successful, but is very labor intensive. Digging out individual plants is also possible, but also labor intensive. Deep cultivation will also kill the plants but is not practical in most situations.
Cultural	Grazing will not control fennel and often spreads the population. Burning is not effective, as fennel will quickly recover following the fire. However, fall burns followed by herbicide treatment the following two springs reduced fennel cover. Burning can also stimulate the seedbank to germinate, which can reduce the number of years necessary for control.
Biological	Because fennel is the same species as the cultivated fennel, there are no biological control agents available.

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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 0.25 to 0.5% of v/v solution for spot treatment **Timing:** Postemergence to fully developed leaves but before flowering. **Remarks:** 2,4-D will damage other broadleaf species and is not as effective as triclopyr.
Triclopyr *Garlon 3A*, *Garlon 4 Ultra*	**Rate:** Broadcast foliar treatment: 1 to 2 qt product/acre (1 to 2 lb a.e./acre). Spot treatment: 0.5 to 1% v/v solution **Timing:** Postemergence to fully developed leaves but before flowering. The best treatment timing is during the wet season from late February to early March. For spot treatment, lower rates can be used early in the season. **Remarks:** Triclopyr is a broadleaf herbicide that is the standard for fennel control. It is very effective and can also be used in combination with glyphosate at 1 lb a.e./acre each.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** Broadcast foliar treatment: 5 pt product (*Roundup ProMax*)/acre (2.8 lb a.e./acre). Spot treatment: 2 to 5% v/v solution **Timing:** Postemergence to fully developed leaves but before flowering. Control is less effective once plant has bolted. **Remarks:** Glyphosate is nonselective. It gives very effective control and can also be used in combination with triclopyr at 1 lb a.e./acre each.

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.

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Lepidium latifolium L.

Perennial pepperweed (tall whitetop)



Family: Brassicaceae
Range: All western states, except North and South Dakota.
Habitat: Many different areas and habitats, including wetlands, riparian areas, meadows, vernal pools, salt marshes, flood plains, sand dunes, roadsides, irrigation ditches, ornamental plantings, and agronomic crops, including alfalfa, orchards, vineyards, and irrigated pastures. Most typically found on moist or seasonally wet sites in the west, and most problematic in riparian or wetland areas. Tolerates saline and alkaline conditions.
Origin: Native to Eurasia.
Impacts: Perennial pepperweed can rapidly form large, dense stands that displace desirable vegetation and wildlife. Populations easily spread along waterways and can infest entire stream corridors, riparian areas, or irrigation structures. Roots do not hold soil together well, allowing erosion of river, stream, or ditch banks. Flooded streams often wash away roots growing along the streambank, and new infestations develop downstream. Once established, perennial pepperweed is persistent and difficult to control in crops, natural areas, and ornamental plantings. Perennial pepperweed reduces forage quality in hay and pasture. Perennial pepperweed plants extract salts from deep soil and deposit them on the soil surface, inhibiting the germination and growth of other species that are sensitive to salinity.
Western states listed as Noxious Weed: California, Colorado, Idaho, Montana, New Mexico, Oregon, South Dakota, Utah, Washington, Wyoming
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Perennial pepperweed is an erect perennial to 6 ft tall. The crown and lower stems are weakly woody. The foliage lacks hairs and is green to gray-green, often dusted with powdery white caused by a rust fungus. The basal leaves are larger and wider than stem leaves, to 1 ft long and 4 inches wide, with serrate margins. The aboveground parts typically die in late fall and winter, leaving dead stems and thatch which can persist for several years. The roots are long, thick, minimally branched, and vigorously creeping. Most grow in the top 2 ft of soil, but some can penetrate to a depth of 10 ft or more.

The inflorescences are rounded to pyramidal and consist of numerous small white flowers. The flowers have four petals, producing small pods (about 2 mm long) with tiny reddish-brown seeds (about 1 mm long). Perennial pepperweed is a prolific seed producer. Laboratory tests suggest seeds germinate readily with fluctuating temperatures and adequate moisture; however, seeds do not appear to remain viable in the soil for extended periods. As a result, perennial pepperweed reproduces primarily vegetatively from roots and root fragments. Large root fragments can survive desiccation on the soil surface for extended periods, and fragments as small as 0.5 to 1 inch long and 2 to 8 mm in diameter can develop into new plants. Root fragments and seeds disperse with flooding, soil movement, and human and animal activities.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Seedlings are easily controlled by hand-pulling or tillage, but these techniques do not control established plants because shoots quickly resprout from vast root reserves. In addition, seedlings are not often encountered. Root segments as small as 1 inch are capable of producing new shoots. Cultivation and tillage typically increase infestations by dispersing root fragments. Clean equipment after tillage to prevent spreading root fragments. Mowing stimulates perennial pepperweed plants to resprout and produce new growth, but mowing is

	helpful for removing accumulated thatch. Mowing breaks old stems into small fragments and helps prevent shading of favorable species. Combining mowing with herbicides has been shown to be an effective control strategy. For best results, mow plants at the bolting or flower bud stage and apply herbicides to resprouting shoots once they have reached the flower bud stage.
Cultural	Cattle, sheep, and goats will graze perennial pepperweed, especially rosettes in early spring. When stands are dense it becomes difficult for most animals to graze. Goats appear to tolerate heavy consumption of fresh plants. Sheep and goats permanently maintained in a pasture suppress growth of perennial pepperweed. However, once livestock are removed, plants quickly resprout. Burning is not effective at reducing perennial pepperweed stands, but it is helpful at removing accumulated thatch. Perennial pepperweed thatch burns best in winter or spring under dry conditions before initiation of spring growth. Seasonal flooding for an extended period during the growing season can significantly reduce populations. It is not known how long perennial roots can survive flooded conditions, but anecdotal information indicates that 6 months of submergence are required. Establishing desirable vegetation in disturbed areas can suppress perennial pepperweed and slow reinvasion after control. Because perennial pepperweed is very competitive, seed or transplant desirable vegetation after dense perennial pepperweed stands are controlled. Choose vigorous, fast-growing plant species that are adapted to the site. Perennial grasses are a good choice for natural areas and pastures. Grasses are tolerant of broadleaf-selective herbicides, and over time grasses form a thick sod that prevents future weed establishment. In pastures, promote grass expansion and vigor with fertilization and grazing management.
Biological	Biological control agents are being evaluated for use on perennial pepperweed in the United States, but currently no organisms are available.

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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 2 qt product/acre (1.9 lb a.e./acre) **Timing:** Postemergence at rosette to flowering stages. Most effective at flower bud or flowering stage. **Remarks:** 2,4-D often requires annual application for multiple years. It is broadleaf-selective and safe on most grasses. 2,4-D has minimal soil activity. Do not apply ester formulations when outside temperatures exceed 80°F. Amine forms are as effective as ester forms, and amine forms reduce the chance of off-target movement.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** 2 to 4 qt product (*Roundup ProMax*)/acre (2.25 to 4.5 lb a.e./acre). Spot treatment: 2 % product v/v **Timing:** Postemergence from seedling to bloom stage. Most effective at flower bud or flowering stage. **Remarks:** Glyphosate will not kill seeds or inhibit germination the following season. Glyphosate is nonselective and has no soil activity. It can create bare ground conditions that are susceptible to weed recruitment. In areas with desirable vegetation, use spot treatment. Glyphosate is a good control option if reseeding is planned shortly after application, as it will not injure seedlings emerging after application. Add a surfactant when using a formulation where it is not already included (e.g., *Rodeo, Aquamaster*).
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1 to 2.6 oz product/acre (0.75 to 1.95 oz a.i./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective at flower bud or flowering stage. **Remarks:** Chlorsulfuron has long soil residual activity. It has mixed selectivity, but is generally safe on grasses. Always use a surfactant. 2,4-D at 1 to 2 pt/acre can be tank-mixed with chlorsulfuron for

	quicker burndown. *Telar* can be used near water, but cannot be applied to water. Chlorsulfuron is included with aminocyclopyrachlor in *Perspective*. This combination (i.e., formulation) is expected to provide good control, but has not been reported.
Imazapic *Plateau*	**Rate:** 8 to 12 oz product/acre (2 to 3 oz a.e./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective from the bud to the late flowering stage. **Remarks:** Imazapic gives effective control with some soil residual activity. It can be used in combination with glyphosate (premix trade name of *Journey*). Selective to most native grasses. Higher rates may suppress seedings of some cool-season grasses. Add a methylated seed oil. Imazapic is not registered for use in California.
Imazapyr *Habitat*	**Rate:** 1 to 2 qt product/acre (0.5 to 1 lb a.e./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective from the bud to the late flowering stage. **Remarks:** *Habitat* is registered for aquatic use. Also effective following early season mowing and/or disking. It is nonselective, has long soil residual activity, and leaves more bare ground than other treatments, even a year after application. Add a spray adjuvant.
Metsulfuron *Escort*	**Rate:** 1 to 2 oz product/acre (0.6 to 1.2 oz a.i./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective at flower bud and flowering stage. **Remarks:** Metsulfuron has similar activity compared to chlorsulfuron. Metsulfuron has some soil residual activity. Always use a surfactant. Metsulfuron can be tank-mixed with 2,4-D for quicker burndown. Other premix formulations of metsulfuron can be used at similar application timing. These include *Cimarron Max* (metsulfuron + dicamba + 2,4-D) and *Cimarron X-tra* (metsulfuron + chlorsulfuron). Metsulfuron is not registered for use in California.
Propoxycarbazone-sodium *Canter R+P*	**Rate:** 0.9 to 1.2 oz product/acre (0.63 to 0.84 oz a.i./acre) **Timing:** Postemergence to young, rapidly growing plants. **Remarks:** Propoxycarbazone is a broad-spectrum herbicide that will control many species. It will provide only partial control of perennial pepperweed. Perennial grass species vary in tolerance. A non-ionic surfactant should be added at 0.25 to 0.5% v/v solution.

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.

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Taeniatherum caput-medusae (L.) Nevski
(= *Elymus caput-medusae* L. [Jepson Manual 2012])

Medusahead



Family: Poaceae
Range: Arizona, California, Idaho, Nebraska, Nevada, Oregon, Utah, Washington; a few locations in the northeastern states.
Habitat: Disturbed sites, grassland, rangeland, openings in chaparral, oak woodlands, and rarely in agronomic fields. Generally in areas that receive at least 9 inches of rain per year, so not common in the low desert. Grows best on clay soils or where deep soil moisture is available late in the growing season.
Origin: Native to the Mediterranean region.
Impact: Dense stands displace desirable vegetation and reduce livestock and wildlife carrying capacity. Unpalatable to livestock except during the early growth stages. The stiff awns and hard florets can injure eyes, nostrils, and mouths of grazing animals. Birds and rodents usually avoid feeding on the seeds. Senesced plants form a dense layer of thatch that takes a couple of years to decompose. The thatch layer changes the temperature and moisture dynamics of the soil, reduces seed germination of other species, and creates fuel for wildfires.
Western states listed as Noxious Weed: California, Colorado, Nevada, Oregon, Utah
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Medusahead is a noxious rangeland weed that is increasing its range in most of the western states. It is an ascending to erect winter annual grass to 2 ft tall, producing spikes of long-awned spikelets. Medusahead matures at least 2 to 4 weeks later in the season than most other annual grasses, and from a distance, the yellowish-green sheen of dense stands is highly visible after other annual grasses turn brown. The mature plant has slender stems, and the leaf surfaces are glabrous or covered with soft, short hairs, and often appear glassy under magnification. Medusahead produces fibrous roots that grow throughout the cool season, depleting upper soil moisture early in the growing season and accessing deep soil moisture later on.

Medusahead flowers in early summer, often after other annual plants have senesced. Its spikes are 0.5 to 2 inches long excluding awns, and the main spike axis does not break apart at maturity. The fertile seeds have long, often twisted, awns 1 to 3 inches long; the seeds and awns are covered with minute, upward-pointing barbs and are rough to the touch. Seed production is usually prolific. Some florets (seeds) can remain attached to spikes long after plants turn brown. This characteristic allows seeds to disperse by clinging to the feet, fur, and feathers of animals and the shoes and clothing of people.

Most seeds germinate in fall after the first rain, but some seeds remain dormant or germinate in winter or spring. Seeds can germinate in dense litter under low moisture conditions. Seedlings remain attached to the long-awned floret. Seedlings can survive desiccation of the primary root and develop adventitious roots when moisture becomes available. Most seed appears to germinate or lose viability within 2 years in the field.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	There are mixed reports on the effectiveness of mowing. Early-season mowing is likely to be ineffective and may harm other species. Late-season mowing, at the boot to early flowering stage, may help to suppress medusahead. However, mowing after seed set will disperse the seeds. In areas where medusahead has built up a heavy thatch, removal of the thatch by raking, tillage, or burning

	can reduce dominance by medusahead and can help other plant species to get established. Tillage (disking and plowing) will control existing medusahead plants, as well as burying seed and breaking up deep thatch layers. Tillage should be accomplished before seed set. In rangeland or wildland areas, the increased potential for soil erosion, loss of soil moisture, loss of organic matter, and loss of macrobiotic crusts may outweigh the weed control benefits of tillage. These factors should be considered before applying tillage over a large area.
Cultural	The use of fire has given mixed results for medusahead control. Burning in low-elevation, warm-winter sites (e.g., California's Central Valley and foothills) can be extremely effective. Burns are conducted when medusahead is beginning to head out but before seed drop, when most desirable plants have already dropped seed. Two years of burning can nearly eliminate an infestation. In contrast, burning in high-elevation, cool-winter sites usually fails to control medusahead. It is thought that because of reduced ecosystem productivity and a shorter growing season at these sites, there isn't adequate fuel to carry a fire hot enough to kill medusahead seeds. Because of its high silica content, livestock generally avoid grazing medusahead as it approaches maturity. However, heavy grazing in spring, when medusahead is still palatable, can reduce, but not eliminate, an infestation. To limit seed dispersal, animals should be removed before the plants mature. Spring grazing is especially effective in areas where dried medusahead litter has been previously burned or grazed. Best control is achieved if plants are grazed in the stage of boot to flowerhead emergence. In experimental trials, medusahead populations have been reduced using confined grazing with sheep. In recent trials, fertilizing pastures with nitrogen improved the palatability of medusahead, making it attractive to cattle and resulting in medusahead suppression. As discussed above, thatch removal by raking, tillage, or burning can favor establishment of desirable plants. This can also improve efficacy of subsequent applications of some soil-applied herbicides, particularly imazapic.
Biological	Crown rot fungus (*Fusarium culmorum*), an endemic fungus of dry soils in the western states, is a potential biocontrol agent. However, there are no studies to show its effectiveness.

CHEMICAL CONTROL

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GROWTH REGULATORS	
Aminopyralid *Milestone*	**Rate:** 7 to 14 oz product/acre (1.75 to 3.5 oz a.e./acre) **Timing:** Preemergence in fall. **Remarks:** A broadleaf-selective herbicide that is safe on most grasses. There is a 2(ee) Supplemental label for this use in Arizona, California, Colorado, Idaho, Oregon, Washington, Wyoming, and Utah. Research in California's Central Valley showed that 14 oz of *Milestone* (spot treatment rate)/acre gave ~90% control of medusahead, and 7 oz/acre gave ~60% control.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** 0.75 to 1 pt product (*Roundup ProMax*)/acre (0.42 to 0.56 lb a.e./acre) for early-season selective control in shrubland or other perennial systems; 1 to 2 qt product (*Roundup ProMax*)/acre (1.1 to 2.25 lb a.e./acre) for late-season, nonselective control. **Timing:** For selective control, apply postemergence in spring after all seedlings are up and before heading; the tillering stage is ideal. For late-season, nonselective control, apply to rapidly growing plants before seeds are produced. **Remarks:** Glyphosate is a nonselective herbicide with no soil activity.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapic *Plateau*	**Rate:** 4 to 12 oz product/acre (1 to 3 oz a.e./acre) **Timing:** Fall or spring. In warm-winter areas, fall applications may be most effective. In colder climates, spring applications after snow melt are better. **Remarks:** Imazapic has some soil residual activity and mixed selectivity. It tends to favor members of the

	Asteraceae and some grasses. Use a spray adjuvant for postemergence applications. Effects vary depending on soil texture and soil organic matter. Heavy soils and high organic matter may require higher rates. Imazapic also can tie up in litter, and its efficacy is reduced under situations where there is lots of thatch on the soil surface. Not registered for use in California.
Rimsulfuron *Matrix*	**Rate:** 4 oz product/acre (1 oz a.i./acre) **Timing:** Preemergence (fall) to early postemergence (early spring). **Remarks:** Rimsulfuron controls several annual grasses and broadleaves. Perennial grasses are tolerant to fall applications when established and grown under dryland conditions. Application to rapidly growing or irrigated perennial grasses may result in their injury or death. It provides soil residual control in cool climates but degrades rapidly under warm conditions. Rimsulfuron will not control summer annual weeds when applied in fall or spring. Add a surfactant when applying postemergence.
Sulfometuron *Oust* and others	**Rate:** 0.75 to 1.5 oz product/acre (0.56 to 1.13 oz a.i./acre) **Timing:** Preemergence to early postemergence. Preemergence (fall) applications are generally more effective. **Remarks:** Sulfometuron is a broad-spectrum herbicide that is fairly safe on native perennial grasses. This can be an advantage in revegetation use. Use lower rates in arid environments, higher rates in wetter areas (> 20 inches rainfall) and on high organic matter soils. It has fairly long soil residual activity.
Sulfometuron + chlorsulfuron *Landmark XP*	**Rate:** 1.5 to 2.25 oz product/acre **Timing:** Preemergence, in fall or after soil thaws in spring. **Remarks:** See sulfometuron.

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Rubus armeniacus Focke

Himalaya blackberry



Family: Rosaceae
Range: Common throughout the western United States, except in Wyoming, North and South Dakota.
Habitat: Disturbed, open, moist sites such as canals, ditch banks, fencerows, roadsides, open fields, and riparian zones, in a variety of plant communities. It can also tolerate periodic flooding with brackish water.
Origin: A cultivar introduced from Eurasia, originating from Armenia, quickly spread throughout Europe and the rest of the world.
Impact: Himalaya blackberry is a highly competitive plant with a growth form that allows it to quickly crowd out native species. Its thickets have dense canopies allowing little light penetration and reducing the growth of understory plants. In riparian areas it can prevent access to water sources for livestock and wildlife.
Western states listed as Noxious Weed: California, Oregon
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Himalaya blackberry is an evergreen erect shrub that grows up to 10 ft tall and is climbing, mounded, or trailing. The aboveground canes are usually biennial while the roots are perennial. The roots are found in the top 20 inches of the soil but may grow down to a depth of 7 ft in loose soil. The roots can sprout new shoots from root buds, and in good conditions root fragments may sprout a new plant. The stems are green to purplish-red, woody, strongly angled, and are protected against predation by straight or curved pickles with a thick base. The leaves are pinnately compound with 3 to 5 leaflets that are dark green with a white underside covered with dense short hairs. The leaflets are broadest above the middle, toothed and sometimes shallowly lobed.

The flowers of Himalaya blackberry are white to pinkish and numerous in non-glandular panicles. They are self-fertile with 5 petals, and numerous stamens and pistils. The fruit are edible and an aggregate of drupelets that adhere to a fleshy receptacle. The mature berries are ovoid to oblong, black, 0.75 inch long, glossy, and glabrous or slightly pubescent. They typically ripen later in the season than the native berries. Seeds are dispersed primarily by birds. In addition to seeds, plants reproduce by root sprouts and stem tip rooting. Seeds likely only survive a few years in the soil.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling can be an effective control method for small populations. To successfully control populations with mechanical removal, it is important to remove the canes, roots and the root crowns to prevent resprouting. A Pulaski, mattock or similar device can be used to remove plants. Bulldozing may cause resprouting and can spread the weed by fragmenting roots and stems. Cutting and removing only the aboveground biomass will result in the stimulated growth of root sprouts. The root sprouts must be controlled and repeated cutting of the above-ground biomass during flowering time will exhaust the root stores. Tillage can be effective if the canes are raked and removed from the site. However, this will cause significant soil disturbance and is unsuitable in riparian areas.
Cultural	Goats will readily consume Himalaya blackberry and could help to control new populations. It is a common

	method of management in Australia and New Zealand. Their consumption is indiscriminate and could result in the loss of other desirable species. This is particularly true in riparian areas. Burning is only effective if the root sprouts are controlled by other methods, such as chemicals, when they resprout after the burn.
Biological	Blackberry leaf rust fungus (*Phragmidium violaceum*) was discovered in 2005 on the coast of Oregon and has since spread through most of the counties. It appears to have been accidentally introduced. It partially to fully defoliates Himalaya blackberry and evergreen blackberry (*Rubus laciniatus*) and also reduces tip rooting. The fungus is native to Europe, the Middle East and Africa and has been used for years to control native blackberry plants in Australia and New Zealand. It is not an approved biocontrol agent yet and has not shown sustained control of Himalaya blackberry over a wide region.

CHEMICAL CONTROL

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GROWTH REGULATORS	
Dicamba *Banvel*, *Clarity*	**Rate:** 1 to 2 pt product/acre (0.5 to 1 lb a.e./acre) **Timing:** Postemergence, to weed regrowth in the late summer or fall following a mowing or tillage treatment. **Remarks:** Dicamba provides only suppression of growth. It is a broadleaf-selective herbicide often combined with other active ingredients, particularly 2,4-D. Tank mix combinations with glyphosate are also more effective. It may injure grasses at higher rates. Do not apply when outside temperatures exceed 80°F. Do not exceed 64 oz product/acre per year.
Fluroxypyr *Vista XRT*	**Rate:** 22 oz product/acre (7.7 oz a.e./acre) **Timing:** Postemergence when target plants are growing rapidly. **Remarks:** Reduced control occurs if plants are under stressed growth conditions.
Triclopyr *Garlon 3A*, *Garlon 4 Ultra*, *Pathfinder II* Aminopyralid + triclopyr (*Capstone*)	**Rate:** Broadcast foliar treatment: 4 pt product (*Garlon 4 Ultra*)/acre (2 lb a.e./acre). Spot treatment: 0.75 to 1% *Garlon 4 Ultra* or 1% *Garlon 3A*; thoroughly cover the foliage. Basal bark treatment: 20% *Garlon 4 Ultra* mixed with basal oil or seed oil; *Pathfinder II* is a ready-to-use triclopyr/oil mix. Dormant stem and leaf treatment: 1% v/v solution of *Garlon 4 Ultra* with 2 to 3% v/v crop oil concentrate or seed oil. For *Capstone* use 8 to 9 pt product/acre. **Timing:** Postemergence in mid-summer or early fall after flowering and start of fruit set. 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 mid-fall basal bark treatment might be desirable to avoid human contact with the chemical. For dormant stem and leaf treatment apply to dormant leaves and stems in late fall and winter in a 3% crop oil concentrate mixture. 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. **Remarks:** Foliage or stems (dormant stem application) must be thoroughly wet. Triclopyr is broadleaf-selective and safe on most grasses. It is most effective on smaller plants and has little or no residual activity. For basal bark treatment, thoroughly cover a 12 to 15-in basal section of the stem with spray but not to the point of runoff. *Garlon 3A* and other amine formulations are registered for aquatic use. Ester formulations (e.g., *Garlon 4 Ultra*) may volatilize if applied in warm temperatures. Application in some counties and grape-growing areas may be restricted. Sometimes aminopyralid + triclopyr (*Capstone*) or glyphosate and triclopyr (1% solution each) are used to achieve better control.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup*, *Accord XRT II*, and others	**Rate:** Broadcast foliar treatment: 2 to 3 qt product (*Roundup ProMax*)/acre (2.25 to 3.4 lb a.e./acre). Spot treatment: 0.5 to 1.5% v/v solution. **Timing:** Postemergence in late summer to early fall when canes are growing rapidly, have reached full

	leaf maturity, and after berries are formed. Fall treatments must be made before a killing frost. **Remarks:** Fall treatment symptoms may not show before frost. Retreatment may be necessary for complete control. Trailing blackberry is more difficult to control. Glyphosate controls grasses in the treated area as well as other vegetation. To obtain good control complete foliage coverage (spray-to-wet) is essential. Burning or mowing 40 to 60 days after spraying with glyphosate increases the level of control and also contributes to pasture establishment by removing stem debris. Shoots recovering from sublethal glyphosate treatment tend to die more quickly when subjected to heavy grazing. Sometimes glyphosate and triclopyr (1% each in solution) are used in combination to achieve better control.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Metsulfuron *Escort*	**Rate:** 0.5 to 1 oz product/acre (0.3 to 0.6 oz a.i./acre) **Timing:** Postemergence, to fully leafed-out vegetation before fall leaf coloration. **Remarks:** Metsulfuron is primarily active on broadleaf species. Apply only to pasture, rangeland, and non-crop sites. Do not apply when plants are under stressed growing conditions. Metsulfuron can be used in a premix with aminopyralid (*Opensight*) or a tank mix with triclopyr for better control. Metsulfuron and its formulations are not registered for use in California.
Sulfometuron *Oust* and others	**Rate:** 3 to 4 oz product/acre (2.25 to 3 oz a.i./acre) **Timing:** Early postemergence when target plants are germinating or actively growing. Will only be effective on very small plants and not on fully mature plants. **Remarks:** Add a surfactant at 0.25% v/v for improved control.
PHOTOSYNTHETIC INHIBITORS	
Hexazinone *Velpar L*	**Rate:** 3 to 4 gal product/acre (6 to 8 lb a.i./acre) **Timing:** Preemergence or postemergence when plants are germinating or actively growing. **Remarks:** Hexazinone is used as a nonselective herbicide in non-cropland areas and as a selective herbicide in reforestation practices. It only suppresses the growth of Himalaya blackberry. Use higher rates on fine textured soils and soils with high organic matter. Do not apply to frozen ground. Non-target plants may be adversely affected from drift and run-off. Apply when there is adequate moisture for activation. Hexazinone can be mixed with triclopyr for better control. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.
Tebuthiuron *Spike*	**Rate:** 20 lb product (*Spike 20P*)/acre (4 lb a.i./acre) **Timing:** Preemergence before the start of spring growth or before expected seasonal rainfall. **Remarks:** Do not apply tebuthiuron at more than 20 lb/acre. Do not apply more than 10 lb/acre in areas that receive 20 inches or less of annual rainfall. May injure non-target species. Follow restrictions on the label for use around desirable plants.

ECOMMENDED 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.

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Aegilops cylindrica Host.; jointed goatgrass
Aegilops triuncialis L.; barb goatgrass

Jointed goatgrass and barb goatgrass



Family: Poaceae
Range: Jointed goatgrass is found in all western states. Barb goatgrass is found only in California and Oregon, primarily in northern California, especially the Central Valley foothills northward to southern Oregon. Both are expanding their distribution.
Habitat: Disturbed and undisturbed grasslands, oak woodlands, fields, rangelands, pastures, and roadsides. Barb goatgrass tolerates serpentine and hard, shallow, dry, gravelly soils but usually is not found in chaparral. Jointed goatgrass also infests grain fields, especially winter wheat.
Origin: Both species are native to Mediterranean Europe and western Asia.
Impacts: Plants have high silica content, resulting in a persistent thatch that can suppress other species. Barb goatgrass is late-maturing and drought-tolerant, enabling it to occupy and form monocultures in marginal environments. Tough seedheads with long barbed awns are inconvenient for humans and can injure livestock, even fatally. Jointed goatgrass joints are difficult to separate from wheat grains, and contaminated wheat harvests are reduced in quality and value.
Western states listed as Noxious Weed: *A. cylindrica*, Arizona, California, Colorado, Idaho, New Mexico, Oregon, Washington; *A. triuncialis*, California, Oregon
California Invasive Plant Council (Cal-IPC) Inventory: *A. triuncialis*, High Invasiveness

Jointed goatgrass and barb goatgrass are late-maturing winter annual grasses with spikes that resemble those of winter wheat. Both species can hybridize with wheat. Unlike wheat, goatgrass spikes break apart into hardened sections called joints.

Goatgrass plants grow up to 20 inches tall. Jointed goatgrass foliage looks similar to winter wheat, but blades, auricles, ligules, and leaf sheaths have evenly spaced, fine hairs along the margins. Barb goatgrass has gray-green foliage, spreading to erect, usually sparsely covered with fine hairs.

Goatgrass seedheads have spikelets arranged alternately along a zigzag rachis. The spikelets are large, hard, and cylindrical to cone-shaped, with long awns. Barb goatgrass, in particular, has stiff, barbed awns; mature seedheads break off whole and can work their way into fur or clothing. The goatgrasses go to seed later than most annual grasses, usually in late spring to early summer. Jointed goatgrass seedheads are 1 to 5 inches long, and barb goatgrass seedheads are 1 to 2.5 inches long. At maturity, heads turn reddish to purple and then dry to a straw color. Eventually the seedheads break apart into joints (spikelets attached to a piece of rachis). Once on the ground, the joints often can survive field burns because of their hard coat. The spikes and joints disperse by attaching to animals, humans, equipment or vehicles.

Seeds germinate in fall and winter, sometimes while still attached to the joints. In fact, joints often remain attached to the lower shoot of dug-up seedlings. Barb goatgrass seeds can remain viable for 2 years or more on the soil, while jointed goatgrass seeds can remain viable for 3 to 5 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling or hoeing small infestations is effective, if the roots are pulled and air-dried. Mowing can reduce seed production, but timing is critical. Mowing should occur after flowering, but before goatgrass seeds reach the soft boot stage. Early mowing will result in new tiller growth, and late mowing will only spread viable seed. Tillage may be used in certain situations. In agricultural fields, sweep tillage or V-blade tillage may be used during fallow periods. Conventional deep plowing will bury goatgrass seed beyond emergence depth. However, buried seed may be viable for up to 5 years, and secondary tillage may bring goatgrass seed back up to a successful

	emergence depth (< 5 in).
Cultural	Heavy grazing throughout the growing season and high intensity/short duration grazing periodically during the growing season appear to increase plant density. Both species mature later than most rangeland annual grasses, providing a window for controlling goatgrass seed production. It is important to burn before the joints disarticulate, to ensure seed kill. Burning will not effectively control seed on the soil surface. Goatgrass germination may increase the year after burning due to increased fertility and light penetration. Therefore, a second year management strategy must be incorporated, and the population should be monitored for several years. In rangeland, burning the first year followed by herbicide and spring seeding the second year may improve barb goatgrass control. For jointed goatgrass in winter wheat, burning fields after harvest can reduce germination of joints at the surface by 90% or more.
Biological	**Naturally occurring bacterial strains that infect annual brome and jointed goatgrass, but have no effect on wheat, have been isolated in Kansas and Washington. These bacteria may soon be used in a bio-herbicidal approach for** jointed goatgrass control in winter wheat. However, their utility in rangelands has not been explored.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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,* and others	**Rate:** 1 qt product (*Roundup ProMax*)/acre for young plants < 6" tall (1.1 lb a.e./acre); 1.5 to 4 qt product (*Roundup ProMax*)/acre (1.7 to 4.5 lb a.e./acre) for larger plants or plants under stress. **Timing:** Postemergence in late winter to early spring. Apply to rapidly growing, non-stressed plants before flowering. If possible, apply before desirable perennials have emerged. According to label recommendations, seedling goatgrass can be selectively suppressed in pasture with 5 to 11 oz *Roundup ProMax* (or other trade name)/acre. **Remarks:** Glyphosate has no soil activity and is nonselective, so may kill desirable competitors. Its effectiveness is increased by addition of ammonium sulfate.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapic *Plateau*	**Rate:** 4 to 6 oz product/acre (1 to 1.5 oz a.e./acre) **Timing:** Preemergence in fall or postemergence in early spring. **Remarks:** Mixed selectivity, tending to favor Asteraceae and some grasses. Safe for most native grasses, but higher rates may suppress seed of some cool-season grasses. Use lower rates for dry climates and low leaf litter and higher rates as moisture increases and/or leaf litter increases. Use methylated seed oil surfactant. Imazapic has long soil residual activity. Imazapic is not registered for use in California.
Propoxycarbazone-sodium *Canter R+P*	**Rate:** 1.2 oz product/acre (0.84 oz a.i./acre) **Timing:** Postemergence from the 2-leaf to 2-tiller stage when plants are growing rapidly. **Remarks:** Propoxycarbazone is a broad-spectrum herbicide that will control many species. It will provide only partial control of jointed goatgrass and perhaps barb goatgrass. Perennial grass species vary in tolerance. A non-ionic surfactant should be added at 0.25 to 0.5% v/v solution.
Sulfometuron *Oust* and others	**Rate:** 1.33 to 2 oz product/acre (1 to 1.5 oz a.i./acre) **Timing:** Preemergence or early postemergence in fall or in late winter after emergence but before goatgrass is 3 inches tall. **Remarks:** Sulfometuron has mixed selectivity. It is fairly safe on native perennial grasses, especially wheatgrass. Other desirable grasses may be stunted, stressed, or injured. Good for revegetation use. Should be used with a surfactant for early postemergence treatments. Sulfometuron has fairly long soil residual activity. Do not let spray drift onto sensitive crops. May move long distances in dry light windblown soils.
Sulfometuron + chlorsulfuron *Landmark XP*	**Rate:** 1.5 oz product/acre **Timing:** Preemergence, in fall or after soil thaws in spring. **Remarks:** See sulfometuron.

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.

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Ailanthus altissima (Mill.) Swingle

Tree-of-heaven



Family: Simaroubaceae
Range: Throughout the United States except Montana, North Dakota, South Dakota, and Wyoming.
Habitat: Disturbed places, roadsides, urban waste areas, landscaped sites, and many natural communities, including riparian areas, grassland, and woodland. Tolerates shade, many types of pollution, and harsh soil conditions, including acidic soils of mine spoils and phosphorus-poor soils. It can grow in most environments, including pavement cracks.
Origin: Native to China and introduced to North America as a landscape ornamental, as a food plant for a certain type of silkworm, and as a culturally important medicinal plant of Chinese immigrants.
Impacts: Forms dense thickets that compete with native vegetation and reduce wildlife habitat, particularly in riparian areas. Often considered a tree-fall hazard around homes and buildings, and the roots can damage pavement, roads, and foundations. May have allelopathic properties that inhibit the germination of other plants. Although not considered toxic, handling tree-of-heaven foliage can cause contact dermatitis in sensitive individuals, and the pollen is a common allergen.
Western states listed as Noxious Weed: California
California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness

Tree-of-heaven is a fast-growing deciduous tree to nearly 70 ft tall, with large, pinnate-compound leaves. The leaves have an unpleasant skunky odor, especially when crushed. The tree produces a long, deep taproot with many creeping roots that sucker freely. Creeping roots may extend to about 50 ft in all directions.

Trees are dioecious (male or female), with females producing a winged fruit called a samara. Fruits mature in late summer and disperse from fall through the following spring with wind, water, and possibly birds. Most seeds probably fall close to the parent plant. Female trees typically begin to produce fruits at several years of age. One tree can produce 325,000 seeds or more annually, a large proportion of which are viable. Seeds generally survive about 1 year under field conditions and usually do not develop a persistent seed bank. Seedlings typically do not survive in shaded understory conditions. In addition to seed, plants reproduce vegetatively from creeping roots. Root sprouts tolerate shade better than seedlings, and new trees more often develop from the roots of established trees. New shoots can sprout up to 50 ft away from the parent tree and often grow more than 3 ft per year under favorable conditions. Individual trees typically have a life span of 30 to 50 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling can remove seedlings, but once underground creeping roots have developed, this technique is generally not effective. For saplings or small trees, a weed wrench or other woody weed extractor can be used. Care must be taken to extract the entire root or stump sprouting will occur. Best results are achieved when soil is moist.
Cultural	A heavily shaded environment will reduce the establishment of tree-of-heaven.
Biological	No biological control agents have been released for the control of tree-of-heaven.

CHEMICAL CONTROL

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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.

GROWTH REGULATORS	
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product (*Perspective*)/acre **Timing:** Postemergent to foliage of young trees in summer to early fall. **Remarks:** *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Triclopyr *Garlon 3A, Garlon 4 Ultra, Pathfinder II* Aminopyralid + triclopyr *Capstone*	**Rate:** Foliar spot treatment: 1 to 2% v/v solution of *Garlon 4 Ultra* or 1 to 1.5% v/v *Capstone* and water plus 0.5% v/v non-ionic surfactant to thoroughly wet all leaves. Basal cut stump treatment: 20 to 25% *Garlon 4 Ultra* in 80% oil carrier. Cut stump treatment: 20 to 25% *Garlon 3A* in water. Basal bark treatment: 20 to 30% *Garlon 4 Ultra* in 70 to 80% oil carrier, or *Pathfinder II* as a ready-to-use formulation. Stem injection treatment: one cut per every 3 inches of stem diameter, and 1 ml of undiluted *Garlon 3A* added to each cut. For clumps, one hack per every 6 inches of total stem diameter. Treat largest stems. **Timing:** Foliar treatments best when leaves are fully expanded. Cut stump, basal cut stump, basal bark and stem injection treatments can be used anytime, but are best when used in late summer or early fall. **Remarks:** Triclopyr is a selective herbicide for broadleaf species and will not damage desirable grasses growing nearby. Foliar treatment should only be made on small trees, saplings, or seedlings. For cut stump treatments, cut stems horizontally at or near ground level, then immediately apply herbicide solution to cover the outer 20% of the stump face. Coppicing and root suckering typically occur after cutting, but the treatment should control most resprouts. Others have found that stem injection, then cut stump treatment can completely kill tree. Basal bark treatment: spray the lower trunk, including the root collar, to a height of 12 to 15 inches from the ground; the spray should thoroughly wet the lower stem but not to the point of runoff. For stem injection treatments, be sure that each cut goes well into or below the cambium layer. Trees should not be cut for at least 4 months after basal bark and stem injection treatments. A dye can be added to either product. Triclopyr can be applied as a premix with aminopyralid (*Capstone*) at 8 to 9 pt product/acre. Triclopyr can also be mixed with picloram or imazapyr for basal bark treatments (20% *Garlon 4 Ultra* + 5% *Tordon 22K* or 3% *Stalker*). Basal bark applications are made as described for triclopyr. Trees should not be cut for at least one month after treatment. Picloram is not registered for use in California.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** Foliar spot treatment: 2 to 4% solution of glyphosate (*Roundup ProMax* or similar product) and water plus 0.5% v/v non-ionic surfactant to thoroughly wet all leaves. Stem injection treatment: one cut per every 3 inches of stem diameter, and 1 ml of undiluted herbicide added to each cut. For clumps, one hack per every 6 inches of total stem diameter. Treat largest stems. **Timing:** Foliar treatments best when leaves are fully expanded. For stem injection treatments, root injury is increased when applied mid-June to mid-September (fall color). **Remarks:** A nonselective systemic herbicide. Can also be mixed with dicamba to achieve good control with foliar applications. Stem injection and cut stump applications are made as described for triclopyr. Like triclopyr, there is extensive coppicing with a cut stump treatment. Others have found that stem injection with glyphosate, then cut stump treatment can completely kill tree.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapyr *Arsenal, Habitat, Stalker, Chopper, Polaris*	**Rate:** Cut stump treatment: 20% *Stalker* or *Chopper* formulation v/v in 80% oil carrier or 20% *Arsenal* or *Habitat* v/v in 80% water carrier. Stem injection treatment: one cut per every 3 inches of stem diameter, and 1 ml of undiluted herbicide (*Arsenal* or *Habitat*) added to each cut. For clumps, one hack per every 6 inches of total stem diameter. Treat largest stems. Basal bark treatment: 20% *Stalker* or *Chopper* formulation v/v in 80% oil carrier.

	Timing: Best when used in late summer to early fall, but before leaf drop. **Remarks:** Soil residual herbicide. May result in bare ground around trees for some time after treatment. Applications are made as described for triclopyr. Imazapyr is the most consistent and best stem treatment for tree-of-heaven.
Metsulfuron *Escort*	**Rate:** 2 oz product/acre for foliar application (1.2 oz a.i./acre) **Timing:** Treatments best when leaves are fully expanded. **Remarks:** Can be tank mixed with glyphosate or triclopyr. Not registered for use in California.

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.

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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

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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.

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Carduus acanthoides L.; plumeless thistle
Carduus nutans L.; musk thistle
Carduus pycnocephalus L.; Italian thistle
Carduus tenuiflorus Curtis; slenderflower thistle

Plumeless, musk, Italian, and slenderflower thistle



Family: Asteraceae
Range: Musk thistle is found in all western states. Plumeless thistle is found in most western states, except Oregon, Nevada, Utah and Arizona. Italian and slenderflower thistle are most common in west coast states, Washington, Oregon and California. Italian thistle is also found in Idaho.
Habitat: Disturbed open sites, roadsides, pastures, annual grasslands, and waste areas. These thistles can tolerate a relatively wide range of soil types but prefer fertile, well-drained soils.
Origin: All species are native to Europe and the Mediterranean region.
Impacts: These thistles can dominate sites and crowd out native species and forage plants. The spines inhibit grazing and discourage livestock and wildlife from entering infested areas.
Western states listed as Noxious Weed: *C. acanthoides*, Arizona, California, Colorado, Oregon, South Dakota, Washington, Wyoming; *C. nutans*, California, Colorado, Idaho, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming; *C. pycnocephalus*, California, Oregon, Washington; *C. tenuiflorus*, California, Oregon, Washington
California Invasive Plant Council (Cal-IPC) Inventory: *C. acanthoides* and *C. tenuiflorus*, Limited Invasiveness; *C. nutans* and *C. pycnocephalus*, Moderate Invasiveness

The weedy *Carduus* thistles are winter annuals or biennials with prickly leaves and stems with prickly wings. Plumeless thistle and musk thistle grow to 5 ft tall. They are closely related and may hybridize. Italian thistle and slenderflower thistle are also closely related and can grow to 6.5 ft tall. All these thistles form deep taproots. Plants may grow as a biennial, germinating in winter to early spring and existing as a rosette until flower stems develop in spring to summer of the following year. After bolting, stems branch near the top. Stem leaves taper down the stem as spiny wings.

All these thistles produce purple to pink, rarely white, flowers in summer. Plumeless and musk thistle have typical hemispherical thistle flowers, while Italian and slenderflower thistle flowers are more cylindrical in shape. Musk thistle flowers are often nodding on long stalks. Reproduction in all these species is only by seed. Seeds typically fall near the parent plant or are disperse to greater distances with wind. Seeds that germinate in late summer to fall often behave as winter annuals and flower in the following summer. Seeds rarely persist in the soil seedbank for more than a few years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	These thistles can be cultivated or manually removed when small. To control by cutting, use a sharpened shovel at the top of the root crown. Grubbing hoes must cut the plants 2 to 4 inches below ground level to prevent resprouting from dormant axillary buds.

	Mowing the plant during flowering can greatly reduce seed production, though a single mowing is seldom sufficient due to the wide differences in the maturity of plants in a natural population. For mowing, wait till plants bolt and are about to flower. This may require repeated visits at weekly intervals over the 4 to 7 week blooming period, because not all plants bloom simultaneously. Plants will regrow if mowed before they are fully bolted. Plants cut 4 days after the first flowers open can produce viable seed.
Cultural	Large livestock tend to avoid grazing on thistles, although horses and cattle have been known to eat the flowerheads. Sheep will eat the rosettes. Goats like the flowerheads and are able to digest the seed. Depending on timing, the soil seedbank, the plant community, and other factors, fire may help control thistles or may promote their invasion. Grass fires may not be hot enough to kill the root crown of thistle rosettes, but a flamer can be used to kill individual plants. In general, thistles compete poorly with healthy established grasses and other vegetation. Establishment of selected, aggressive grasses can be an effective cultural control of thistles.
Biological	The thistle head weevil (*Rhinocyllus conicus*) is an introduced biocontrol agent that attacks *Carduus* species and several other thistles. It is established in much of the northwestern and north central United States. The weevil gives effective control of musk thistle in parts of Montana, less so in other areas. The crown weevil (*Trichosirocalus horridus*) and thistle crown fly (*Cheilosia corydon*) also are locally established. The fungus musk thistle rust (*Puccinia carduorum*) may soon be approved as a biocontrol agent.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 2 qt product/acre (0.95 to 1.9 lb a.e./acre) **Timing:** Postemergence in the rosette stage. **Remarks:** 2,4-D is broadleaf-selective and has no soil activity. It may require repeat application. It is not the most effective treatment, but is widely used because of low cost. Do not apply ester formulations when outside temperatures exceed 80°F.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 3 to 4.5 oz product/acre **Timing:** Postemergence in spring up to flowering, or in fall rosette stage. **Remarks:** *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid *Milestone*	**Rate:** 4 to 5 oz product/acre (1 to 1.25 oz a.e./acre) **Timing:** Preemergence in winter to early spring and postemergence to seedling treatments in spring up to flower bud stage. Can be applied in fall in cold-winter areas. Apply when plants are at the late bolt through early flowering stages. For late applications starting at the late bud stage, 2,4-D at 1 lb ae/acre should be tank-mixed with *Milestone*. **Remarks:** Aminopyralid is one of the most effective herbicides for thistles. It is a broadleaf herbicide like picloram, but more selective and with a shorter soil residual activity. Aminopyralid is generally safe on grasses. It has longer soil residual and higher activity than clopyralid.
Aminopyralid + 2,4-D, *Forefront HL*; Aminopyralid + metsulfuron, *Opensight*; Aminopyralid + triclopyr, *Capstone*	**Rate:** 1.5 to 2 pt *Forefront HL*/acre; 1 to 3 oz *Opensight*/acre; 4 to 6 pt *Capstone*/acre **Timing:** Postemergence in rosette to bolting stages. **Remarks:** These combinations are broadleaf-selective. *Opensight* is not registered for use in California.
Clopyralid	**Rate:** 0.25 to 1.33 pt product/acre (1.5 to 8 oz a.e./acre)

Transline	**Timing:** Postemergence in spring, up to the flower bud stage. **Remarks:** Clopyralid is a broadleaf herbicide that is more selective to some broadleaf plants than picloram. It is very safe on grasses.
Clopyralid + 2,4-D *Curtail*	**Rate:** 2 to 4 qt product/acre (use higher rate if plants are drought-stressed) **Timing:** Postemergence to rapidly growing weeds from full rosette to early flower bud. **Remarks:** The combination is broadleaf-selective with a wide range of susceptible species.
Dicamba *Banvel, Clarity*	**Rate:** 0.5 to 2 pt product/acre (0.25 to 1 lb a.e./acre); 8 to 16 oz product/acre for rosettes, up to 2 pt product/acre for bolting plants **Timing:** Postemergence to rapidly growing plants up to bolting. Application to smaller plants gives better control. **Remarks:** Dicamba is a broadleaf-selective herbicide often combined with other active ingredients. It is effective earlier in the season than 2,4-D. It is also effective when tank-mixed with 2,4-D (0.75 lb a.e./acre 2,4-D + 0.25 lb a.e./acre dicamba). Dicamba has very limited soil residual. Avoid drift to sensitive crops. Do not apply when outside temperatures exceed 80°F. Dicamba is available mixed with diflufenzopyr in a formulation called *Overdrive*. The combination is broadleaf-selective, but safe on most grasses. This has been reported to be effective on plumeless and musk thistle, and may have a similar effect on other members of the genus *Carduus*. Diflufenzopyr is an auxin transport inhibitor which causes dicamba to accumulate in shoot and root meristems, increasing its activity. *Overdrive* is applied postemergence at 4 to 8 oz product/acre on rapidly growing plants. Higher rates should be used on large annuals and biennials or when treating perennial weeds. Add a non-ionic surfactant to the treatment solution at 0.25% v/v or a methylated seed oil at 1% v/v solution.
Fluroxypyr *Vista XRT*	**Rate:** 22 oz product/acre (7.7 oz a.e./acre) **Timing:** Postemergence to rapidly growing weeds. **Remarks:** Fluroxypyr is broadleaf-selective and safe on most grasses.
Picloram *Tordon 22K*	**Rate:** 0.67 to 1 qt product/acre (0.33 to 0.5 lb a.e./acre) **Timing:** Postemergence from flower bud stage to senescence. Most effective in fall treatments. **Remarks:** Picloram is one of the most effective herbicides for this weed and can provide 2 years of control. Most broadleaf plants are susceptible, but it is relatively safe on established grasses. It can injure young or germinating grasses. Picloram is also effective when mixed with dicamba or 2,4-D. It has long soil residual activity. Picloram can be used in a premix with 2,4-D (*Grazon P+D*) or fluroxypyr (*Surmount*) for the control of *Carduus* species. Picloram is a restricted use herbicide. Picloram and its formulations are not registered for use in California.
Triclopyr *Garlon 3A, Garlon 4 Ultra*	**Rate:** 1.33 to 2.66 qt *Garlon 3A*/acre or 1 to 2 qt *Garlon 4 Ultra*/acre (1 to 2 lb a.e./acre) **Timing:** Postemergence to rapidly growing weeds. **Remarks:** Triclopyr is broadleaf-selective and safe on most grasses. It is most effective on smaller plants. *Garlon 4 Ultra* is formulated as a low volatile ester. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage. Rates are based on those reported for Canada thistle.
Triclopyr + 2,4-D *Crossbow*	**Rate:** 2 to 4 qt product/acre **Timing:** Postemergence during the rosette stage. **Remarks:** Include non-ionic surfactant at 1 qt/100 gal water (0.25% v/v).
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** 1.33 to 2.67 qt product (*Roundup ProMax*)/acre (1.5 to 3 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants in bud stage. **Remarks:** Glyphosate has no soil activity and is nonselective. Repeat applications may be necessary. It is more effective with the addition of ammonium sulfate.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1 to 2.6 oz product/acre (0.75 to 1.95 oz a.i./acre) **Timing:** Postemergence in fall to new rosettes, or to rosettes in spring before bolting. Chlorsulfuron

	or metsulfuron applied from the bolting through very early bud stage eliminated viable achene development. **Remarks:** Chlorsulfuron has mixed selectivity, but is generally safe on grasses. Use a surfactant. It can be used in late season applications to reduce seed production and has fairly long soil residual activity. Fall application may injure desirable bromes.
Imazapic *Plateau*	**Rate:** 8 to 12 oz product/acre (2 to 3 oz a.e./acre) **Timing:** Preemergence or early postemergence. Only suppression of musk thistle when applied preemergence. **Remarks:** Imazapic has mixed selectivity and some soil residual activity. Although the label indicates that musk thistle can be controlled with imazapic, it generally tends to favor members of the Asteraceae and some grasses. Use a methylated seed oil surfactant at 0.25% v/v. Not registered for use in California.
Imazapyr *Arsenal, Habitat, Stalker, Chopper, Polaris*	**Rate:** 3 to 4 pt product/acre (0.75 to 1 lb a.e./acre) **Timing:** Preemergence or postemergence. **Remarks:** Imazapyr is a nonselective herbicide. Rates are based on those reported for bull thistle.
Metsulfuron *Escort*	**Rate:** 0.5 to 1 oz product/acre (0.3 to 0.6 oz a.i./acre) **Timing:** Postemergence to young, rapidly growing weeds in spring before flowering, or in fall to new rosettes. Chlorsulfuron or metsulfuron applied from the bolting through very early bud stage eliminated viable achene development. Metsulfuron seemed to work a bit better than chlorsulfuron. **Remarks:** Metsulfuron has mixed selectivity and is generally safe on grasses. Use a surfactant. It can be tank-mixed with aminopyralid (*Opensight*), 2,4-D and/or dicamba. Metsulfuron has some soil residual activity. It is not registered for use in California.
Metsulfuron + chlorsulfuron *Cimarron X-tra*	**Rate:** 0.5 oz product/acre **Timing:** Postemergence before flowering. **Remarks:** It is not registered for use in California.
Sulfometuron *Oust* and others	**Rate:** 6 to 8 oz product/acre (4.5 to 6 oz a.i./acre) **Timing:** Preemergence or early postemergence, during the rainy season when weeds are germinating or rapidly growing. **Remarks:** Sulfometuron has mixed selectivity, but is fairly safe on native perennial grasses, especially wheatgrass. This rate is very high and may not be the best option. Desirable grasses may be stunted, stressed, or injured. Sulfometuron has fairly long soil residual activity.
PHOTOSYNTHETIC INHIBITORS	
Hexazinone *Velpar L*	**Rate:** 4 to 6 pt product/acre (1 to 1.5 lb a.e./acre) **Timing:** Preemergence before weeds emerge or postemergence to young plants. **Remarks:** Hexazinone has both foliar and soil activity. In soil applications, rates will vary with soil texture and soil organic matter; best results when applied to moist soil. Use rates will also vary depending on the weed species to be controlled. Hardwood trees near application site can absorb this chemical through the roots and may be injured or killed. Do not spray near the root zone of desirable hardwood trees or shrubs. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.

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.

This WEED REPORT does not constitute a formal recommendation. When using herbicides always read the label, and when in doubt consult your farm advisor or county agent.

This WEED REPORT is an excerpt from the book *Weed Control in Natural Areas in the Western United States* and is available wholesale through the UC Weed Research & Information Center (wric.ucdavis.edu) or retail through the Western Society of Weed Science (wsweedscience.org) or the California Invasive Species Council (cal-ipc.org).

Centaurea solstitialis L.

Yellow starthistle



Family: Asteraceae
Range: Most contiguous states, except a few southern and northeastern states.
Habitat: Open disturbed sites, open hillsides, grassland, rangeland, open woodlands, fields, pastures, roadsides, waste places. May also inhabit cultivated fields. Does not tolerate low light areas or shading.
Origin: Southern Europe. Accidentally introduced as a seed contaminant in alfalfa. It has spread rapidly since its introduction into California in the mid-1800s.
Impacts: Plants are highly competitive and typically develop dense, impenetrable stands that displace desirable vegetation in natural areas, rangelands, roadsides and other places. Yellow starthistle is considered one of the most serious rangeland weeds in the western U.S. Yellow starthistle is sometimes problematic in grain fields, where the seeds can contaminate the grain harvest and lower its quality and value. Yellow starthistle contains an unidentified compound that causes nigropallidal encephalomalacia or chewing disease in horses.
Western states listed as Noxious Weed: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Yellow starthistle is a simple to bushy winter annual, occasionally biennial, with spiny yellow-flowered heads and stiff wiry stems to 6 ft tall. Plants form a basal rosette of leaves until mid-spring. Stem leaves are alternate and mature foliage is grayish- to bluish-green, densely covered with fine white cottony hairs. Its leaf bases form wings along the stems. Rosette leaves typically wither by flowering time. The taproot can extend deep into the soil (> 6 ft) allowing plants to utilize deep soil moisture not available to other annual species, particularly grasses.

The flowerheads are solitary on stem tips, and consist of numerous yellow disk flowers. The phyllaries are densely to sparsely covered with cottony hairs or with patches of hairs at the bases of the spines. The central spine of the main phyllaries is 10 to 25 mm long, stiff, yellowish to straw-colored throughout. Yellow starthistle reproduces only by seed and develops two types of achenes. The outer ring of achenes is a dull dark brown, often speckled with tan, lacking pappus bristles, and often remaining in heads. The inner achenes are glossy, gray or tan to mottled cream-colored and tan, with slender white pappus bristles 2 to 5 mm long. Most seeds fall near the parent plant. Some seed is viable 8 days after flower initiation. Large flushes of seeds typically germinate after the first fall rains, but smaller germination flushes can occur during winter and early spring. Seeds can survive for up to about 10 years in the field under certain environmental conditions, but it appears that few seeds survive beyond 4 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand removal, mowing, or cultivation, when used to prevent seed production over 2 to 3 years or more (the soil life of the seeds), can reduce or eliminate an infestation. Manual removal of yellow starthistle is most effective with small patches or in maintenance programs where plants are sporadically located in the grassland system. This usually occurs with a new infestation or in the third year or later in a long-term management program. These methods can also be important in steep or uneven terrain where other mechanical tools (e.g., mowing) are impossible to use. To ensure that

	plants do not recover it is important to detach all above-ground stem material. Leaving even a 2-inch piece of the stem can result in recovery if leaves and buds are still attached to the base of the plant. The best timing for manual removal is after plants have bolted but before they produce viable seed (i.e. early flowering). At this time, plants are easy to recognize, and some or most of the lower leaves have senesced. If hand removal is conducted after plants begin to produce seeds, it may be necessary to put pulled plants in bags and remove them from the site. Hand removal is particularly easy in areas with competing vegetation. Under this condition, yellow starthistle will develop a more erect slender stem with few basal leaves. These plants are relatively brittle and easy to remove. In addition, they usually lack leaves at the base and, consequently, rarely recover even when a portion of the stem is left intact. Hand removal options for yellow starthistle typically include hand pulling, hoeing, or string trimming. Systematic surveys and repeated removal should be conducted every 2 to 4 weeks throughout the growing season. Mowing is most effective when 2 to 5% of the total population of seedheads is in bloom. Mowing too early can result in higher seed production. Plants should be cut below the height of the lowest branches. It will require multiple years of continuous mowing to successfully manage yellow starthistle. Mowing is best used in an integrated approach. Since it is a late season management tool, it is best employed in the later years of a long-term management program or in a lightly infested area. Mowing is not feasible in many locations due to rocks and steep terrain. Mowing is not always successful and can decrease the reproductive efforts of insect biocontrol agents, injure late growing native forb species, and reduce fall and winter forage for wildlife and livestock. The success of mowing depends on proper timing and the growth form of the plant. Mowing too early (before seedheads reach spiny stage) or too late (after seed set) will usually increase the yellow starthistle problem. Mowing too early in the season can remove competitive grass cover and promote vigorous yellow starthistle regrowth. If done too late, mowing scatters yellow starthistle seed. Best results were obtained by mowing once at the early flowering stage, and again 4 to 6 weeks later to cut regrowth during the floral bud stage. A dense spring canopy of desirable vegetation optimizes yellow starthistle control. Yellow starthistle plants with an erect, high-branching growth form are effectively controlled by a single mowing at the early flowering stage, while sprawling low-branching plants cannot be controlled even with repeated mowing. Despite its limitations, mowing conducted at the early flowering stage, before viable seed production, can be very effective for yellow starthistle control. Anecdotal information also indicates that mowing the standing skeletons in fall, before the first rains, can form a mulch that blocks light and suppresses subsequent germination of yellow starthistle. A flail mower is considered best. The yellow starthistle litter layer may be less suppressive to grass germination, as it is not as light dependent as yellow starthistle. Tillage is effective, and is occasionally used on roadsides. It is also often used in agricultural lands, which is probably why yellow starthistle is not a significant cropland weed. In wildlands and rangelands, tillage is usually not appropriate because it can damage important desirable species, increase erosion, alter soil structure, and expose the soil for rapid reinfestation if subsequent rainfall occurs. Any tillage operation that severs the roots below the soil surface can effectively control yellow starthistle. Early summer tillage, before viable seeds are set, and repeated tillage following rainfall/germination events will rapidly deplete the yellow starthistle seed bank, but may also have the same effect on the seed bank of desirable species.
Cultural	High-intensity short-duration grazing by sheep, goats, or cattle should be implemented during the period when yellow starthistle plants have bolted to just before they produce spiny heads. Cattle and sheep avoid yellow starthistle once the buds produce spines, whereas goats continue to browse plants even in the flowering stage. For this reason, goats have become a more popular method for controlling yellow starthistle in relatively small infestations. Grazing the weed during the bolting stage can provide palatable high protein forage (8 to 14%). This can be particularly useful in late spring and early summer when other annual species have senesced. Grazing alone will not provide long-term management or eradication of yellow starthistle, but can be a valuable tool in an integrated management program. This prescription must be continued for at least 3 years in a severe infestation to reduce the yellow starthistle seed bank. Prescribed burns can provide control if conducted at the proper timing. Burning should be timed to coincide with the very early yellow starthistle flowering stage. At this time yellow starthistle has yet to produce viable seed, whereas seeds of most desirable species have dispersed and grasses have dried to provide adequate fuel. Fire has little if any impact on seeds in the soil. Burning at other times may enhance yellow starthistle survival by removing the thatch and encouraging seed germination in fall. The ability to use repeated burning depends on climatic and environmental conditions. In areas where

	resources are ample and total plant biomass is abundant, 2 or 3 consecutive years of burning may be practical. However, in other situations, fuel loads may not be sufficient to allow multiple year burns. Consequently, prescribed burning may be more appropriate as part of an integrated approach. Air quality issues can be significant when burns are conducted adjacent to urban areas. A major risk of prescribed burning is the potential of fire escapes. This risk is greatest when burns are conducted during the summer months. In some areas, burning can lead to rapid invasion by other undesirable species with wind-dispersed seeds, particularly members of the sunflower family. In addition to summer burning, yellow starthistle seedlings have been controlled using winter or early spring flaming. This technique is somewhat nonselective, and control of yellow starthistle is inconsistent. When spring drought follows a flaming treatment, control of yellow starthistle can be excellent. In contrast, a wet spring can lead to complete failure and increased yellow starthistle infestation, particularly since competing species may be dramatically suppressed.
Biological	Six insects have become established for the control of yellow starthistle in the western United States. These include three species of weevils (seed-head weevil [*Bangasternus orientalis*], flower weevil [*Larinus curtus*], and the hairy weevil [*Eustenopus villosus*]), and three species of flies (seed-head fly [*Urophora sirunaseva*], peacock fly [*Chaetorellia australis*], and the false peacock fly [*Chaetorellia succinea*]). All six insects attack the flower heads of yellow starthistle and produce larvae that develop and feed within the seedhead. Of these, only four have become well established. Of these, only two, *Eustenopus villosus* and *Chaetorellia succinea*, have any significant impact on reproduction. The combination of these two insects reduces seed production by 43 to 76%. Although this level of suppression is not sufficient to provide long-term yellow starthistle management, the use of biological control agents can be an important component of an integrated management approach. A more successful biological control program will likely require the introduction of plant pathogens or other insects which attack roots, stems, or foliage. A new potential biological control agent is a root-feeding weevil, *Ceratapion basicorne*, that has shown promise under greenhouse conditions. It has yet to be approved, but is expected to be released in the next couple of years. The most widely studied pathogen for yellow starthistle control is the Mediterranean rust fungus *Puccinia jaceae*. It can attack the leaves and stem of yellow starthistle, causing enough stress to reduce flowerhead and seed production. Although it has been released it does not seem to have much impact on yellow starthistle populations.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 1.5 pt product/acre (0.48 to 0.72 lb a.e./acre) for small rosettes, 2 to 4 pt product/acre (0.95 to 1.9 lb a.e./acre) for larger plants up to bolting **Timing:** Postemergence from rosette to beginning of bolting, but before flowering. **Remarks:** 2,4-D controls larger plants well, but is not considered as effective as other growth regulator herbicides for season-long control. It is broadleaf-selective and may injure other non-target species, particularly crop plants. 2,4-D has no soil activity. Do not apply ester formulation when outside temperatures exceed 80°F. Amine forms are as effective as ester forms for small rosettes, and amine forms reduce the chance of off-target movement from volatility.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 3 to 5 oz product (*Perspective*)/acre **Timing:** Postemergence and preemergence. Postemergence applications are most effective when applied to plants from the seedling to the mid-rosette stage. **Remarks:** Aminocyclopyrachlor gives control of yellow starthistle similar to aminopyralid. *Perspective* provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for

	use in California and some counties of Colorado (San Luis Valley).
Aminopyralid *Milestone*	**Rate:** 3 to 5 oz product/acre (0.75 to 1.25 oz a.e./acre). Use higher rates when weeds are larger. **Timing:** Postemergence and preemergence. Postemergence applications are most effective when applied to plants from the seedling to the mid-rosette stage. Earlier applications (i.e., in fall) may not provide full-season control, and later applications (bolting to early spiny stage) will require higher rates. **Remarks:** Aminopyralid is one of the most effective herbicides for the control of yellow starthistle. It is safe on grasses, although preemergence application at high rates can greatly suppress invasive annual grasses, such as medusahead. Aminopyralid has a longer residual and higher activity than clopyralid. Other members of the Asteraceae and Fabaceae are very sensitive to aminopyralid. For postemergence applications, a non-ionic surfactant (0.25 to 0.5% v/v spray solution) enhances control under adverse environmental conditions; however, this is not normally necessary. Other premix formulations of aminopyralid can also be used for yellow starthistle control. These include *Opensight* (aminopyralid + metsulfuron; 1.5 to 2 oz product/acre) and *Forefront HL* (aminopyralid + 2,4-D; 2 to 2.6 pt product/acre), both applied at the rosette to bolting stages.
Clopyralid *Transline*	**Rate:** 0.25 to 0.67 pt product/acre (1.5 to 4 oz a.e./acre). Seedlings and rosettes can be treated at the lower rate, but bolted plants should be treated at higher rates. **Timing:** Postemergence and preemergence. For postemergence application, apply to plants from seedling to mid-bolting stage. However, since clopyralid has a shorter soil residual compared to aminopyralid, optimal timing is at the later rosette stages, but before bolting. Earlier applications (i.e., in fall) may not provide full-season control, and later applications (bolting to early spiny stage) will require higher rates and may not give sufficient control. **Remarks:** Clopyralid gives excellent control of yellow starthistle. While it is very safe on grasses, it will injure many members of the Asteraceae, particularly thistles, and can also injure legumes, including clovers. Most other broadleaf species and all grasses are not injured. When clopyralid is used to control seedlings a surfactant is not necessary. However, when treating older plants or plants exposed to moderate levels of drought stress, surfactants can enhance the activity of the herbicide.
Clopyralid + 2,4-D *Curtail*	**Rate:** 2 to 4 qt *Curtail*/acre **Timing:** Same as for clopyralid. **Remarks:** Add a non-ionic surfactant.
Dicamba *Banvel, Clarity*	**Rate:** 0.5 pt product/acre (0.25 lb a.e./acre) for seedlings, 1 to 1.5 pt product/acre (0.5 to 0.75 lb a.e./acre) for larger plants up to bolting. **Timing:** Postemergence to plants from rosette to beginning of bolting. **Remarks:** Dicamba is a broadleaf-selective herbicide often combined with other active ingredients. It is not typically used alone to control yellow starthistle. Dicamba is available mixed with diflufenzopyr in a formulation called *Overdrive*. This has been reported to be effective on yellow starthistle. Diflufenzopyr is an auxin transport inhibitor which causes dicamba to accumulate in shoot and root meristems, increasing its activity. *Overdrive* is applied postemergence at 4 to 8 oz product/acre to rapidly growing plants. Higher rates should be used on large annuals. Add a non-ionic surfactant to the treatment solution at 0.25% v/v or a methylated seed oil at 1% v/v solution.
Picloram *Tordon 22K*	**Rate:** 1 to 1.5 pt product/acre (4 to 6 oz a.e./acre) **Timing:** Postemergence and preemergence. Postemergence applications should be made to plants from rosette to bud formation stage. Apply when there is adequate soil moisture and weeds are growing rapidly. **Remarks:** Picloram acts much like aminopyralid, aminocyclopyrachlor, and clopyralid, but gives a broader spectrum of control and has much longer soil residual activity. It can provide about 2 to 3 years of control. Most broadleaf plants are susceptible. Although well-developed grasses are not usually injured by labeled use rates, some applicators have noted that young grass seedlings with fewer than four leaves may be killed. Do not apply near trees. *Tordon 22K* is a federally restricted use pesticide. Picloram is not registered for use in California.

Triclopyr *Garlon 3A, Garlon 4 Ultra*	**Rate:** 1 pt *Garlon 4 Ultra* or 1.33 pt *Garlon 3A*/acre (0.5 lb a.e./acre) for seedlings, up to 3 pt *Garlon 4 Ultra* or 4 pt *Garlon 3A*/acre (1.5 lb a.e./acre) for larger plants. **Timing:** Postemergence from seedling to bolting stage. **Remarks:** Triclopyr has little to no residual activity. It is broadleaf-selective and typically does not harm grasses. *Garlon 4 Ultra* is formulated as a low volatile ester. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** Broadcast foliar treatment: 1.33 to 2.67 qt product (*Roundup ProMax*)/acre (1.5 to 3 lb a.e./acre). Spot treatment: 1% to 2% v/v solution **Timing:** Postemergence to plants from bolting to beginning of flowering. **Remarks:** Glyphosate is the most effective herbicide for late season control. Good coverage, clean water, and rapidly growing yellow starthistle plants are all essential for adequate control. It has no soil activity and is nonselective. To achieve selectivity, it can be applied using a wiper or spot treatment to control current year's plants.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1.33 to 2.6 oz product/acre (1 to 1.95 oz a.i./acre) **Timing:** Preemergence activity only. Chlorsulfuron does not have postemergence activity on yellow starthistle and must be used in combination with 2,4-D, dicamba, or triclopyr to provide effective control. **Remarks:** Chlorsulfuron has mixed selectivity on both broadleaf and grass species but is generally safe on grasses. It has fairly long soil residual activity. Herbicide solution requires constant agitation during application.
Imazapyr *Arsenal, Habitat, Stalker, Chopper, Polaris*	Not often used for yellow starthistle control but has been shown to be somewhat effective at 3 to 4 pt product/acre. It has preemergence and some postemergence activity, and a long soil residual.
Sulfometuron *Oust* and others	Not often used for yellow starthistle control but has been shown to be somewhat effective at 1 to 2 oz product/acre. It has preemergence activity only, and a long soil residual.
PHOTOSYNTHETIC INHIBITORS	
Hexazinone *Velpar L*	Not often used for yellow starthistle control but has been shown to be somewhat effective at 1 to 2.5 gal product/acre. It has preemergence activity only, and a long soil residual. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.

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.

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Conium maculatum L.

Poison-hemlock



Family: Apiaceae
Range: Throughout the contiguous U.S., including every western state.
Habitat: Moist soil along hedgerows, along the banks of streams and rivers, roadsides and wastelands, woodlands, meadows, and pastures.
Origin: Native to Europe.
Impact: Produces piperidine alkaloids which are highly toxic to humans and animals. Domestic animals such as swine, cattle, goats, horses, and sheep can be poisoned by the toxin coniine after ingesting any portion of the plant. Poison-hemlock is the most toxic to cattle. Symptoms can include vomiting, nausea, trembling, rapid respiration, joint and movement problems, slow, weak and rapid pulse, increased salivation and urination, convulsions, paralysis, coma, and death from respiratory paralysis. Ingestion during fetal development can result in severe birth defects.
States listed as Noxious Weed: Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, Washington
California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness

Poison-hemlock is a tall branching biennial to 4 to 6 ft tall. The stem is erect, hollow, smooth, bright green with a distinctive mottled appearance and irregular purple splotches. The long-stalked leaves are glabrous, up to 2 ft long, bright green, alternate, and tripinnately compound (divided into leaflets which are again divided and subdivided). Its root is a long, forked, fleshy taproot, pale yellow in color, with numerous lateral roots.

The inflorescence is a compound umbel with 12 to 16 rays, and numerous small white flowers located at the terminal positions. Each flower produces two gray-brown seeds with five wavy longitudinal ridges. The seeds have the highest concentration of coniine. Poison hemlock smells like mouse urine when crushed, a characteristic of the poisonous alkaloids. Plants reproduce only by seed. Most seeds fall near the parent plant. Seed dispersal is prolonged and occurs from late summer through winter. Most seeds germinate almost immediately if conditions are favorable, but a small proportion remains dormant. Dormant seeds require a period of high summer and/or low winter temperatures before they can germinate. Seeds survive up to about 3 years under field conditions.

NON-CHEMICAL CONTROL

Mechanical (mowing, plowing, and cultivation)	Hand removal is recommended for small infestations. When pulling the plants, dig down and remove the entire taproot. Wear gloves and wash hands after working with poison-hemlock. Manual control efforts can be successful, but can cause soil disturbance encouraging further germination of seeds. Solid carpets of hemlock seedlings are not uncommon following soil disturbance. Cutting is ineffective; the plants send up new seed stalks in the same season the cutting occurs. Establishment of populations can be prevented with repeated cultivation and plowing.
Cultural	Due to the plant's toxicity, grazing is not recommended for control. Even dried plant parts are not safe as the toxins take several years to dissipate. Use certified weed-free hay to prevent the poisoning of livestock. Do not burn, as toxins can be released into the air through the smoke.
Biological	There are no known biological controls. Since its introduction to North America, only a few native insects have been able to overcome its toxic defenses. These attack the seedhead, but do very little damage to the rest of the plant.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 1 to 4 pt product/acre (0.48 to 1.9 lb a.e./acre) **Timing:** Postemergence in seedling to rosette stage. **Remarks:** Broadleaf-selective, most effective when applied soon after plants emerge. Adding a wetting agent may enhance control. Also effective tank mixed with dicamba.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product/acre **Timing:** Postemergence in seedling to rosette stage. **Remarks:** Broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid + metsulfuron *Opensight*	**Rate:** 2.5 to 3.3 oz product/acre **Timing:** Preemergence in fall, or postemergence in the seedling to rosette stage. **Remarks:** Not registered for use in California.
Triclopyr *Garlon 4 Ultra, Remedy Ultra*	**Rate:** 5 to 8 pt product/acre (2.5 to 4 lb a.e./acre) **Timing:** Postemergence in seedling to rosette stage. **Remarks:** Broadleaf-selective, safe on most grasses. Most effective on smaller plants. *Garlon 4 Ultra* and *Remedy Ultra* are low volatile esters. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage. Also effective in a premix with 2,4-D (*Crossbow*) or tank mixed with clopyralid (*Transline*).
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** Broadcast treatment: 1.33 to 2.67 qt product (*Roundup ProMax*)/acre (1.5 to 3 lb a.e./acre). Spot treatment: 1 to 1.5% v/v solution **Timing:** Best when applied postemergence to rapidly growing plants before bolting. However, higher rates can control plants at the bud to full bloom stage. **Remarks:** Glyphosate is a nonselective herbicide that has no soil activity. Add a non-ionic surfactant.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1 to 2.6 oz product/acre (0.75 to 1.95 oz a.i./acre) **Timing:** Postemergence to rapidly growing plants. **Remarks:** Desirable grasses should be well established before application.
Imazapic *Plateau*	**Rate:** 8 to 12 oz product/acre (2 to 3 oz a.e./acre) **Timing:** Preemergence. **Remarks:** Mixed selectivity, favors members of the Asteraceae and some grasses. Some soil residual activity. In postemergence applications, use methylated seed oil at 1.5 to 2 pt/acre. Not registered for use in California.
Imazapyr *Arsenal AC, Habitat, Stalker, Chopper, Polaris*	**Rate:** 2 pt product (*Arsenal AC*)/acre (1 lb a.e./acre); 4 pt product (*Habitat*)/acre (1 lb a.e./acre) + 1 qt/acre methylated seed oil **Timing:** Preemergence or early postemergence in the rosette stage. **Remarks:** Nonselective. Long soil residual, leaves more bare ground than other treatments, even a year after application. Do not apply more than 3 qt product/acre. *Habitat* is an aquatic registered formulation for use close to water.
Metsulfuron *Escort*	**Rate:** 1 oz product/acre (0.6 oz a.i./acre) **Timing:** Postemergence to rapidly growing plants. **Remarks:** Use a non-ionic surfactant or silicone surfactant. Prevent drift to sensitive plants. Apply only to pastures, rangeland, and non-crop sites. Metsulfuron can also be used in a premix with dicamba + 2,4-D (*Cimarron Max*). Metsulfuron and its formulations are not registered in California.

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Dittrichia graveolens (L.) Greuter

Stinkwort





Family: Asteraceae
Range: In the western United States, stinkwort is only found in California. It is also found in a few northeastern states.
Habitat: Disturbed soils of roadsides, wasteland, gravel areas, levees, and washes; sometimes in pastures, fields, riparian woodlands, and margins of tidal marshes or vernal pools. Grows best on well-drained, sandy or gravelly soils. Thrives in areas with hot, dry summers, but does not require them. Can grow on serpentine, saline, and metal-contaminated soils.
Origin: Native to southern Europe.
Impacts: Stinkwort is rapidly expanding its range. Often found in disturbed sites on the urban fringe, where its sticky, smelly foliage interferes with human activity. In Australia, where stinkwort has been for 150 years, it has naturalized in many habitats. It causes allergic contact dermatitis in humans; it also has been implicated in livestock deaths by enteritis owing to the barbed pappus bristles puncturing the small intestine. Its impact in natural areas is not known, but it is just beginning to invade open riparian or grazing areas.
California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness (Alert)

Stinkwort is an erect, fall-flowering annual growing up to 3 ft tall. A recent introduction to the west coast, stinkwort was first reported in California in the mid-1980s. Its sticky, glandular-hairy foliage is intensely aromatic. The oils on the foliage, especially on mature plants, make it difficult to control with postemergence herbicides. Stinkwort germinates during winter but remains small until spring. During late spring and summer, it develops into a shrubby, pyramid- or sphere-shaped plant which superficially resembles Russian-thistle or kochia. Stinkwort is a member of the Inuleae tribe and is related to the cudweeds (*Gnaphalium* spp.), but more closely resembles native tarweeds (*Holocarpha*, *Hemizonia*). Its leaves are linear to lance-shaped, typically 0.5 to 1 inch long by only 1 to 3 mm wide.

Unlike most annual, and particularly winter annual weeds, it flowers from September to December, producing small yellow flowerheads around 0.25 inch diameter. The flowerheads turn reddish as they age. Its seeds are tiny, with a barbed pappus, and are readily distributed by wind, water, or by sticking to fur or clothing. The seeds reportedly have a short life in the soil, probably less than 3 years.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Stinkwort has a relatively shallow root system, so it can be controlled by hoeing or pulling. When doing any kind of mechanical control of stinkwort, wear appropriate protective clothing (long sleeves, long pants, gloves) to minimize exposure to the irritating oils. Once stinkwort goes into flower, plants should be bagged and taken off site, because seeds may ripen on the cut plants. Mowing can give partial control, but this plant often has low branches below the level of most mowers, so it may regrow. Mowing a second time, especially in mid- to late summer after the soil has dried out, may give improved control.
Cultural	There is no information available on grazing for the control of stinkwort. It is likely that the plant is not very

	palatable to livestock. Burning alone is not likely to be a good control for stinkwort. It usually grows in locations without enough grasses for dry fuel. Even so, if a burn was successful in controlling the current year's plants, this would likely just clear off the site for a subsequent flush of stinkwort the following winter. Potentially, this could be followed with herbicide treatment as part of an integrated management strategy as with yellow starthistle. Stinkwort establishes and thrives in open, disturbed sites. To limit its chances for establishing, minimize disturbances such as overgrazing and soil manipulation. Pastures should be managed for dense, competitive stands; aim for maximum ground cover in spring, when stinkwort seedlings are trying to establish.
Biological	No biocontrol agents are presently known for this species.

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.

Because of stinkwort's sticky foliar oils, many sources recommend using ester formulations of growth regulator herbicides (2,4-D, MCPA, triclopyr, etc.)

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 2 to 4 pt product/acre (0.95 to 1.9 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants. Smaller plants are easier to control. **Remarks:** 2,4-D is a broadleaf-selective herbicide with no soil activity. Ester formulations appear better at cutting through the oils on the foliage, but do not apply ester formulations when outside temperatures exceed 80°F. A related chemical, MCPA, is commonly used for control of stinkwort in Australia at rates of 25 oz product/acre (0.75 lb a.e./acre). Timing and remarks are similar to 2,4-D.
Aminocyclopyrachlor + chlorsulfuron *Perspective*	**Rate:** 4.75 to 8 oz product/acre **Timing:** In spring either preemergence or postemergence. For postemergence applications, treat until bolting. **Remarks:** Controls many broadleaf species. Although generally safe to grasses, it may suppress some annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. Not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid + 2,4-D, *Forefront HL*; Aminopyralid + metsulfuron, *Opensight*; Aminopyralid + triclopyr, *Capstone*	**Rate:** 1.5 to 2.1 pt *Forefront HL*/acre; 2.5 to 3.3 oz *Opensight*/acre; 4 to 6 pt *Capstone*/acre **Timing:** Postemergence to plants in the rosette to bolting stages. **Remarks:** These combinations are broadleaf-selective. Recommended rates based on those reported for knapweeds or perennial thistles. *Opensight* is not registered for use in California.
Dicamba *Banvel, Clarity*	**Rate:** 2 to 4 pt product/acre (1 to 2 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants. **Remarks:** Broadleaf-selective herbicide often combined with other active ingredients. Also effective tank-mixed with 2,4-D. It will kill above-ground parts of the plant, but new rosettes will regenerate from the root system. Its use may require repeat applications. Avoid drift to sensitive crops. Do not apply when outside temperatures exceed 80°F. Dicamba + MCPA (3 to 5 oz dicamba product plus 14 to 20 oz MCPA product) is a standard treatment for stinkwort in Australia.
Triclopyr *Garlon 4 Ultra*	**Rate:** 2 to 4 pt product/acre (0.75 to 1.5 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants before flowering. Smaller plants are easier to

	control. **Remarks:** Broadleaf-selective, generally safe on established grasses. It has little to no soil activity. *Garlon 4 Ultra* is formulated as a low volatile ester. However, in warm temperatures, spraying onto hard surfaces such as rocks or pavement can increase the risk of volatilization and off-target damage.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** 2 to 4 pt product (*Roundup ProMax*)/acre (1.1 to 2.25 lb a.e./acre) **Timing:** Postemergence to rapidly growing plants in late spring to early summer, after desirable competitors have senesced. **Remarks:** Nonselective, no soil activity. Effectiveness may be increased by adding ammonium sulfate.

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Foeniculum vulgare Mill.

Fennel



Family: Apiaceae
Range: Particularly a problem in California, but found throughout many western states including Washington, Oregon, Arizona, Nevada, Utah, New Mexico and Texas.
Habitat: Fennel prefers open disturbed areas and has invaded roadsides, slopes, fields, grasslands, coastal scrub, riparian and wetland areas, and other natural communities, particularly in coastal regions.
Origin: Native to southern Europe. Birds and rodents consume the seeds, and feral pigs relish the roots.
Impacts: Established plants are competitive, and soil disturbance facilitates the development of dense stands, which can exclude native vegetation in some areas. Unlike the weedy form, cultivated varieties are seldom invasive. Fennel is also rated as a noxious weed in some regions of Australia.
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Fennel is an aromatic perennial with a deep thick taproot. Plants can grow to 10 ft tall, with finely dissected leaves divided into numerous thread-like segments. Foliage and seeds have a strong licorice or anise scent, especially when crushed. Different varieties are cultivated as a spice or vegetable, for an essential oil used to flavor foods, and in some countries, for medicinal purposes.

The inflorescence consists of several flat-topped compound umbels of small yellow flowers. Fruits separate into two halves (mericarps) at maturity. Plants reproduce by seed and sometimes vegetatively from root or crown fragments. Seeds are dispersed with water, soil movement, animals, human activities, and as a seed contaminant. Seeds appear to survive several years under field conditions. Fragmentation of roots and crowns may occur during flooding events, mudslides, or agricultural operations. New shoots grow from the crown and lower portions of overwintering stems in mid-winter to early spring.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand chop small infestations (large fennel plants have a very substantial root, so this labor intensive). Slashing just before flowering may kill the plants, or repeat slashing of regrowth may be needed. Even if plants recover, slashing the stems at flowering will prevent seed set. The use of a mattock to remove the plant can also be successful, but is very labor intensive. Digging out individual plants is also possible, but also labor intensive. Deep cultivation will also kill the plants but is not practical in most situations.
Cultural	Grazing will not control fennel and often spreads the population. Burning is not effective, as fennel will quickly recover following the fire. However, fall burns followed by herbicide treatment the following two springs reduced fennel cover. Burning can also stimulate the seedbank to germinate, which can reduce the number of years necessary for control.
Biological	Because fennel is the same species as the cultivated fennel, there are no biological control agents available.

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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 0.25 to 0.5% of v/v solution for spot treatment **Timing:** Postemergence to fully developed leaves but before flowering. **Remarks:** 2,4-D will damage other broadleaf species and is not as effective as triclopyr.
Triclopyr *Garlon 3A, Garlon 4 Ultra*	**Rate:** Broadcast foliar treatment: 1 to 2 qt product/acre (1 to 2 lb a.e./acre). Spot treatment: 0.5 to 1% v/v solution **Timing:** Postemergence to fully developed leaves but before flowering. The best treatment timing is during the wet season from late February to early March. For spot treatment, lower rates can be used early in the season. **Remarks:** Triclopyr is a broadleaf herbicide that is the standard for fennel control. It is very effective and can also be used in combination with glyphosate at 1 lb a.e./acre each.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** Broadcast foliar treatment: 5 pt product (*Roundup ProMax*)/acre (2.8 lb a.e./acre). Spot treatment: 2 to 5% v/v solution **Timing:** Postemergence to fully developed leaves but before flowering. Control is less effective once plant has bolted. **Remarks:** Glyphosate is nonselective. It gives very effective control and can also be used in combination with triclopyr at 1 lb a.e./acre each.

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Lepidium latifolium L.

Perennial pepperweed (tall whitetop)



Family: Brassicaceae
Range: All western states, except North and South Dakota.
Habitat: Many different areas and habitats, including wetlands, riparian areas, meadows, vernal pools, salt marshes, flood plains, sand dunes, roadsides, irrigation ditches, ornamental plantings, and agronomic crops, including alfalfa, orchards, vineyards, and irrigated pastures. Most typically found on moist or seasonally wet sites in the west, and most problematic in riparian or wetland areas. Tolerates saline and alkaline conditions.
Origin: Native to Eurasia.
Impacts: Perennial pepperweed can rapidly form large, dense stands that displace desirable vegetation and wildlife. Populations easily spread along waterways and can infest entire stream corridors, riparian areas, or irrigation structures. Roots do not hold soil together well, allowing erosion of river, stream, or ditch banks. Flooded streams often wash away roots growing along the streambank, and new infestations develop downstream. Once established, perennial pepperweed is persistent and difficult to control in crops, natural areas, and ornamental plantings. Perennial pepperweed reduces forage quality in hay and pasture. Perennial pepperweed plants extract salts from deep soil and deposit them on the soil surface, inhibiting the germination and growth of other species that are sensitive to salinity.
Western states listed as Noxious Weed: California, Colorado, Idaho, Montana, New Mexico, Oregon, South Dakota, Utah, Washington, Wyoming
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Perennial pepperweed is an erect perennial to 6 ft tall. The crown and lower stems are weakly woody. The foliage lacks hairs and is green to gray-green, often dusted with powdery white caused by a rust fungus. The basal leaves are larger and wider than stem leaves, to 1 ft long and 4 inches wide, with serrate margins. The aboveground parts typically die in late fall and winter, leaving dead stems and thatch which can persist for several years. The roots are long, thick, minimally branched, and vigorously creeping. Most grow in the top 2 ft of soil, but some can penetrate to a depth of 10 ft or more.

The inflorescences are rounded to pyramidal and consist of numerous small white flowers. The flowers have four petals, producing small pods (about 2 mm long) with tiny reddish-brown seeds (about 1 mm long). Perennial pepperweed is a prolific seed producer. Laboratory tests suggest seeds germinate readily with fluctuating temperatures and adequate moisture; however, seeds do not appear to remain viable in the soil for extended periods. As a result, perennial pepperweed reproduces primarily vegetatively from roots and root fragments. Large root fragments can survive desiccation on the soil surface for extended periods, and fragments as small as 0.5 to 1 inch long and 2 to 8 mm in diameter can develop into new plants. Root fragments and seeds disperse with flooding, soil movement, and human and animal activities.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Seedlings are easily controlled by hand-pulling or tillage, but these techniques do not control established plants because shoots quickly resprout from vast root reserves. In addition, seedlings are not often encountered. Root segments as small as 1 inch are capable of producing new shoots. Cultivation and tillage typically increase infestations by dispersing root fragments. Clean equipment after tillage to prevent spreading root fragments. Mowing stimulates perennial pepperweed plants to resprout and produce new growth, but mowing is

	helpful for removing accumulated thatch. Mowing breaks old stems into small fragments and helps prevent shading of favorable species. Combining mowing with herbicides has been shown to be an effective control strategy. For best results, mow plants at the bolting or flower bud stage and apply herbicides to resprouting shoots once they have reached the flower bud stage.
Cultural	Cattle, sheep, and goats will graze perennial pepperweed, especially rosettes in early spring. When stands are dense it becomes difficult for most animals to graze. Goats appear to tolerate heavy consumption of fresh plants. Sheep and goats permanently maintained in a pasture suppress growth of perennial pepperweed. However, once livestock are removed, plants quickly resprout. Burning is not effective at reducing perennial pepperweed stands, but it is helpful at removing accumulated thatch. Perennial pepperweed thatch burns best in winter or spring under dry conditions before initiation of spring growth. Seasonal flooding for an extended period during the growing season can significantly reduce populations. It is not known how long perennial roots can survive flooded conditions, but anecdotal information indicates that 6 months of submergence are required. Establishing desirable vegetation in disturbed areas can suppress perennial pepperweed and slow reinvasion after control. Because perennial pepperweed is very competitive, seed or transplant desirable vegetation after dense perennial pepperweed stands are controlled. Choose vigorous, fast-growing plant species that are adapted to the site. Perennial grasses are a good choice for natural areas and pastures. Grasses are tolerant of broadleaf-selective herbicides, and over time grasses form a thick sod that prevents future weed establishment. In pastures, promote grass expansion and vigor with fertilization and grazing management.
Biological	Biological control agents are being evaluated for use on perennial pepperweed in the United States, but currently no organisms are available.

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.

GROWTH REGULATORS	
2,4-D Several names	**Rate:** 2 qt product/acre (1.9 lb a.e./acre) **Timing:** Postemergence at rosette to flowering stages. Most effective at flower bud or flowering stage. **Remarks:** 2,4-D often requires annual application for multiple years. It is broadleaf-selective and safe on most grasses. 2,4-D has minimal soil activity. Do not apply ester formulations when outside temperatures exceed 80°F. Amine forms are as effective as ester forms, and amine forms reduce the chance of off-target movement.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II*, and others	**Rate:** 2 to 4 qt product (*Roundup ProMax*)/acre (2.25 to 4.5 lb a.e./acre). Spot treatment: 2 % product v/v **Timing:** Postemergence from seedling to bloom stage. Most effective at flower bud or flowering stage. **Remarks:** Glyphosate will not kill seeds or inhibit germination the following season. Glyphosate is nonselective and has no soil activity. It can create bare ground conditions that are susceptible to weed recruitment. In areas with desirable vegetation, use spot treatment. Glyphosate is a good control option if reseeding is planned shortly after application, as it will not injure seedlings emerging after application. Add a surfactant when using a formulation where it is not already included (e.g., *Rodeo, Aquamaster*).
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Chlorsulfuron *Telar*	**Rate:** 1 to 2.6 oz product/acre (0.75 to 1.95 oz a.i./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective at flower bud or flowering stage. **Remarks:** Chlorsulfuron has long soil residual activity. It has mixed selectivity, but is generally safe on grasses. Always use a surfactant. 2,4-D at 1 to 2 pt/acre can be tank-mixed with chlorsulfuron for

	quicker burndown. *Telar* can be used near water, but cannot be applied to water. Chlorsulfuron is included with aminocyclopyrachlor in *Perspective*. This combination (i.e., formulation) is expected to provide good control, but has not been reported.
Imazapic *Plateau*	**Rate:** 8 to 12 oz product/acre (2 to 3 oz a.e./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective from the bud to the late flowering stage. **Remarks:** Imazapic gives effective control with some soil residual activity. It can be used in combination with glyphosate (premix trade name of *Journey*). Selective to most native grasses. Higher rates may suppress seedings of some cool-season grasses. Add a methylated seed oil. Imazapic is not registered for use in California.
Imazapyr *Habitat*	**Rate:** 1 to 2 qt product/acre (0.5 to 1 lb a.e./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective from the bud to the late flowering stage. **Remarks:** *Habitat* is registered for aquatic use. Also effective following early season mowing and/or disking. It is nonselective, has long soil residual activity, and leaves more bare ground than other treatments, even a year after application. Add a spray adjuvant.
Metsulfuron *Escort*	**Rate:** 1 to 2 oz product/acre (0.6 to 1.2 oz a.i./acre) **Timing:** Postemergence from seedling to flowering stage. Most effective at flower bud and flowering stage. **Remarks:** Metsulfuron has similar activity compared to chlorsulfuron. Metsulfuron has some soil residual activity. Always use a surfactant. Metsulfuron can be tank-mixed with 2,4-D for quicker burndown. Other premix formulations of metsulfuron can be used at similar application timing. These include *Cimarron Max* (metsulfuron + dicamba + 2,4-D) and *Cimarron X-tra* (metsulfuron + chlorsulfuron). Metsulfuron is not registered for use in California.
Propoxycarbazone-sodium *Canter R+P*	**Rate:** 0.9 to 1.2 oz product/acre (0.63 to 0.84 oz a.i./acre) **Timing:** Postemergence to young, rapidly growing plants. **Remarks:** Propoxycarbazone is a broad-spectrum herbicide that will control many species. It will provide only partial control of perennial pepperweed. Perennial grass species vary in tolerance. A non-ionic surfactant should be added at 0.25 to 0.5% v/v solution.

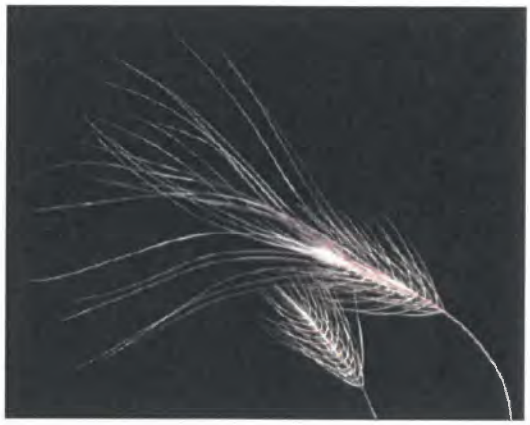
RECOMMENDED CITATION: DiTomaso, J.M., G.B. Kyser et al. 2013. *Weed Control in Natural Areas in the Western United States.* Weed Research and Information Center, University of California. 544 pp.

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Taeniatherum caput-medusae (L.) Nevski
(= *Elymus caput-medusae* L. [Jepson Manual 2012])

Medusahead



Family: Poaceae
Range: Arizona, California, Idaho, Nebraska, Nevada, Oregon, Utah, Washington; a few locations in the northeastern states.
Habitat: Disturbed sites, grassland, rangeland, openings in chaparral, oak woodlands, and rarely in agronomic fields. Generally in areas that receive at least 9 inches of rain per year, so not common in the low desert. Grows best on clay soils or where deep soil moisture is available late in the growing season.
Origin: Native to the Mediterranean region.
Impact: Dense stands displace desirable vegetation and reduce livestock and wildlife carrying capacity. Unpalatable to livestock except during the early growth stages. The stiff awns and hard florets can injure eyes, nostrils, and mouths of grazing animals. Birds and rodents usually avoid feeding on the seeds. Senesced plants form a dense layer of thatch that takes a couple of years to decompose. The thatch layer changes the temperature and moisture dynamics of the soil, reduces seed germination of other species, and creates fuel for wildfires.
Western states listed as Noxious Weed: California, Colorado, Nevada, Oregon, Utah
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Medusahead is a noxious rangeland weed that is increasing its range in most of the western states. It is an ascending to erect winter annual grass to 2 ft tall, producing spikes of long-awned spikelets. Medusahead matures at least 2 to 4 weeks later in the season than most other annual grasses, and from a distance, the yellowish-green sheen of dense stands is highly visible after other annual grasses turn brown. The mature plant has slender stems, and the leaf surfaces are glabrous or covered with soft, short hairs, and often appear glassy under magnification. Medusahead produces fibrous roots that grow throughout the cool season, depleting upper soil moisture early in the growing season and accessing deep soil moisture later on.

Medusahead flowers in early summer, often after other annual plants have senesced. Its spikes are 0.5 to 2 inches long excluding awns, and the main spike axis does not break apart at maturity. The fertile seeds have long, often twisted, awns 1 to 3 inches long; the seeds and awns are covered with minute, upward-pointing barbs and are rough to the touch. Seed production is usually prolific. Some florets (seeds) can remain attached to spikes long after plants turn brown. This characteristic allows seeds to disperse by clinging to the feet, fur, and feathers of animals and the shoes and clothing of people.

Most seeds germinate in fall after the first rain, but some seeds remain dormant or germinate in winter or spring. Seeds can germinate in dense litter under low moisture conditions. Seedlings remain attached to the long-awned floret. Seedlings can survive desiccation of the primary root and develop adventitious roots when moisture becomes available. Most seed appears to germinate or lose viability within 2 years in the field.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	There are mixed reports on the effectiveness of mowing. Early-season mowing is likely to be ineffective and may harm other species. Late-season mowing, at the boot to early flowering stage, may help to suppress medusahead. However, mowing after seed set will disperse the seeds. In areas where medusahead has built up a heavy thatch, removal of the thatch by raking, tillage, or burning

	can reduce dominance by medusahead and can help other plant species to get established. Tillage (disking and plowing) will control existing medusahead plants, as well as burying seed and breaking up deep thatch layers. Tillage should be accomplished before seed set. In rangeland or wildland areas, the increased potential for soil erosion, loss of soil moisture, loss of organic matter, and loss of macrobiotic crusts may outweigh the weed control benefits of tillage. These factors should be considered before applying tillage over a large area.
Cultural	The use of fire has given mixed results for medusahead control. Burning in low-elevation, warm-winter sites (e.g., California's Central Valley and foothills) can be extremely effective. Burns are conducted when medusahead is beginning to head out but before seed drop, when most desirable plants have already dropped seed. Two years of burning can nearly eliminate an infestation. In contrast, burning in high-elevation, cool-winter sites usually fails to control medusahead. It is thought that because of reduced ecosystem productivity and a shorter growing season at these sites, there isn't adequate fuel to carry a fire hot enough to kill medusahead seeds. Because of its high silica content, livestock generally avoid grazing medusahead as it approaches maturity. However, heavy grazing in spring, when medusahead is still palatable, can reduce, but not eliminate, an infestation. To limit seed dispersal, animals should be removed before the plants mature. Spring grazing is especially effective in areas where dried medusahead litter has been previously burned or grazed. Best control is achieved if plants are grazed in the stage of boot to flowerhead emergence. In experimental trials, medusahead populations have been reduced using confined grazing with sheep. In recent trials, fertilizing pastures with nitrogen improved the palatability of medusahead, making it attractive to cattle and resulting in medusahead suppression. As discussed above, thatch removal by raking, tillage, or burning can favor establishment of desirable plants. This can also improve efficacy of subsequent applications of some soil-applied herbicides, particularly imazapic.
Biological	Crown rot fungus (*Fusarium culmorum*), an endemic fungus of dry soils in the western states, is a potential biocontrol agent. However, there are no studies to show its effectiveness.

CHEMICAL CONTROL

The following specific use information is based on published papers and 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.

GROWTH REGULATORS	
Aminopyralid *Milestone*	**Rate:** 7 to 14 oz product/acre (1.75 to 3.5 oz a.e./acre) **Timing:** Preemergence in fall. **Remarks:** A broadleaf-selective herbicide that is safe on most grasses. There is a 2(ee) Supplemental label for this use in Arizona, California, Colorado, Idaho, Oregon, Washington, Wyoming, and Utah. Research in California's Central Valley showed that 14 oz of *Milestone* (spot treatment rate)/acre gave ~90% control of medusahead, and 7 oz/acre gave ~60% control.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II,* and others	**Rate:** 0.75 to 1 pt product (*Roundup ProMax*)/acre (0.42 to 0.56 lb a.e./acre) for early-season selective control in shrubland or other perennial systems; 1 to 2 qt product (*Roundup ProMax*)/acre (1.1 to 2.25 lb a.e./acre) for late-season, nonselective control. **Timing:** For selective control, apply postemergence in spring after all seedlings are up and before heading; the tillering stage is ideal. For late-season, nonselective control, apply to rapidly growing plants before seeds are produced. **Remarks:** Glyphosate is a nonselective herbicide with no soil activity.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapic *Plateau*	**Rate:** 4 to 12 oz product/acre (1 to 3 oz a.e./acre) **Timing:** Fall or spring. In warm-winter areas, fall applications may be most effective. In colder climates, spring applications after snow melt are better. **Remarks:** Imazapic has some soil residual activity and mixed selectivity. It tends to favor members of the

	Asteraceae and some grasses. Use a spray adjuvant for postemergence applications. Effects vary depending on soil texture and soil organic matter. Heavy soils and high organic matter may require higher rates. Imazapic also can tie up in litter, and its efficacy is reduced under situations where there is lots of thatch on the soil surface. Not registered for use in California.
Rimsulfuron *Matrix*	**Rate:** 4 oz product/acre (1 oz a.i./acre) **Timing:** Preemergence (fall) to early postemergence (early spring). **Remarks:** Rimsulfuron controls several annual grasses and broadleaves. Perennial grasses are tolerant to fall applications when established and grown under dryland conditions. Application to rapidly growing or irrigated perennial grasses may result in their injury or death. It provides soil residual control in cool climates but degrades rapidly under warm conditions. Rimsulfuron will not control summer annual weeds when applied in fall or spring. Add a surfactant when applying postemergence.
Sulfometuron *Oust* and others	**Rate:** 0.75 to 1.5 oz product/acre (0.56 to 1.13 oz a.i./acre) **Timing:** Preemergence to early postemergence. Preemergence (fall) applications are generally more effective. **Remarks:** Sulfometuron is a broad-spectrum herbicide that is fairly safe on native perennial grasses. This can be an advantage in revegetation use. Use lower rates in arid environments, higher rates in wetter areas (> 20 inches rainfall) and on high organic matter soils. It has fairly long soil residual activity.
Sulfometuron + chlorsulfuron *Landmark XP*	**Rate:** 1.5 to 2.25 oz product/acre **Timing:** Preemergence, in fall or after soil thaws in spring. **Remarks:** See sulfometuron.

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.

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Rubus armeniacus Focke

Himalaya blackberry



Family: Rosaceae
Range: Common throughout the western United States, except in Wyoming, North and South Dakota.
Habitat: Disturbed, open, moist sites such as canals, ditch banks, fencerows, roadsides, open fields, and riparian zones, in a variety of plant communities. It can also tolerate periodic flooding with brackish water.
Origin: A cultivar introduced from Eurasia, originating from Armenia, quickly spread throughout Europe and the rest of the world.
Impact: Himalaya blackberry is a highly competitive plant with a growth form that allows it to quickly crowd out native species. Its thickets have dense canopies allowing little light penetration and reducing the growth of understory plants. In riparian areas it can prevent access to water sources for livestock and wildlife.
Western states listed as Noxious Weed: California, Oregon
California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness

Himalaya blackberry is an evergreen erect shrub that grows up to 10 ft tall and is climbing, mounded, or trailing. The aboveground canes are usually biennial while the roots are perennial. The roots are found in the top 20 inches of the soil but may grow down to a depth of 7 ft in loose soil. The roots can sprout new shoots from root buds, and in good conditions root fragments may sprout a new plant. The stems are green to purplish-red, woody, strongly angled, and are protected against predation by straight or curved pickles with a thick base. The leaves are pinnately compound with 3 to 5 leaflets that are dark green with a white underside covered with dense short hairs. The leaflets are broadest above the middle, toothed and sometimes shallowly lobed.

The flowers of Himalaya blackberry are white to pinkish and numerous in non-glandular panicles. They are self-fertile with 5 petals, and numerous stamens and pistils. The fruit are edible and an aggregate of drupelets that adhere to a fleshy receptacle. The mature berries are ovoid to oblong, black, 0.75 inch long, glossy, and glabrous or slightly pubescent. They typically ripen later in the season than the native berries. Seeds are dispersed primarily by birds. In addition to seeds, plants reproduce by root sprouts and stem tip rooting. Seeds likely only survive a few years in the soil.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Hand pulling can be an effective control method for small populations. To successfully control populations with mechanical removal, it is important to remove the canes, roots and the root crowns to prevent resprouting. A Pulaski, mattock or similar device can be used to remove plants. Bulldozing may cause resprouting and can spread the weed by fragmenting roots and stems. Cutting and removing only the aboveground biomass will result in the stimulated growth of root sprouts. The root sprouts must be controlled and repeated cutting of the above-ground biomass during flowering time will exhaust the root stores. Tillage can be effective if the canes are raked and removed from the site. However, this will cause significant soil disturbance and is unsuitable in riparian areas.
Cultural	Goats will readily consume Himalaya blackberry and could help to control new populations. It is a common

	method of management in Australia and New Zealand. Their consumption is indiscriminate and could result in the loss of other desirable species. This is particularly true in riparian areas. Burning is only effective if the root sprouts are controlled by other methods, such as chemicals, when they resprout after the burn.
Biological	Blackberry leaf rust fungus (*Phragmidium violaceum*) was discovered in 2005 on the coast of Oregon and has since spread through most of the counties. It appears to have been accidentally introduced. It partially to fully defoliates Himalaya blackberry and evergreen blackberry (*Rubus laciniatus*) and also reduces tip rooting. The fungus is native to Europe, the Middle East and Africa and has been used for years to control native blackberry plants in Australia and New Zealand. It is not an approved biocontrol agent yet and has not shown sustained control of Himalaya blackberry over a wide region.

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. Excellent control information, both chemical and non-chemical, can be obtained at http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7434.html#MANAGEMENT and http://extension.oregonstate.edu/catalog/pdf/em/em8894.pdf.

GROWTH REGULATORS	
Dicamba *Banvel, Clarity*	**Rate:** 1 to 2 pt product/acre (0.5 to 1 lb a.e./acre) **Timing:** Postemergence, to weed regrowth in the late summer or fall following a mowing or tillage treatment. **Remarks:** Dicamba provides only suppression of growth. It is a broadleaf-selective herbicide often combined with other active ingredients, particularly 2,4-D. Tank mix combinations with glyphosate are also more effective. It may injure grasses at higher rates. Do not apply when outside temperatures exceed 80°F. Do not exceed 64 oz product/acre per year.
Fluroxypyr *Vista XRT*	**Rate:** 22 oz product/acre (7.7 oz a.e./acre) **Timing:** Postemergence when target plants are growing rapidly. **Remarks:** Reduced control occurs if plants are under stressed growth conditions.
Triclopyr *Garlon 3A, Garlon 4 Ultra, Pathfinder II* Aminopyralid + triclopyr (*Capstone*)	**Rate:** Broadcast foliar treatment: 4 pt product (*Garlon 4 Ultra*)/acre (2 lb a.e./acre). Spot treatment: 0.75 to 1% *Garlon 4 Ultra* or 1% *Garlon 3A*; thoroughly cover the foliage. Basal bark treatment: 20% *Garlon 4 Ultra* mixed with basal oil or seed oil; *Pathfinder II* is a ready-to-use triclopyr/oil mix. Dormant stem and leaf treatment: 1% v/v solution of *Garlon 4 Ultra* with 2 to 3% v/v crop oil concentrate or seed oil. For *Capstone* use 8 to 9 pt product/acre. **Timing:** Postemergence in mid-summer or early fall after flowering and start of fruit set. 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 mid-fall basal bark treatment might be desirable to avoid human contact with the chemical. For dormant stem and leaf treatment apply to dormant leaves and stems in late fall and winter in a 3% crop oil concentrate mixture. 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. **Remarks:** Foliage or stems (dormant stem application) must be thoroughly wet. Triclopyr is broadleaf-selective and safe on most grasses. It is most effective on smaller plants and has little or no residual activity. For basal bark treatment, thoroughly cover a 12 to 15-in basal section of the stem with spray but not to the point of runoff. *Garlon 3A* and other amine formulations are registered for aquatic use. Ester formulations (e.g., *Garlon 4 Ultra*) may volatilize if applied in warm temperatures. Application in some counties and grape-growing areas may be restricted. Sometimes aminopyralid + triclopyr (*Capstone*) or glyphosate and triclopyr (1% solution each) are used to achieve better control.
AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Roundup, Accord XRT II*, and others	**Rate:** Broadcast foliar treatment: 2 to 3 qt product (*Roundup ProMax*)/acre (2.25 to 3.4 lb a.e./acre). Spot treatment: 0.5 to 1.5% v/v solution. **Timing:** Postemergence in late summer to early fall when canes are growing rapidly, have reached full

	leaf maturity, and after berries are formed. Fall treatments must be made before a killing frost. **Remarks:** Fall treatment symptoms may not show before frost. Retreatment may be necessary for complete control. Trailing blackberry is more difficult to control. Glyphosate controls grasses in the treated area as well as other vegetation. To obtain good control complete foliage coverage (spray-to-wet) is essential. Burning or mowing 40 to 60 days after spraying with glyphosate increases the level of control and also contributes to pasture establishment by removing stem debris. Shoots recovering from sublethal glyphosate treatment tend to die more quickly when subjected to heavy grazing. Sometimes glyphosate and triclopyr (1% each in solution) are used in combination to achieve better control.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Metsulfuron *Escort*	**Rate:** 0.5 to 1 oz product/acre (0.3 to 0.6 oz a.i./acre) **Timing:** Postemergence, to fully leafed-out vegetation before fall leaf coloration. **Remarks:** Metsulfuron is primarily active on broadleaf species. Apply only to pasture, rangeland, and non-crop sites. Do not apply when plants are under stressed growing conditions. Metsulfuron can be used in a premix with aminopyralid (*Opensight*) or a tank mix with triclopyr for better control. Metsulfuron and its formulations are not registered for use in California.
Sulfometuron *Oust* and others	**Rate:** 3 to 4 oz product/acre (2.25 to 3 oz a.i./acre) **Timing:** Early postemergence when target plants are germinating or actively growing. Will only be effective on very small plants and not on fully mature plants. **Remarks:** Add a surfactant at 0.25% v/v for improved control.
PHOTOSYNTHETIC INHIBITORS	
Hexazinone *Velpar L*	**Rate:** 3 to 4 gal product/acre (6 to 8 lb a.i./acre) **Timing:** Preemergence or postemergence when plants are germinating or actively growing. **Remarks:** Hexazinone is used as a nonselective herbicide in non-cropland areas and as a selective herbicide in reforestation practices. It only suppresses the growth of Himalaya blackberry. Use higher rates on fine textured soils and soils with high organic matter. Do not apply to frozen ground. Non-target plants may be adversely affected from drift and run-off. Apply when there is adequate moisture for activation. Hexazinone can be mixed with triclopyr for better control. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.
Tebuthiuron *Spike*	**Rate:** 20 lb product (*Spike 20P*)/acre (4 lb a.i./acre) **Timing:** Preemergence before the start of spring growth or before expected seasonal rainfall. **Remarks:** Do not apply tebuthiuron at more than 20 lb/acre. Do not apply more than 10 lb/acre in areas that receive 20 inches or less of annual rainfall. May injure non-target species. Follow restrictions on the label for use around desirable plants.

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Tamarix aphylla (L.) Karst.; athel tamarisk
Tamarix chinensis Lour.; Chinese tamarisk
Tamarix gallica L.; French tamarisk
Tamarix parviflora DC.; smallflower tamarisk
Tamarix ramosissima Ledeb.; saltcedar, and hybrids of *T. ramosissima*, *T. gallica*, and *T. chinensis*



Saltcedar and tamarisk



Family: Tamaricaceae
Range: All western and southwestern states, some species widely planted.
Habitat: River, lake and pond margins, washes, roadsides, ditches, flats, sand dunes, desert springs. Grows best in alkaline soil, but tolerates salinity and acidity. Mature plants survive desert heat, below-freezing temperatures, periodic flooding, drought, burning.
Origin: Native to eastern Asia, northern Africa, the Middle East, India, and southern Europe. *Tamarix* species were introduced as landscape ornamentals and have escaped cultivation in many states, especially in the southwest. Athel tamarisk is still widely sold as an ornamental, but is not as invasive as the other species.
Impacts: All species are facultative phreatophytes that can use both surface and groundwater. The presence of numerous trees along riparian corridors or around desert springs can seriously reduce underground water tables and surface water availability, drying up wetlands, and reducing flows. Roots extract salts from deep soil layers and excrete it from the leaves. Salt is deposited on the soil surface with the leaf litter. The increased salinity of the upper soil profile inhibits the growth, survival, and recruitment of desirable native vegetation. Although some animals will seek cover or nest in *Tamarix* thickets, most wildlife does not consume *Tamarix* foliage, fruits, or seeds. *Tamarix* species can increase flooding in riparian areas by narrowing channel width. In addition, the plants are flammable and can introduce fire into wetland and riparian communities that are not adapted to periodic burning.
Western states listed as Noxious Weed: *T. parviflora*, California, Colorado, Montana, Nevada, New Mexico, North Dakota, South Dakota, Wyoming. *T. ramosissima* and hybrids, California, Colorado, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming. *T. chinensis*, California, Colorado, Montana, New Mexico, North Dakota, South Dakota, Wyoming. *T. gallica*, California, Montana, New Mexico, South Dakota, Wyoming
California Invasive Plant Council (Cal-IPC) Inventory: *T. parviflora* and *T. ramosissima*, High Invasiveness; *T. aphylla*, Limited Invasiveness

Tamarix species are small trees or shrubs with tiny scale- or awl-like leaves. Smallflower tamarisk is the shortest of the species and grows to about 15 ft tall. Saltcedar, Chinese tamarisk, and French tamarisk grow to about 20 ft tall. All four of these species are deciduous and have awl-like twig leaves that strongly overlap each other and have acute tips. The foliage of saltcedar, Chinese tamarisk, and French tamarisk is usually more bluish-green than smallflower tamarisk. Athel tamarisk grows to 40 ft tall and is evergreen or semi-evergreen. Its twig leaves are scale-like, not or barely overlapping, and appear like small segments along a stem. *Tamarix* species typically develop an efficient, deep root system (> 15 ft deep) and have a high evapotranspiration rates

in arid climates during the warm season. This occurs because once the roots are within the water table they branch profusely into numerous lateral roots to several feet long.

The inflorescences of *Tamarix* species consist of racemes, mostly 3 to 5 mm wide, typically simple, but occasionally compound and panicle-like. The flowers have a nectar disc at the base which is useful for species identification. Flowers of saltcedar, Chinese tamarisk, and French tamarisk are white, pale or dark pink, mostly with 5 sepals, petals, and stamens. Flowers of smallflower tamarisk are typically pale to dark pink, mostly with 4 sepals, petals, and stamens. Athel tamarisk flowers are white to pale pink, mostly with 5 sepals, petals, and stamens. Plants all reproduce by seed, although seed production is not common in athel tamarisk, and sometimes vegetatively from root sprouts and stem fragments. Stem fragments can take root when buried in a moist substrate, such as might occur with a flooding event. The fruit is a small capsule, often less than 5 mm long, with numerous minute seeds. One mature saltcedar plant can produce about 500,000 seeds per year. Seeds disperse primarily with wind and water, and germination occurs shortly after seed dispersal in spring through summer. Seeds lack a dormancy period, and most germinate within 24 hours after contacting water. Seeds typically survive for only 5 weeks. Individual trees can live 75 to 100 years or more.

Although saltcedar (*T. ramosissima*) and Chinese tamarisk (*T. chinensis*) do not hybridize in their native range, they appear to hybridize extensively in the United States. This hybrid is the most common invasive *Tamarix* species from Oklahoma to Washington to California. Seed viability is high in the hybrids. Less extensively, hybrids between saltcedar and Chinese tamarisk with smallflower tamarisk (*T. parviflora*), Canary Island tamarisk (*T. canariensis*) and French tamarisk (*T. gallica*) also occur. The abundance of invasive hybrids may explain the confusion associated with the identification of *Tamarix* species in the western states.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Mechanical control methods include mowing, burning, chopping, chaining, and disking. However, these methods usually only suppress saltcedar temporarily and will not eradicate infestations. Saltcedar is also able to resprout vigorously from the root crown following mechanical control methods. These methods can be labor intensive and expensive and may be more effective on small infestations. Hand pulling can be an effective way to control tamarisk in situations where plants are small, where access is difficult, or where herbicides cannot be used. Hand pulling is generally used to control new *Tamarix* seedlings and small plants around isolated desert springs in national parks after the larger plants have been killed with other techniques. Mowing is occasionally useful to reduce the volume of tamarisk before treatment with herbicide, especially in relatively level sites where prescribed burning is not feasible. However, a single cutting of tamarisk is ineffective, because tamarisks resprout vigorously. By comparison, cutting combined with herbicide treatment can be a very effective integrated approach. In addition, cutting tamarisk can reduce consumption of ground water, through removal of transpiring leaves. Heavy equipment can be used to remove entire plants. However, this is expensive, and any fragments that move into the water column may resprout and form new populations. This technique also causes considerable soil disturbance and ecosystem disruption. A root plow pulled by a bulldozer has become a standard method for saltcedar control, providing good to excellent control. Root plowing is most effective when the soil is relatively dry and when combined with follow-up treatments such as hand grubbing resprouts or applying herbicides. Root plowing may affect desirable vegetation and could lead to wind erosion. Another technique uses site preparation tractors or skid steers equipped with forestry mulching attachments, such as a hydro-ax. These are adapted to forestry brush and tree clearing. The hydro-ax can mow or chip either living or dead saltcedar at about 1 acre/hr on level terrain.
Cultural	Cattle, goats, and sheep will graze saltcedar plants if desirable vegetation is lacking. Saltcedar has little nutritional value and cattle will only graze young seedlings early in the year. Goats might be able to control dense stands of tamarisk where little native vegetation is present, particularly if the stands are cut or burned first, with goats eating the regrowth. As a stand-alone strategy, burning has not been successful. Saltcedar is generally top-killed by burning, but plants readily resprout from the remaining root crown and adventitious buds on the lateral roots. Repeated yearly burns can suppress saltcedar and kill some of the plants after 3 to 4 years. Furthermore, burning may suppress saltcedar infestations by eliminating the closed canopy, slowing the rate of invasion, and allowing desirable vegetation to respond, thereby increasing biodiversity. Prescribed burns can be followed up with herbicide treatments to control resprouting plants. One strategy is to cut 20 to 25% of the largest tamarisk plants in stands several months before burning to create enough dry ground fuel to carry a fire. For greatest

	efficacy, burning should be conducted during the hottest part of summer, when plants experience the greatest water stress. If floods occur during the period of poplar/cottonwood (*Populus* spp.) or willow (*Salix* spp.) seeding (which precedes saltcedar seeding), then natural revegetation will consist of almost pure stands of those, with very little saltcedar. Young seedlings of saltcedar can be controlled by flooding for 1 month.
Biological	The release of the saltcedar leaf beetle (*Diorhabda carinulata*) from China has made significant impacts on many populations of saltcedar. This insect feeds on the leaves of saltcedar and slowly reduces plant vigor. Tamarisk does not usually die from a single defoliation from tamarisk beetles, and it can resprout within several weeks of defoliation. Repeated defoliation of individual tamarisk trees can lead to severe dieback the next season and death of the tree within several years. Data indicate that 4 years of defoliation can result in about 60% mortality. Biological control will not eradicate tamarisk but it has the potential to suppress tamarisk populations by 75 to 85%. Since its release, the beetle has defoliated tens of thousands of acres of tamarisk in Nevada, Utah, Colorado and Wyoming. The insect spreads rapidly but is poorly adapted to more southern regions of the U.S. This led to further exploration to find better adapted biotypes or species of *Diorhabda*. In this process, five sibling species were found to comprise a new *Diorhabda* species group. Each species has unique biogeographical traits suiting them to different regions invaded by tamarisk in North America. Four species were previously tested and verified as specific feeders of tamarisk, and released in North America under the name *D. elongata*. *D. carinulata* from China and Kazakhstan (old name *D. e. deserticola*), is successfully suppressing tamarisk over large areas of the Great Basin desert. The true *D. elongata* is establishing well in California and parts of west Texas and is best suited for Mediterranean habitats. *D. sublineata* has potential for the Sonoran and southeastern Chihuahuan deserts. *D. carinata* should be best suited for the Great Plains grasslands and the Mojave and northern Chihuahuan deserts. A fifth species, *D. meridionalis*, may be suited to subtropical maritime deserts but has yet to be safety tested. One controversial aspect of the release of the tamarisk beetle is that defoliation can locally reduce nesting habitat for riparian woodland birds until native woodland flora recover. This has primarily centered on the federally endangered southwestern willow flycatcher, *Empidonax traillii* ssp. *extimus*. The beetles have defoliated some tamarisk nest trees of the southwestern willow flycatcher on the Virgin River in southern Utah, and actions to protect the flycatcher are under consideration. In some areas, tamarisk may be replaced by grasslands or shrublands, resulting in losses of riparian forest habitat for birds.

CHEMICAL CONTROL

The following specific use information is based on publications and reports by researchers and land managers. These are the products that provide effective control. Those that do not provide sufficient control have been omitted from the table. 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. The best publication for the management of saltcedar species is published through Colorado State University, entitled *Tamarisk: Best Management Practices in Colorado Watersheds.*

GROWTH REGULATORS	
Triclopyr *Garlon 3A, Garlon 4 Ultra, Pathfinder II*	**Rate:** Cut stump treatment: 50% to undiluted *Garlon 3A* (in water) or 25 to 100% *Garlon 4 Ultra* (in oil). Basal bark treatment: 20 to 30% *Garlon 4 Ultra* in oil on young trees without well-developed bark. **Timing:** While many sources indicate that applications can be applied year round, it is best to apply in summer or fall when plants are still growing and not water stressed. At this time, the greatest amount of herbicide will translocate to the below-ground tissues. **Remarks:** Cut stump treatments can be very effective. Cut stems horizontally at or near ground level, and immediately apply herbicide solution to cover the outer 20% of the stump face. Can be mixed with a color dye to determine which trees have been treated. Basal bark treatments should be made to smaller trees with thin bark. Spray the lower trunk, including the root collar, to a height of 12 to 15 inches from the ground; the spray should thoroughly wet the lower stem but not to the point of runoff. For smaller trees 3 to 4 ft tall, a foliar treatment of 7 oz aminopyralid (*Milestone*) + 3 qt *Garlon 4 Ultra*/acre with 0.25% non-ionic surfactant or 1 qt/acre seed oil surfactant gives good control. Follow-up treatment of resprouts with this mixture will be necessary. This mixture is selective and will not injure desirable grasses.

AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Rodeo, Aquamaster*	**Rate:** Broadcast foliar treatment: 1.5 to 3.3 qt product (*Roundup ProMax*)/acre (1.7 to 3.7 lb a.e./acre). Cut stump treatment: 100% of concentrated product to wet the cambial area of the stump face. **Timing:** Broadcast treatments should be made in late summer or early fall when plants are translocating carbohydrates to the below-ground tissues. Cut stump treatments can be made year-round but avoid treatment under drought conditions. **Remarks:** Glyphosate provides only partial control of *Tamarix* species. Because the herbicide precipitates out when in contact with divalent and trivalent salts, the salty excretions on the foliar glands will reduce the effectiveness of glyphosate. Foliar treatment with glyphosate will probably be most effective if applied shortly after a rainfall event.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapyr *Arsenal AC, Habitat, Stalker, Chopper, Polaris*	**Rate:** Broadcast foliar treatment: 1 qt product (*Arsenal AC*)/acre or 2 qt product (*Habitat*)/acre (1 lb a.i./acre). Spot treatment: 1% v/v *Habitat* spray-to-wet or 3 to 5% for low volume treatments in 10 gal water per acre (GPA). Cut stump treatment: 10% v/v of concentrate on outer cambial region. **Timing:** Late summer or early fall when plants are fully expanded and are translocating carbohydrates to the below-ground tissues. **Remarks:** Imazapyr is the most widely used herbicide to control saltcedar. Both conventional and low-volume applications can give good control. For foliar broadcast or spot treatments add 1% v/v of a non-ionic surfactant or methylated seed oil. Imazapyr is relatively nonselective and can damage or kill other desirable non-target species through direct contact or drift. Low volume treatments are applied to the upper portions of the plant, with coverage not exceeding 30%. Low volume treatments can be very effective on previously burned, recovering plants 6 to 10 ft tall. Spot treatments can be made using a drizzle gun. In addition to ground equipment, treatments can be made by aerial equipment. Helicopter treatments are considered better than fixed-wing as they allow for more consistent results. Herbicide activity may be reduced as saltcedar height and stem number increase. Plants should not be removed for at least 2 years to ensure good control. ALS-resistant kochia has invaded some locations after control of *Tamarix* with imazapyr.
Imazapyr + glyphosate	**Rate:** Broadcast foliar treatment: 1.5 to 2 pt *Habitat*/acre plus 1 to 2 pt glyphosate product/acre. Spot foliar treatment: 0.5% v/v of each product for most consistent results. Apply with 0.25% v/v non-ionic surfactant. **Timing:** Postemergence treatments should be made in late summer or early fall when plants are translocating carbohydrates to the below-ground tissues. **Remarks:** This combination is nonselective. Spot treatments can be made using a drizzle gun. Plants should not be removed for at least 2 years to ensure good control.

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.

This WEED REPORT does not constitute a formal recommendation. When using herbicides always read the label, and when in doubt consult your farm advisor or county agent.

This WEED REPORT is an excerpt from the book *Weed Control in Natural Areas in the Western United States* **and is available wholesale through the UC Weed Research & Information Center (wric.ucdavis.edu) or retail through the Western Society of Weed Science (wsweedscience.org) or the California Invasive Species Council (cal-ipc.org).**

Tamarix aphylla (L.) Karst.; athel tamarisk
Tamarix chinensis Lour.; Chinese tamarisk
Tamarix gallica L.; French tamarisk
Tamarix parviflora DC.; smallflower tamarisk
Tamarix ramosissima Ledeb.; saltcedar, and hybrids of *T. ramosissima, T. gallica,* and *T. chinensis*



Saltcedar and tamarisk



Family: Tamaricaceae
Range: All western and southwestern states, some species widely planted.
Habitat: River, lake and pond margins, washes, roadsides, ditches, flats, sand dunes, desert springs. Grows best in alkaline soil, but tolerates salinity and acidity. Mature plants survive desert heat, below-freezing temperatures, periodic flooding, drought, burning.
Origin: Native to eastern Asia, northern Africa, the Middle East, India, and southern Europe. *Tamarix* species were introduced as landscape ornamentals and have escaped cultivation in many states, especially in the southwest. Athel tamarisk is still widely sold as an ornamental, but is not as invasive as the other species.
Impacts: All species are facultative phreatophytes that can use both surface and groundwater. The presence of numerous trees along riparian corridors or around desert springs can seriously reduce underground water tables and surface water availability, drying up wetlands, and reducing flows. Roots extract salts from deep soil layers and excrete it from the leaves. Salt is deposited on the soil surface with the leaf litter. The increased salinity of the upper soil profile inhibits the growth, survival, and recruitment of desirable native vegetation. Although some animals will seek cover or nest in *Tamarix* thickets, most wildlife does not consume *Tamarix* foliage, fruits, or seeds. *Tamarix* species can increase flooding in riparian areas by narrowing channel width. In addition, the plants are flammable and can introduce fire into wetland and riparian communities that are not adapted to periodic burning.
Western states listed as Noxious Weed: *T. parviflora*, California, Colorado, Montana, Nevada, New Mexico, North Dakota, South Dakota, Wyoming. *T. ramosissima* and hybrids, California, Colorado, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming. *T. chinensis*, California, Colorado, Montana, New Mexico, North Dakota, South Dakota, Wyoming. *T. gallica*, California, Montana, New Mexico, South Dakota, Wyoming
California Invasive Plant Council (Cal-IPC) Inventory: *T. parviflora* and *T. ramosissima*, High Invasiveness; *T. aphylla*, Limited Invasiveness

Tamarix species are small trees or shrubs with tiny scale- or awl-like leaves. Smallflower tamarisk is the shortest of the species and grows to about 15 ft tall. Saltcedar, Chinese tamarisk, and French tamarisk grow to about 20 ft tall. All four of these species are deciduous and have awl-like twig leaves that strongly overlap each other and have acute tips. The foliage of saltcedar, Chinese tamarisk, and French tamarisk is usually more bluish-green than smallflower tamarisk. Athel tamarisk grows to 40 ft tall and is evergreen or semi-evergreen. Its twig leaves are scale-like, not or barely overlapping, and appear like small segments along a stem. *Tamarix* species typically develop an efficient, deep root system (> 15 ft deep) and have a high evapotranspiration rates

in arid climates during the warm season. This occurs because once the roots are within the water table they branch profusely into numerous lateral roots to several feet long.

The inflorescences of *Tamarix* species consist of racemes, mostly 3 to 5 mm wide, typically simple, but occasionally compound and panicle-like. The flowers have a nectar disc at the base which is useful for species identification. Flowers of saltcedar, Chinese tamarisk, and French tamarisk are white, pale or dark pink, mostly with 5 sepals, petals, and stamens. Flowers of smallflower tamarisk are typically pale to dark pink, mostly with 4 sepals, petals, and stamens. Athel tamarisk flowers are white to pale pink, mostly with 5 sepals, petals, and stamens. Plants all reproduce by seed, although seed production is not common in athel tamarisk, and sometimes vegetatively from root sprouts and stem fragments. Stem fragments can take root when buried in a moist substrate, such as might occur with a flooding event. The fruit is a small capsule, often less than 5 mm long, with numerous minute seeds. One mature saltcedar plant can produce about 500,000 seeds per year. Seeds disperse primarily with wind and water, and germination occurs shortly after seed dispersal in spring through summer. Seeds lack a dormancy period, and most germinate within 24 hours after contacting water. Seeds typically survive for only 5 weeks. Individual trees can live 75 to 100 years or more.

Although saltcedar (*T. ramosissima*) and Chinese tamarisk (*T. chinensis*) do not hybridize in their native range, they appear to hybridize extensively in the United States. This hybrid is the most common invasive *Tamarix* species from Oklahoma to Washington to California. Seed viability is high in the hybrids. Less extensively, hybrids between saltcedar and Chinese tamarisk with smallflower tamarisk (*T. parviflora*), Canary Island tamarisk (*T. canariensis*) and French tamarisk (*T. gallica*) also occur. The abundance of invasive hybrids may explain the confusion associated with the identification of *Tamarix* species in the western states.

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GROWTH REGULATORS	
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BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazapyr *Arsenal AC, Habitat, Stalker, Chopper, Polaris*	**Rate:** Broadcast foliar treatment: 1 qt product (*Arsenal AC*)/acre or 2 qt product (*Habitat*)/acre (1 lb a.i./acre). Spot treatment: 1% v/v *Habitat* spray-to-wet or 3 to 5% for low volume treatments in 10 gal water per acre (GPA). Cut stump treatment: 10% v/v of concentrate on outer cambial region. **Timing:** Late summer or early fall when plants are fully expanded and are translocating carbohydrates to the below-ground tissues. **Remarks:** Imazapyr is the most widely used herbicide to control saltcedar. Both conventional and low-volume applications can give good control. For foliar broadcast or spot treatments add 1% v/v of a non-ionic surfactant or methylated seed oil. Imazapyr is relatively nonselective and can damage or kill other desirable non-target species through direct contact or drift. Low volume treatments are applied to the upper portions of the plant, with coverage not exceeding 30%. Low volume treatments can be very effective on previously burned, recovering plants 6 to 10 ft tall. Spot treatments can be made using a drizzle gun. In addition to ground equipment, treatments can be made by aerial equipment. Helicopter treatments are considered better than fixed-wing as they allow for more consistent results. Herbicide activity may be reduced as saltcedar height and stem number increase. Plants should not be removed for at least 2 years to ensure good control. ALS-resistant kochia has invaded some locations after control of *Tamarix* with imazapyr.
Imazapyr + glyphosate	**Rate:** Broadcast foliar treatment: 1.5 to 2 pt *Habitat*/acre plus 1 to 2 pt glyphosate product/acre. Spot foliar treatment: 0.5% v/v of each product for most consistent results. Apply with 0.25% v/v non-ionic surfactant. **Timing:** Postemergence treatments should be made in late summer or early fall when plants are translocating carbohydrates to the below-ground tissues. **Remarks:** This combination is nonselective. Spot treatments can be made using a drizzle gun. Plants should not be removed for at least 2 years to ensure good control.

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ATTACHMENT B

CDFW Streambed Alteration Agreement

EPIMS Notification No. YOL-13602-R2

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH CENTRAL REGION
1701 NIMBUS ROAD, SUITE A
RANCHO CORDOVA, CA 95670

STREAMBED ALTERATION AGREEMENT
EPIMS NOTIFICATION NO. YOL-13602-R2
CACHE CREEK

YOLO COUNTY
HUFF'S CORNER STABILIZATION/RESTORATION PROJECT

This Streambed Alteration Agreement (Agreement) is entered into between the California Department of Fish and Wildlife (CDFW) and Yolo County (Permittee) as represented by Eliza Sabatini.

RECITALS

WHEREAS, pursuant to Fish and Game Code section 1602, Permittee notified CDFW on October 15, 2021 that Permittee intends to complete the project described herein.

WHEREAS, pursuant to Fish and Game Code section 1603, CDFW has determined that the project could substantially adversely affect existing fish or wildlife resources and has included measures in this Agreement necessary to protect those resources.

WHEREAS, Permittee has reviewed this Agreement and accepts its terms and conditions, including the measures to protect fish and wildlife resources.

NOW THEREFORE, Permittee agrees to complete the project in accordance with this Agreement.

PROJECT LOCATION

The project is located at the section of Cache Creek known as "Huff's Corner", a reach on the south bank extending approximately 2,700 feet upstream from the Interstate 5 (I-5) crossing, in the County of Yolo, State of California; Latitude 38.722082°, Longitude -121.808254°; Assessor's Parcel Numbers 025-310-044-000 and 025-310-025-000.

Exhibit A shows the project location.

PROJECT DESCRIPTION

The project consists of two distinct components, including restoring the existing 2,700-foot-long reach of levee to its original design profile, and reconfiguring a segment of the Cache Creek channel to address ongoing erosion of the south bank.

Levee Rehabilitation

The existing 2,700-foot-long reach of levee at Huff's Corner has been identified as being freeboard deficient (i.e., below the design height). The project will raise the entire reach approximately 4 to 6 feet to meet the 1957 design profile. This will include removal and replacement of approximately 1,100 feet of County Road 18, which is located along the western portion of the levee crown.

To accommodate the required elevation, the land side base of the levee will be widened by approximately 12 to 15 feet. In addition, the portion of the levee that extends northward from the hairpin turn of County Road 18 to I-5 will be completely graded down to level earth and a new levee will be built in the same location.

Major construction activities for the levee raise will include clearing, grubbing, and stripping of the widened levee footprint; degradation of the existing levee; construction of approximately 2,700 linear feet of reconfigured levee; restoration of the final levee embankment and staging/laydown areas; installation of erosion control vegetation on the embankment slopes and toe access corridors as appropriate; replacement of County Road 18, including signage and road markings; and installation /replacement of gates, fences, and other similar features.

Channel Reconfiguration

The south bank of Cache Creek at Huff's Corner has approximately 100 linear feet of near-vertical bank, 30 to 50 feet high, which is undercut into the levee slope. The root cause of the erosion has been identified as an abrupt, near 90-degree bend of Cache Creek at the site of the worst erosion. Significant point bar deposition has occurred on the inside edge of the bend opposite the eroded scarp. A vegetated island also exists in the channel at this location which, along with the point bar, constrains the river flow and pushes it against the eroding scarp. The project will repair this erosion site and reconfigure the channel to reduce future erosion.

The project will address these issues using a three-pronged approach. First, sediment will be removed and off-hauled from the north-side secondary channel. Second, some of the vegetation currently stabilizing the mid-channel island will be removed. Finally, a sacrificial terrace will be constructed along the south bank which will serve to reduce flow velocity against the bank and direct flow more towards the center of the channel. Additionally, boulders will be imported and placed along the south bank.

Major construction activities for the erosion control/channel reconfiguration will include excavation and export of sediment; removal and export of vegetation; installing deterrents for motorized vehicle access; and placement of boulders along the south bank.

In-channel work will be conducted while Cache Creek is dry.

Exhibit B shows the Channel Reconfiguration and Levee Rehabilitation areas.

PROJECT IMPACTS

Existing fish or wildlife resources the project could substantially adversely affect include: fish species, amphibians, and other aquatic and terrestrial plant and wildlife species.

The adverse effects the project could have on the fish or wildlife resources identified above include: loss of foraging, nesting, and shelter habitat; disruption to wildlife; disturbance of nesting due to increased human activity, noise, and vibrations; direct mortality or injury to individual plants and animals caused by construction activities; introduction of sedimentation or other pollutants into the watercourse; short-term release of contaminants (e.g., incidental from construction); change in contour of bed, channel or bank; loss of bank stability during construction; increase of bank erosion during construction; and disturbance from project activity.

The project will temporarily disturb/remove vegetation from the following habitat types within the channel and riparian corridor of Cache Creek:

Natural Community	**Impacted Acres**
Cottonwood/Valley Oak Riparian	0.46
Mixed Willow Riparian	0.90
Riparian Scrub	0.36
Herbaceous	2.70
Riverine	0.86
Barren	0.47
Total	**5.75**

Vegetation removed by project activities will include, but is not limited to, removal of up to 118 native trees with trunk diameters at breast height (DBH) over four inches.

MEASURES TO PROTECT FISH AND WILDLIFE RESOURCES

1. Administrative Measures

Permittee shall meet each administrative requirement described below.

1.1 Documentation at Project Site. Permittee shall make this Agreement, any extensions and amendments to this Agreement, and all related notification materials and California Environmental Quality Act (CEQA) documents, readily

available at the project site at all times and shall be presented to CDFW personnel, or personnel from another state, federal, or local agency upon request.

1.2 Providing Agreement to Persons at Project Site. Permittee shall provide copies of this Agreement and any extensions and amendments to this Agreement to all persons who will be working on the project at the project site on behalf of Permittee, including but not limited to contractors, subcontractors, inspectors, and monitors.

1.3 Notification of Conflicting Provisions. Permittee shall notify CDFW if Permittee determines or learns that a provision in this Agreement might conflict with a provision imposed on the project by another local, state, or federal agency. In that event, CDFW shall work with the Permittee to resolve any conflict.

1.4 Project Site Entry. Permittee agrees that CDFW personnel may enter the project site at any time to verify compliance with this Agreement.

1.5 No Trespass. To the extent that any provisions of this Agreement provide for activities that require the Permittee to traverse another owner's property, such provisions are agreed to with the understanding that the Permittee possesses the legal right to so traverse. In the absence of such right, any such provision is void.

1.6 Notification of Project Modification. Permittee agrees to notify CDFW of any modifications made to the project plans submitted to CDFW.

1.7 Change of Conditions and Need to Cease Operations. If conditions arise, or change, in such a manner as to be considered deleterious to the stream or wildlife, operations shall cease until corrective measures approved by CDFW are taken.

1.8 Does Not Authorize "Take". This Agreement does not authorize "take" of any California Endangered Species Act (CESA) listed species. Take is defined in Fish and Game Code section 86, as hunt, pursue, catch, capture or kill or attempt to hunt, pursue, catch, capture, or kill. If there is potential for take of any listed species to occur, Permittee shall consult with CDFW and demonstrate compliance with CESA.

1.9 CEQA Compliance. Permittee shall implement and adhere to the mitigation measures in the Mitigated Negative Declaration (MND) (SCH No. 2021050214), and all associated documents adopted by the County of Yolo as lead agency for the project pursuant to the CEQA (Pub. Resources Code, § 21000 et seq.). If the results of focused or pre-commencement surveys indicate that additional impacts may result from project activities that were not analyzed in the CEQA document, then the Permittee should comply with CEQA before the project commences.

1.10 Yolo HCP/NCCP Compliance. Permittee shall implement and adhere to all relevant avoidance and minimization measures and land cover fees required by the Yolo Habitat Conservation Plan/Natural Community Conservation Plan (Yolo

HCP/NCCP). Relevant Yolo HCP/NCCP avoidance and minimization measures for this project include:

a. AMM3, Confine and Delineate Work Area,
b. AMM4, Cover Trenches and Holes during Construction and Maintenance,
c. AMM5, Control Fugitive Dust,
d. AMM6, Conduct Worker Training,
e. AMM7, Control Nighttime Lighting of Construction Sites,
f. AMM8, Avoid and Minimize Effects of Construction Staging Areas and Temporary Work Areas,
g. AMM12, Minimize Take and Adverse Effects on Habitat of Valley Elderberry Longhorn Beetle,
h. AMM14, Minimize Take and Adverse Effects on Habitat of Western Pond Turtle, and
i. AMM16, Minimize Take and Adverse Effects on Habitat of Swainson's Hawk and White-Tailed Kite

2. Avoidance and Minimization Measures

To avoid or minimize adverse impacts to fish and wildlife resources identified above, Permittee shall implement each measure listed below.

2.1 Work Period. Project construction activities covered under this Agreement shall be confined to the period between May 1 and October 31 of the same calendar year during the term of this Agreement. *Revegetation, restoration and erosion control work is not confined to this time period.*

2.2 In-Channel Work Period. No work shall be conducted within the channel of Cache Creek while water is present unless approved in writing by CDFW. If work must be conducted within the wetted portion of the channel, Permittee shall submit to CDFW for review and approval a detailed plan to temporarily dewater or divert flows around the work area.

2.3 Work Period in Low Rainfall / Dry Weather Only. The work period within the channel of Cache Creek shall be restricted to periods of low rainfall (less than 1/2-inch per 24-hour period) and periods of dry weather (with less than a 40% chance of rain). Permittee shall monitor the National Weather Service (NWS) 72-hour forecast for the project area. No work shall occur during a dry-out period of 24 hours after the above referenced wet weather. Weather forecasts shall be provided upon request by the CDFW. *All erosion control measures shall be initiated prior to all storm events. Revegetation, restoration and erosion control work is not confined to this work period.*

2.4 Designated Biologist(s). At least thirty (30) days before initiating ground- or vegetation-disturbing activities, Permittee shall submit to CDFW in writing the name, qualifications, business address, and contact information for a biological monitor(s) (Designated Biologist). Permittee shall obtain CDFW's written approval of the Designated Biologist(s) prior to the commencement of project activities. The

Designated Biologist(s) shall be knowledgeable and experienced in the biology and natural history of local fish and wildlife resources present at the project site.

2.5 Designated Biologist Authority. The Designated Biologist(s) shall have authority to immediately stop any activity that is not in compliance with this Agreement, and/or to order any reasonable measure to avoid or minimize impacts to fish and wildlife resources. Neither the Designated Biologist(s) nor CDFW shall be liable for any costs incurred as a result of compliance with this measure. This includes cease-work orders issued by the CDFW.

2.6 On-site Education. Permittee shall conduct an education program for all persons employed or otherwise working on the project site prior to performing any work on-site. The program shall consist of a presentation from one or more Designated Biologists that includes a discussion of the biology of the habitats and species identified in this Agreement and present at this site. The Designated Biologist(s) shall also include as part of the education program information about the distribution and habitat needs of any special status species that may be present, legal protections for those species, penalties for violations and project-specific protective measures included in this Agreement. Interpretation shall be provided for non-English speaking workers, and the same instruction shall be provided for any new workers prior to their performing work on-site. Permittee shall prepare and distribute cards or a fact sheet that contains this information for workers to carry on-site. Upon completion of the education program, employees shall sign a form stating they attended the program and understand all protection measures. These forms shall be filed at the worksite offices and submitted as instructed in Contact Information section below. Email notification is preferred.

Site Access / Vegetation Removal

2.7 Demarcate Work Area Boundary. In consultation with the Designated Biologist(s), the Permittee shall demarcate the outer perimeter of the work area to prevent damage to adjacent habitat and to provide visual orientation to its limits. Marking shall be in place during all periods of operation. All persons employed or otherwise working on the project site shall be instructed about the restrictions that the marking represents.

2.8 Vegetation Removal. Disturbance or removal of vegetation shall be kept to the minimum necessary to complete project related activities. Except for tree removal already described in the impacts section of this Agreement, no native trees with a DBH in excess of four (4) inches shall be removed or damaged without prior consultation and approval of a CDFW representative. Where native trees or woody riparian vegetation split into several trunks close to ground level, the DBH shall be measured for each trunk and calculated as one tree. Vegetation marked for protection may only be trimmed with hand tools to the extent necessary to gain access to the work sites.

2.9 Remove Cleared Material from Stream. All trimmed or cleared material/vegetation shall be removed from the area and deposited where it cannot re-enter the stream.

Biological Resources

2.10 Leave Wildlife Unharmed. If any wildlife is encountered during the course of construction, said wildlife shall be allowed to leave the construction area unharmed.

2.11 Special-Status Species encountered during work. If the Permittee encounters any special-status species during project activities, work shall be suspended, CDFW notified, and conservation measures shall be developed in agreement with CDFW prior to re-initiating the activity. If during project activities, the Permittee encounters any species listed pursuant to the California Endangered Species Act (CESA), work shall be suspended, and CDFW notified. Work may not re-initiate until the Permittee has consulted with CDFW and can demonstrate compliance with CESA.

2.12 Nesting Bird Survey. A focused survey for nests shall be conducted by a Designated Biologist within three (3) calendar days prior to the beginning of Project-related activities. The Designated Biologist shall survey a minimum radius of 500-foot (for non-raptors) and 1/2-mile (for raptors) around the Project area that can be accessed by Permittee. The results of the survey shall be provided to CDFW upon completion. If no active nests are found, project activities may proceed as scheduled.

2.12.1 Active Nests. If an active nest is found, active nests should be avoided, and a no disturbance or destruction buffer shall be determined and established by a Designated Biologist. The buffer shall be kept in place until after the breeding nesting season or the Designated Biologist confirms the young have fledged, are foraging independently, and the nest is no longer active for the season. The extent of these buffers shall be determined by the Designated Biologist and will depend on the species present, the level of noise or construction disturbance, line of sight between the nest and the disturbance, ambient levels of noise and other disturbances, and other topographical or artificial barriers.

2.12.2 Project Delay. If a lapse in project-related work of fourteen (14) calendar days or longer occurs, the Designated Biologist(s) shall complete another focused survey before Project work can be reinitiated.

2.12.3 Permittee Responsibility. It is the Permittee's responsibility to comply with Fish and Game Code Sections 3503, 3503.5, and 3513, regardless of the time of year. This Agreement does not authorize take of birds, their nests, or their eggs.

2.13 Invasive Species. Permittee shall conduct project activities in a manner that prevents the introduction, transfer, and spread of aquatic, riparian, and terrestrial invasive species from one work site and/or water body to another. Prior to entering

the project area, Permittee shall inspect equipment for invasive species and, if any signs of invasive species are found, the equipment shall be cleaned to remove those species. All visible soil/mud, plant materials, and animal remnants on equipment will be removed prior to entering and exiting the work site and/or between each use in different water bodies. Permittee shall notify CDFW immediately if an invasive species not previously known to occur within the work site is discovered during work activities by contacting CDFW's Invasive Species Program by email at Invasives@wildlife.ca.gov.

2.14 Bat Surveys and Avoidance. Within six months prior to the start of vegetation removal and/or construction, a Designated Biologist with education and experience in bat biology and identification (Designated Bat Biologist) shall survey the project site for potentially suitable bat roosting habitat. Within 48 hours prior to the start of any project activities that may directly or indirectly impact potentially suitable bat roosting habitat, the Designated Bat Biologist shall survey the potential roosting habitat for active roosts. If an active bat roost is found, the Designated Bat Biologist shall establish a no-disturbance buffer around the roost. The width of the buffer shall be determined by the Designated Bat Biologist based on the bat species, specific site conditions, and level of disturbance. The buffer shall be maintained until the Designated Bat Biologist determines that the roost is no longer active.

2.14.1 Tree Trimming and/or Removal. Trimming and/or removal of trees in which suitable roosting habitat (exfoliating bark, cavities, or crevices) is present shall be scheduled either (1) between approximately March 1 (or when evening temperatures are above 45°F and rainfall less than ½ inch in 24 hours occurs) and April 15, prior to parturition of pups; or (2) between September 1 and October 15 (or prior to evening temperatures dropping below 45°F and onset of rainfall greater than ½ inch in 24 hours). Additionally, trees shall be removed in two steps over a period of two days. On the first day, all branches that do not contain roosting habitat shall be removed using chainsaws or similar handheld equipment. The remaining portion of the tree shall be removed on the second day. Tree trimming and/or tree removal may occur outside of this work window, if the Designated Bat Biologist confirms, in consultation with CDFW, that the suitable habitat is not occupied.

2.14.2 Bat Exclusion. If an active bat roost is found in a tree or structure that must be removed, the Designated Bat Biologist shall prepare a plan for the passive exclusion of the bats from the roost for CDFW's review and approval. Exclusion shall be scheduled either (1) between approximately March 1 (or when evening temperatures are above 45°F and rainfall less than ½ inch in 24 hours occurs) and April 15, prior to parturition of pups; or (2) between September 1 and October 15 (or prior to evening temperatures dropping below 45°F and onset of rainfall greater than ½ inch in 24 hours). The Designated Bat Biologist shall monitor the roost prior to exclusion to

confirm that it does not support a maternity colony. If a maternity colony is or may be present, the roost shall be avoided until it is no longer active, or until the Designated Bat Biologist can confirm that no maternity colony is present.

2.15 Avoid Wildlife Entrapment in Trenches. Permittee shall completely cover or provide escape ramps for all trenches and steep-walled holes more than one foot deep at the end of each workday to prevent entrapment of wildlife. Permittee shall ensure that covers are flush with the ground and do not allow small animals to crawl underneath. Prior to the filling of trenches and/or steep-walled holes, the Designated Biologist(s) shall inspect them for trapped wildlife and remove or release any wildlife found.

2.16 Avoid Wildlife Entrapment in Construction Materials. The Designated Biologist(s) shall inspect all open sections of pipe and any other construction materials and equipment that may provide shelter or refuge to wildlife and have been left overnight on the project site for wildlife prior to use. Any wildlife found sheltering in construction materials or equipment shall be allowed to leave, released, or removed prior to use of the materials or equipment.

Erosion Control/Stabilization

2.17 Erosion Control. Permittee shall actively implement best management practices (BMPs) to minimize turbidity and siltation and prevent erosion and the discharge of sediment where it may pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, other sensitive habitat during project activities. Precautions shall include, but are not limited to: pre-construction planning to identify site specific turbidity and siltation minimization measures; best management erosion control practices during project activity; and settling, filtering, or otherwise treating silty and turbid water prior to discharge into a stream or storm drain. This may require the placement of silt fencing, coir logs, coir rolls, straw bale dikes, or other siltation barriers so that silt and/or other deleterious materials are not allowed to pass to downstream reaches.

2.17.1 Monitoring. BMPs shall be monitored daily and repaired if necessary to ensure maximum erosion and sediment control.

2.17.2 Materials. All fiber rolls, straw wattles, and/or hay bales utilized within and adjacent to the project site shall be free of non-native plant materials. Fiber rolls or erosion control mesh shall be made of loose-weave mesh that is not fused at the intersections of the weave, such as jute, or coconut (coir) fiber, or other products without welded weaves. Products with plastic monofilament or cross joints in the netting that are bound/stitched (such as found in straw wattles/fiber rolls and some erosion control blankets), which may cause entrapment of wildlife, shall not be allowed.

2.17.3 Implementation. Passage of sediment beyond the sediment barrier(s) is prohibited. If any sediment barrier fails to retain sediment, corrective

measures shall be taken. The sediment barrier(s) shall be maintained in good operating condition throughout the construction period and the following rainy season. Maintenance includes, but is not limited to, removal of accumulated silt and/or replacement of damaged silt fencing, coir logs, coir rolls, and/or straw bale dikes. Upon the CDFW's determination that turbidity/siltation levels resulting from project-related activities constitute a threat to aquatic life, activities associated with the turbidity/siltation shall be halted until effective CDFW-approved control devices are installed or abatement procedures are initiated.

2.18 Prohibition Against Use of Plastic Netting in Erosion Control Measures. Permittee shall not use temporary or permanent erosion control devices containing plastic netting, including photo- or bio-degradable plastic netting. These items are commonly found in straw waddles (fiber rolls) and erosion control blankets.

2.19 Site Restoration. All areas and access points exposed or disturbed during project activities shall be restored using conditions as set forth in the *Revegetation and Restoration* section above. Seeded areas shall be covered with broadcast straw and/or seeded erosion control blankets.

Avoid/Minimize Effects of Equipment

2.20 Heavy Equipment Maintenance. Motorized equipment and vehicles shall be checked and maintained regularly to prevent leaks of materials that could be deleterious to aquatic and terrestrial life or riparian habitat. Onsite storage, maintenance and/or refueling of vehicles or equipment shall be restricted to designated areas located far enough away from drainage courses to prevent any spills from contaminating aquatic or riparian habitat, either directly or via stormwater runoff. If equipment maintenance or refueling must occur near sensitive habitat, a secondary containment structure shall be used. Drip pans or absorbent materials shall be placed under vehicles and equipment when not in use.

2.21 Minimize Vehicle Parking. Vehicles may enter and exit the work area as necessary for project activities, but may not be parked overnight within ten (10) feet of the drip line of any trees; nor shall vehicles be parked where mechanical fluid leaks may potentially pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, or other sensitive habitat.

2.22 Building Material Storage. Project building material and/or construction equipment shall not be placed where materials could pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, other sensitive habitat, or where they may cover aquatic or riparian vegetation.

2.23 Decontamination of Project Equipment. Permittee shall decontaminate all tools, waders and boots, and other equipment that will enter the water prior to entering and exiting the project site to avoid the introduction and transfer of organisms.

Permittee shall decontaminate project gear and equipment utilizing one of three methods: drying, using a hot water soak, or freezing, as appropriate to the type of gear or equipment. For all methods, Permittee shall begin the decontamination process by thoroughly scrubbing equipment, paying close attention to small crevices such as boot laces, seams, net corners, etc., with a stiff-bristled brush to remove all organisms. To decontaminate by drying, Permittee shall allow equipment to dry thoroughly (i.e., until there is a complete absence of water), preferably in the sun, for a minimum of 48 hours. To decontaminate using a hot water soak, Permittee shall immerse equipment in 140 degrees Fahrenheit or hotter water and soak for a minimum of 5 minutes. To decontaminate by freezing, Permittee shall place equipment in a freezer 32 degrees Fahrenheit or colder for a minimum of eight (8) hours. Repeat decontamination is required only if the equipment/clothing is removed from the site, used within a different waterbody, and returned to the project site.

2.24 Decontamination Sites. Permittee shall perform decontamination of vehicles, watercraft, and other project gear and equipment in a designated location where runoff can be contained and not allowed to pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, or other sensitive habitat.

2.25 Stationary Equipment Leaks. Stationary equipment such as motors, pumps, generators, and welders shall be positioned over drip pans and/or other secondary containment structures. Permittee shall ensure that any secondary containment is sufficient to handle any potential spill or leak.

2.26 Equipment Maintenance and Fueling. No equipment maintenance or fueling shall be done where petroleum products or other pollutants from the equipment may pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, or other sensitive habitat.

2.27 Staging and Storage Areas. Staging and storage areas for equipment, materials, fuels, lubricants, and solvents shall be located more than 150 feet from waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, other sensitive habitat, unless otherwise approved by CDFW in writing. All equipment and fuel stored on site shall be properly contained and protected from rain.

Debris Materials and Waste

2.28 Remove Structures. Project-related structures and associated materials not designed to withstand high water flows or placed in seasonally dry portions of a stream or lake that could be washed downstream or could be deleterious to aquatic life, wildlife, or riparian habitat shall be moved to areas above high water before such flows occur.

2.29 No Dumping. Permittee and all contractors, subcontractors, and employees shall not dump any litter or construction debris on the project site.

2.30 Remove Temporary Flagging, Fencing, and Barriers. Permittee shall remove all temporary flagging, fencing, and/or barriers from the project area and vicinity immediately upon completion of project activities.

2.31 Wash Water. Water containing mud, silt, or other pollutants from equipment washing or other activities, shall not be allowed to enter sensitive areas, or placed in locations where it may pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, or other sensitive habitat.

2.32 Hazardous Materials. Debris, soil, silt, sand, rubbish, construction waste, cement or concrete or washings thereof, asphalt, paint, oil or other petroleum products or any other substances which could be hazardous to aquatic life, or other organic or earthen material from project activities shall not be stored where it may pass into waters of the state (Fish & G. Code § 89.1), the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, other sensitive habitat. Staging and storage areas for equipment, materials, fuels, lubricants and solvents, shall be located more than 150 feet from the waters of the state, the stream bed, bank, or channel (including but not limited to dry, ponded, flowing, or wetland areas), drainages, lakes, or other sensitive habitat, unless otherwise approved by CDFW in writing. Ensure that all construction areas have proper spill clean-up materials (absorbent pads, sealed containers, booms, etc.) to contain the movement of any spilled substances. All debris shall be disposed of properly. BMPs shall be employed to accomplish these requirements. CDFW shall be notified immediately by the Permittee of any spills and shall be consulted regarding clean-up procedures.

2.33 Removal of Debris, Materials and Rubbish. Permittee shall remove all project generated debris, building materials and rubbish from the project area following completion of project activities.

3. Compensatory Measures

To compensate for adverse impacts to fish and wildlife resources identified above that cannot be avoided or minimized, Permittee shall implement each measure listed below.

3.1 Restoration of all Temporary Disturbed Areas. Permittee shall revegetate all temporarily disturbed areas within the channel of Cache Creek as soon as possible and within one year following disturbance. All seed, container stock, cuttings, and/or other plant materials used must be locally native and appropriate for use in wetland and wetland-upland transitional areas.

3.2 Replacement of Trees and Shrubs. Permittee shall replace all native woody trees and shrubs with diameter at breast height (DBH) of four inches or more with the

same species at a ratio of 3:1 or greater at the impact site or an offsite location approved in writing by CDFW. Where native trees or shrubs split into several trunks close to ground level, the DBH shall be measured for each trunk and calculated as one tree. The number of trees to be planted will be determined by assessing the number of live trees with a DBH greater than 4 inches that are removed at the time of construction. The ultimate number of trees required to planted will be provided in the Riparian Restoration Plan (Condition 3.4). Permittee shall include appropriate herbaceous and understory species within the restoration area(s) unless otherwise agreed upon in writing by CDFW.

3.3 Restoration Success Criteria. The riparian restoration shall be considered successful only when at least 70% of the planted trees and shrubs have survived for at least five (5) years, including at least two (2) years without supplemental irrigation. Mortality of trees and shrubs planted in excess of the 3:1 minimum replacement requirement may be discounted when calculating survival rates for the purpose of evaluating the site's success.

3.4 Riparian Restoration Plan. As soon as possible and at least thirty (30) days prior to the onset of restoration work, Permittee shall provide to CDFW for review and approval a Riparian Restoration Plan. Permittee shall obtain CDFW's written approval of the Riparian Restoration Plan before implementing the restoration. The Riparian Restoration Plan shall include, but is not limited to, the following:

a. A description of the existing physical conditions of the restoration areas, including surrounding habitat types, and a map or maps showing the location of the restoration areas;
b. A description of how the restoration areas will be prepared for planting, including the removal of non-native plant species if applicable;
c. An accounting of the number and species of trees and shrubs that were removed from the project area and the number and species of trees and shrubs that will be planted to replace them;
d. An overview of the success criteria for the restoration areas;
e. A planting plan which includes the number and species of trees, shrubs, and any other container stock to be planted, a native seed mix, a description of the spacing of container stock, and a map showing the proposed planting arrangements and designated photo points;
f. An irrigation plan;
g. A timeline for implementation;
h. An overview of invasive plants in the area and a plan to prevent them from establishing within the restoration areas;
i. An overview of any foreseeable problems that may threaten the restoration's success and measures to address them as needed; and
j. Contingency measures for replanting and plan re-design in case success criteria are not met.

4. Reporting Measures

Permittee shall meet each reporting requirement described below.

4.1 Notification of Project Initiation. The Permittee shall notify the CDFW two (2) calendar days prior to beginning work for each construction season. Notification shall be submitted as instructed in Contact Information section below. Email submittal is preferred.

4.2 Notification of Project Completion. Upon completion of the project activities described in this Agreement, the project activities shall be digitally photographed. Photographs shall be submitted to CDFW within fifteen (15) calendar days of project completion. Photographs and project completion notification shall be submitted as instructed in Contact Information section below. Email submittal is preferred.

4.3 Notification to the California Natural Diversity Database. If any special-status species are observed during project implementation, the Permittee shall submit the California Natural Diversity Data Base (CNDDB) Online Field Survey Form electronically at https://www.wildlife.ca.gov/data/CNDDB/submitting-data within five (5) working days of the sightings, and provide a copy of the form, survey map and/or report to the CDFW's Regional office as instructed in Contact Information section below.

4.4 Restoration Monitoring Reports. After completion of the restoration activities, the area of restoration shall be monitored for a minimum of five (5) years and until CDFW determines the success criteria have been met. Each year for at least five years after restoration, a monitoring report shall be submitted to CDFW for review and approval. The report shall discuss the mitigation performance as it relates to the success criteria. The report shall include the success of natural revegetation establishment, survival, percent cover, and height of both tree and shrub species. The number by species of plants replaced, an overview of the revegetation effort, and the method used to assess these parameters shall also be included. The report shall include photos from designated photo stations and other relevant information such as: a summary of invasive species control, methods used to remove non-native plants, and a list of wildlife observed on site.

CONTACT INFORMATION

Any communication that Permittee or CDFW submits to the other shall be in writing and any communication or documentation shall be delivered to the address below by U.S. mail, fax, or email, or to such other address as Permittee or CDFW specifies by written notice to the other.

To Permittee:

Elisa Sabatini
Yolo County Administrator's Office

Attn: Natural Resources Division
625 Court Street, Room 202
Woodland, CA 95695
Phone: (916) 402-3985
Email: elisa.sabatini@yolocounty.org

Contact:

Casey Liebler
Phone: (530) 666-8236
Email: casey.liebler@yolocounty.org

To CDFW:

Department of Fish and Wildlife
North Central Region
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670
Attn: Lake and Streambed Alteration Program
EPIMS Notification No. YOL-13602-R2
Phone: (916) 358-2885
Email: R2LSA@wildlife.ca.gov

LIABILITY

Permittee shall be solely liable for any violations of this Agreement, whether committed by Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents or contractors and subcontractors, to complete the project or any activity related to it that this Agreement authorizes.

This Agreement does not constitute CDFW's endorsement of, or require Permittee to proceed with the project. The decision to proceed with the project is Permittee's alone.

SUSPENSION AND REVOCATION

CDFW may suspend or revoke in its entirety this Agreement if it determines that Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, is not in compliance with this Agreement.

Before CDFW suspends or revokes this Agreement, it shall provide Permittee written notice by certified or registered mail that it intends to suspend or revoke. The notice shall state the reason(s) for the proposed suspension or revocation, provide Permittee an opportunity to correct any deficiency before CDFW suspends or revokes this Agreement, and include instructions to Permittee, if necessary, including but not limited to a directive to immediately cease the specific activity or activities that caused CDFW to issue the notice.

ENFORCEMENT

Nothing in this Agreement precludes CDFW from pursuing an enforcement action against Permittee instead of, or in addition to, suspending or revoking this Agreement.

Nothing in this Agreement limits or otherwise affects CDFW's enforcement authority or that of its enforcement personnel.

OTHER LEGAL OBLIGATIONS

This Agreement does not relieve Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, from complying with, from obtaining any other permits or authorizations that might be required under, other federal, state, or local laws or regulations before beginning the project or an activity related to it. For example, if the project causes take of a species listed as threatened or endangered under the Endangered Species Act (ESA), such take will be unlawful under the ESA absent a permit or other form of authorization from the U.S. Fish and Wildlife Service or National Marine Fisheries Service.

This Agreement does not relieve Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, from complying with other applicable statutes in the Fish and Game Code including, but not limited to, Fish and Game Code sections 2050 *et seq*. (threatened and endangered species), section 3503 (bird nests and eggs), section 3503.5 (birds of prey), section 5650 (water pollution), section 5652 (refuse disposal into water), section 5901 (fish passage), section 5937 (sufficient water for fish), and section 5948 (obstruction of stream).

Nothing in this Agreement authorizes Permittee or any person acting on behalf of Permittee, including its officers, employees, representatives, agents, or contractors and subcontractors, to trespass.

AMENDMENT

CDFW may amend this Agreement at any time during its term if CDFW determines the amendment is necessary to protect an existing fish or wildlife resource.

Permittee may amend this Agreement at any time during its term, provided the amendment is mutually agreed to in writing by CDFW and Permittee. To request an amendment, Permittee shall submit to CDFW a completed CDFW “Request to Amend Lake or Streambed Alteration” form and include with the completed form payment of the corresponding amendment fee identified in CDFW’s current fee schedule (see Cal. Code Regs., tit. 14, § 699.5).

TRANSFER AND ASSIGNMENT

This Agreement may not be transferred or assigned to another entity, and any purported transfer or assignment of this Agreement to another entity shall not be valid or effective, unless the transfer or assignment is requested by Permittee in writing, as specified below, and thereafter CDFW approves the transfer or assignment in writing.

The transfer or assignment of this Agreement to another entity shall constitute a minor amendment, and therefore to request a transfer or assignment, Permittee shall submit to CDFW a completed CDFW "Request to Amend Lake or Streambed Alteration" form and include with the completed form payment of the minor amendment fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5).

EXTENSIONS

In accordance with Fish and Game Code section 1605, subdivision (b), Permittee may request one extension of this Agreement, provided the request is made prior to the expiration of this Agreement's term. To request an extension, Permittee shall submit to CDFW a completed CDFW "Request to Extend Lake or Streambed Alteration" form and include with the completed form payment of the extension fee identified in CDFW's current fee schedule (see Cal. Code Regs., tit. 14, § 699.5). CDFW shall process the extension request in accordance with Fish and Game Code section 1605, subdivisions (b) through (e).

If Permittee fails to submit a request to extend this Agreement prior to its expiration, Permittee must submit a new notification and notification fee before beginning or continuing the project this Agreement covers (Fish & G. Code § 1605, subd. (f)).

EFFECTIVE DATE

This Agreement becomes effective on the date of CDFW's signature, which shall be: 1) after Permittee's signature; 2) after CDFW complies with all applicable requirements under the California Environmental Quality Act (CEQA); and 3) after payment of the applicable Fish and Game Code section 711.4 filing fee listed at https://www.wildlife.ca.gov/Conservation/CEQA/Fees.

TERM

This Agreement shall **expire five (5) years** from the date signed by CDFW. All provisions in this Agreement shall remain in force throughout its term. Permittee shall remain responsible for implementing any provisions specified herein to protect fish and wildlife resources after this Agreement expires or is terminated, as Fish and Game Code section 1605, subdivision (a)(2) requires.

EXHIBITS

The documents listed below are included as exhibits to this Agreement and incorporated herein by reference.

A. Exhibit A. Project Location
B. Exhibit B. Project Areas

AUTHORITY

If the person signing this Agreement (signatory) is doing so as a representative of Permittee, the signatory hereby acknowledges that he or she is doing so on Permittee's behalf and represents and warrants that he or she has the authority to legally bind Permittee to the provisions herein.

AUTHORIZATION

This Agreement authorizes only the project described herein. If Permittee begins or completes a project different from the project this Agreement authorizes, Permittee may be subject to civil or criminal prosecution for failing to notify CDFW in accordance with Fish and Game Code section 1602.

CONCURRENCE

Through the electronic signature by the permittee or permittee's representative as evidenced by the attached concurrence from CDFW's Environmental Permit Information Management System (EPIMS), the permittee accepts and agrees to comply with all provisions contained herein.

The EPIMS concurrence page containing electronic signatures must be attached to this agreement to be valid.

Exhibit A: Project Location

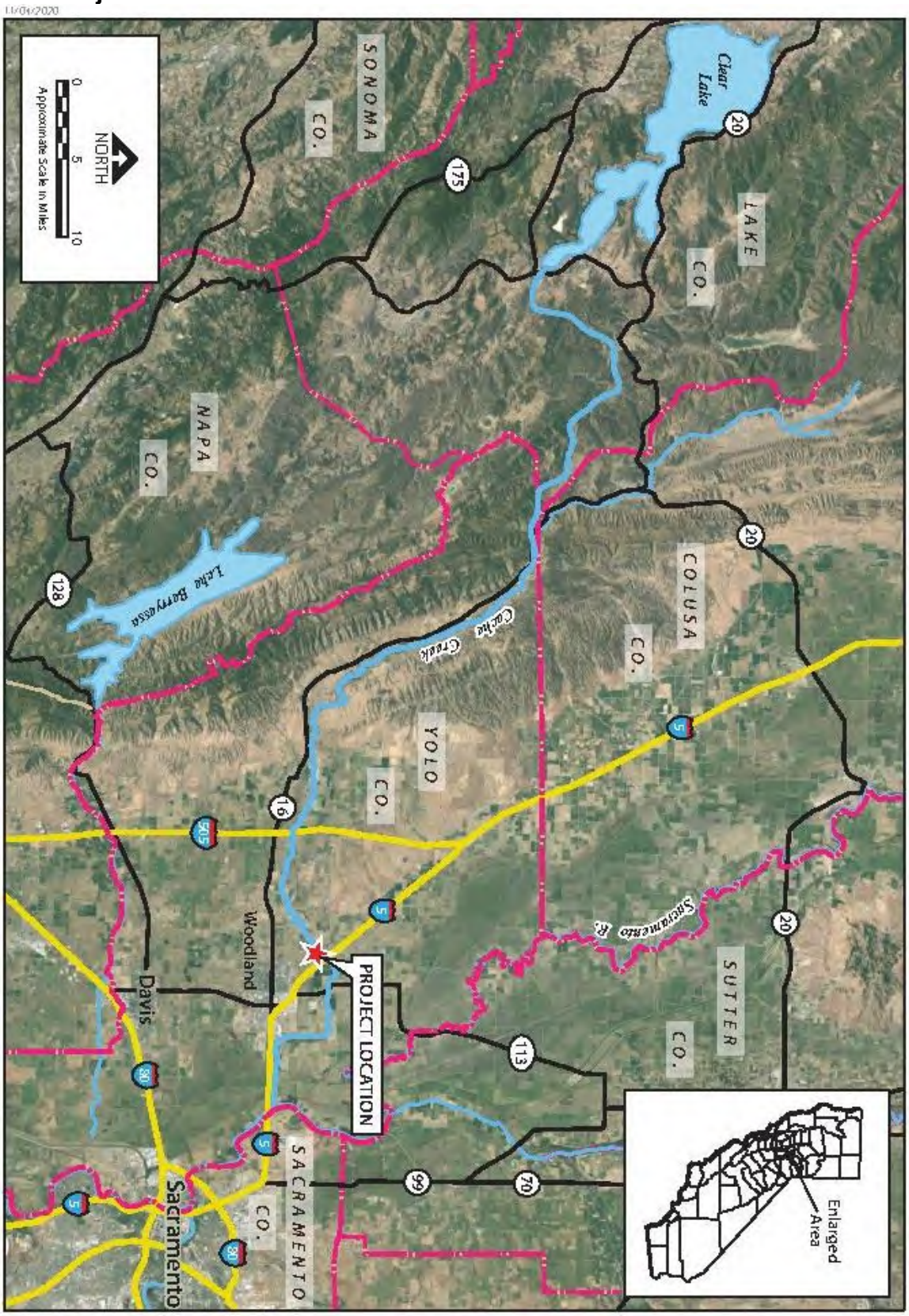


Figure 1
Regional Location of Huff's Corner Project along Cache Creek, Yolo County

Exhibit B: Project Areas

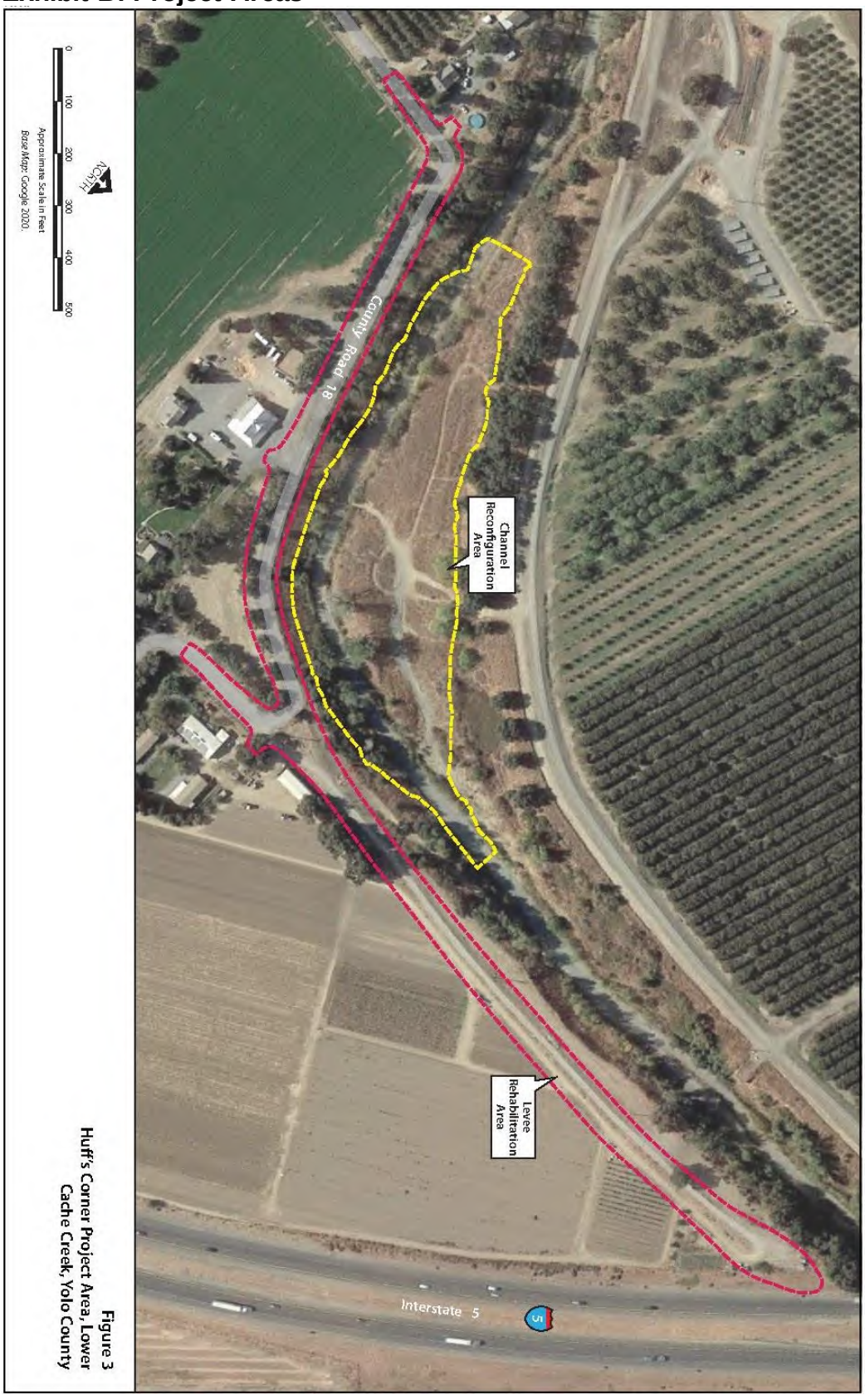


Figure 3
Huff's Corner Project Area, Lower Cache Creek, Yolo County



Permit Details

Permit: EPIMS-YOL-13602-R2 - Huff's Corner Stabilization/Restoration project along Lower Cache Creek, Yolo County - 2022

Status:	Underway
Region:	Region 2
Permittee Organization:	Yolo County
CDFW Contact:	Gabriele Quillman

Standard Agreement

Signature Page

This Standard Agreement is being issued to:

Elisa Sabatini

Final Standard Agreement:* EPIMS-YOL-13602-R2-Final-Standard-Agreement.pdf
Open and print the attached PDF file.

Exhibits

Exhibits 1	
Document Description:	Exhibit A - Locations Map
Document:	Exhibit A Location.jpg

Exhibits 2	
Document Description:	Exhibit B - Project Areas
Document:	Exhibit B Project Areas.jpg

Concurrence

I am the applicant or I have the authority to sign for the applicant. By my signature, I accept and agree to comply with all the provisions contained herein.

Final Agreement Effective Date:

Permittee Electronic Signature: Elisa M. Sabatini
First and Last Name

Date Signed: 08/12/2022

Department of Fish and Wildlife

CDFW Electronic Signature: Jennifer Garcia

CDFW Representative Environmental Program Manager

Title:

Date Signed: 08/16/2022

Acting for: