APPENDIX E

# Baker County

Mason Dam Hydroelectric Project
FERC No. P-12686

# Revegetation/Noxious Weed Management Plan

February 2011

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## I. Introduction

Baker County has applied to the Federal Energy Regulatory Commission (FERC) to develop hydroelectric energy at the existing Mason Dam. Mason Dam is located along the Powder River in Baker County, Oregon approximately 15 miles southwest of Baker City off of State Highway 7 and in the Wallowa-Whitman national Forest.

Mason Dam was built by the US Bureau of Reclamation (BOR) on the Powder River for irrigation, water delivery, and flood control. Mason Dam is 173 feet high, 895 feet long and 875 feet wide from toe to toe. Phillips Reservoir is formed from Mason Dam and covers 2,235 acres, has a total of 95,500 acre-feet, with 90,500 acre-feet being active. Water is stored behind Mason Dam in Phillips Reservoir, and is released during the irrigation season by Baker Valley Irrigation District (BVID). Water is generally stored between October and March and released April through September.

The intake of Mason Dam is located within a 17 x 17 x 13.3 foot high barrier with large bars, spaced 6 inches apart that act as a trash rack. There are two pipes that can be used to release water. One is a 56 inch diameter pipe and the other is a 12 inch diameter pipe. The 56 inch pipe is split into two 33 inch, high pressure gates, which are located in the valve house to control the release into the stilling basin via the tail race. The 12 inch pipe uses a sleeve/weir type valve to release water into the stilling basin. The outlet works consists of a tunnel controlled by the two high pressure gates with hydraulic hoists that have a capacity of 875 cfs at a reservoir elevation of 4070.5 feet. The spillway has an uncontrolled crest and is concrete lined with a maximum capacity of 1,210 cfs at a reservoir elevation of 4077.25 feet. The spillway and outlet works share a common stilling basin.

The proposed hydroelectric plant will contain a single horizontal shaft Francis turbine connected to a 3.4 MW 60 hertz, 12,640 volt generator with a brushless exciter. It will operate efficiently over a head range of 10 to 150 feet, and flows from 120 to 300 cfs. An extended downward tilted draft tube will discharge into the tailrace. The draft tube will be fitted with aeration fittings to provide aspiration of air to increase dissolved oxygen in the river. Plant controls will include a synchronous bypass to initiate the operation of the Reclamation slide gates during turbine shut down. A new hydraulic power unit (HPU) will be provided to increase the rate of the slide gates opening to more closely match the rate of flow lost when the turbine shuts down. Power generated will be sent to the substation .8 miles away from the powerhouse. The current plan is for the line to be overhead following the Black Mountain Road.

## 1.0 Purpose and Scope

The Revegetation/Noxious Weed Management plan documents the obligations of Baker County to:

1) Revegetate areas disturbed by project construction and
2) Control noxious weed that could be introduced or spread by project construction and/or operation.

The mitigation measures described in the plan will apply to all lands lying within the FERC project boundary as shown in the attached Exhibit G drawing (Attachment 7.5), or any revised Exhibit G drawing that may be submitted to FERC in the future to accommodate changes in the project. All construction activities, ground disturbance and permanent project facilities will occur inside this boundary. The mitigation measures described herein will also be applied for an additional 100 ft beyond the FERC boundary in the vicinity of the powerhouse, and an additional 25 ft on each side of the transmission line corridor.

The project impacts to vegetation are expected to be as follows:

- Approximately 1.5 acres at the base of Mason Dam for the new penstock, powerhouse and substation
- Less than 0.05 acres total for the transmission line poles (100 sq ft around each of the 18 power poles)
- Approximately 0.25 acres for a narrow corridor needed to move equipment to the location for building the Idaho Power interconnection

The details for revegatation, site monitoring, and weed treatment are described below.

## 2.0 References

2.1 Baker County 2010 Noxious Weed List

2.2 USDA Forest Service, Region 6, Common Control Measures for Invasive Plants of the Pacific Northwest Region, March 31, 2006, Editor's not added August 9, 2006

2.3 Study Plan 2 & 3 Noxious Weed Survey, Final Report for Baker County Mason Dam Hydroelectric Project

2.4 Umatilla and Wallowa-Whitman National Forests Invasive Plant Program EIS, available online at, www.fs.fed.us/r6/w-w/projects/invasive-plants/index.shtml

## 3.0 Definitions

3.1 Class A Weeds: Mandatory Control County Wide

3.2 Class B Weeds: Widespread and/or of high concern

3.3 Class C Weeds: Widespread and/or of moderate concern

## 4.0 Responsibilities

Baker County will coordinate with the Baker County Weed Department to ensure that the noxious weed control program is effective and in compliance with local, state, and federal regulations.

## 5.0 Procedures

5.1 An adaptive management approach will be taken that ensures early detection and rapid response. For the following reasons, an adaptive management approach was chosen over a site-specific approach.

1. Considering the relatively small elements of scale, we believe it would be erroneous to focus on specific sites (including along the road or around structures), and potentially exclude areas of future weed encroachment of the species currently present.

2. A site-specific approach has the potential to ignore other species that may encroach once the site is opened to project-related disturbance.

3. The very nature of the noxious weed species present on the site requires a comprehensive rather than exclusive focus. Inherent within the nature of invasive noxious weeds is their ability to occupy new sites.

5.2 The project area will be grid surveyed in June and again in September for the first 2 years post-project completion for all "A" and "B" listed weeds.

5.3 All noxious weeds observed during grid surveying will be treated using site-appropriate herbicides, consistent with USDA Forest Service Programmatic EIS. (Available online at, www.fs.fed.us/r6/w-w/projects/invasive-plants/index.shtml)

5.4 Each year, Baker County will obtain the current noxious weed list and update the plan to reflect the changes.

5.5 In January of every year the Hydroelectric Project Manager and the Baker County Weed Department director will discuss and review last years operation, develop the current years operations based on the finding of last year and the updated Noxious weed lists

## 6.0 Mitigation Measures

Mitigation measures are intended to assure that any disturbed areas are restored with beneficial vegetation and that project disturbance does not lead to introduction or spread of noxious weeds. Any areas around the powerhouse that are not revegetated, e.g. permanent parking or storage areas will be managed in a manner that prevents establishment of noxious weeds.

6.1 All disturbed areas would be reseeded with native and desirable non-native seed mixes to benefit wildlife and to prevent spread of noxious weeds. The seed mix will be determined through consultation with the Forest Service and ODF&W.

6.2 No disturbance to wetland habitats is anticipated. However, in the event that disturbance is unavoidable, wetland habitat would be re-contoured and reseeded.

6.3 To prevent the introduction of noxious weed, construction equipment will be cleaned to remove any seeds prior to entry into construction areas.

7.0 Attachments

7.1 Baker County Weed Department Noxious Weed List 2010

7.2 Baker County's Noxious Weed Management Plan Revised January 2008 (Specific Noxious Weed Management Strategies section)

7.3 Common Control Measures for Invasive Plants of the Pacific Northwest Region Updated June 30, 2005

7.4 Agency Consultation Record

7.5 Exhibit G from the FERC License Application

# 2010 Baker County Noxious Weeds
# "Watch List", "A", "B" & "C" Designated Weeds

"A" List Weeds are Eligible for Cost-Share

**"Watch List" – Few Known Sites; Controlled by Weed Supervisor County-Wide**

1. Musk Thistle — *Carduus nutans*
2. Mediterranean sage — *Salvia aethiopis*
3. Dyers Woad — *Istasis tinctoria*
4. Common bugloss — *Anchusa officinalis*

**"A" Designated Weeds – Mandatory Control County-wide**

1. Tansy ragwort — *Senecio jacobaea*
2. Leafy spurge — *Euphorbia esula*
3. Rush skeletonweed — *Chondrilla juncea*
4. Spotted knapweed — *Centaurea maculosa*
5. Diffuse knapweed — *Centaurea diffusa*
6. Dalmation toadflax — *Linaria dalmatica*
7. Yellow starthistle — *Centaurea solstitialis*
8. Perennial pepperweed — *Lepidium latifolium*
9. Purple loosestrife — *Lyrum salicaria*
10. Black henbane — *Hyoscyamus niger*
11. Jointed goatgrass — *Aegilops cylindrica*
12. Buffalobur — *Solanum rostratum*
13. Japanese knotweed — *Polygonum cuspidatum*
14. Scotch Thistle — *Onopordum acanthium*
15. Yellow flag iris — *Iris pseudacorus*
16. Salt Cedar — *Tamarix ramosissima*
17. Whitetop — *Lepidium draba*
18. Russian knapweed — *Centaurea repens*

Whitetop is listed as an "A" weed in designated areas of the County. Pine Valley and West Baker Valley and Bowen Valley/Sumpter areas are Mandatory Control. Contact Baker County Weed Control for specific information at 523-0618.

**"B" Designated Weeds – Widespread and/or of High Concern**

1. Whitetop — *Lepidium draba*

NOTE!: Whitetop is a "B" weed in all other areas of the County not listed in the above section.

2. Canada thistle — *Cirsium vulgare*
3. Venice mallow — *Hibiscus trionum*
4. Yellow toadflax — *Linaria vulgaris*
5. Dodder — *Cuscuta campestris*
6. Chickory — *Cichorium intybus*
7. Teasel — *Dipsacus fullonum*
8. Common Tansy — *Tanacetum vulgare*
9. Klamathweed — *Hypericum perforatum*
10. Puncturevine — *Tribulus terrestris*
11. Myrtle spurge — *Euphorbia myrsinites*
12. Sulfur cinquefoil — *Potentilla recta*

**"C" Designated Weeds – Widespread and/or of Moderate Concern**

1. Poison hemlock — *Conium maculatum*
2. Morningglory — *Convolvulus arvensis*
3. Russian thistle — *Salsola iberica*
4. Medusahead wildrye — *Taeniatherum caput-medusae*
5. Kochia — *Kochia scoparia*
6. Common mullein — *Verbascum thapsis*
7. Moth mullein — *Verbascum blattaria*
8. Bur buttercup — *Ranunculus testiculatus*
9. Water hemlock — Cicuta douglasii

# Attachment 7.2

**NOXIOUS WEED PLAN**
**BAKER COUNTY**
**(Revised)**
**May 9, 2002**

Prepared by: _____
_____
Arnie Grammon, Weed Supervisor Date

Reviewed by:

Weed Advisory Committee:

_____ _____
Bill Shumway, Chairman Date

Road Department:

_____ _____
Ken Helgerson, Road Master Date

Approved by:

Baker County Board of Commissioners:

#1 _____ _____
Brian Cole, Commission Chair Date

#2 _____ _____
Howard Britton, Commissioner Date

#3 _____ _____
Tim Kerns, Commissioner Date

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The last Tuesday of the month, unless otherwise scheduled.

Meeting Procedures

1. The chairperson of the Advisory Committee and the Baker County Weed Supervisor should meet one week prior to a stated meeting to:

a. Discuss and list all agenda items for old and new business.
b. Develop and send agenda to all members including the Baker County commission.

2. The District Weed Supervisor should attend all advisory committee meetings. The Supervisor is to act in the role as a resource person for the Advisory Committee.

3. Minutes of each advisory meeting to be submitted to the Baker County Board of Commissioners, to members, and on a request basis to interested parties.

4. The meeting itself should be conducted in accordance with Baker County established and approved rules. Items to be discussed during the meeting are the ones listed on the agenda. If possible, items under new business should be briefly discussed and referred to the next meeting.

## SPECIFIC NOXIOUS WEED MANAGEMENT STRATEGIES

### Leafy Spurge Management

Leafy Spurge is considered one of the worst range weeds in the west because of it's ability to spread and to defy control. This weed has caused rangelands to become non-productive and has proven to be a liability to landowners.

The Strategy:

There shall be an area of the Alder Creek spurge infestation, which shall be referred to as "the containment area" (approximately 80 sections). Responsibility for, and implementation and control of the spurge in this area, shall rest with the landowner/manager. The County Noxious Weed Program may enter into assistance agreements to reduce the spurge within this area. Efforts to control leafy spurge are non-discretionary and landowners/managers must show a good faith effort, or be cited under Oregon Weed Law.

The landowner is encouraged to develop a long-range plan with the help of Baker County's Weed Supervisor, ODA, NRCS, and OSU Extension Agent for

grazing, biological and chemical control to reduce the spread, stop its further encroachment and to stop the spread off site. The Noxious Weed Program must take responsibility for keeping spurge off the public use roads in the containment area to stop the threat of spurge movement on vehicles.

The remainder of the county shall consider leafy spurge as an "A" Rated weed to be treated with early detection of new infestations and subsequent eradication as the goal.

An important project that needs to continue is the comprehensive survey and mapping
of the areas known to contain spurge. All of the area surrounding Alder Creek and Burnt River should be surveyed and mapped, as well as areas surrounding the small infestations in Pine Valley, Sumpter Valley and the old Ringer Ranch. The small infestations outside of Alder Creek should be treated while this information is being gathered.

All participants in any leafy spurge project must be made aware that this is a very long-term project, but the stakes are high. If we do nothing more than hold our ground we're doing better than most. The alternative is losing the land to the spurge.

**Mediterranean Sage Management**

Mediterranean sage is known to occur only on a limited acreage between Haines and North Powder, Pine Creek (Hereford area), and North Pine Creek on the Wallowa Loop Road out of Halfway. Since these are the only known sites in Baker County and there are none elsewhere in northeast Oregon, Mediterranean sage should be targeted for an active eradication program.

The Strategy:

The Oregon Department of Agriculture and Baker County has done some of the mapping of this site and initiated a containment effort. The infestation appears to have started from road and mining equipment then spread with wind, water and equipment. The Oregon Department of Agriculture and Baker County should cooperatively control this infestation with funding assistance from the Oregon Department of Transportation, BLM, and the private landowner.

**Knapweed Management**

Diffuse, Russian and Spotted Knapweed represents a very severe threat to Baker County from a crop, wildlife and livestock prospective. The knapweeds can be found scattered throughout the county at increasing levels. If prompt action is taken, a serious knapweed problem such as exists in northern Union or

the Columbia Basin counties can be avoided. Knapweeds should be the focus of an intensive education campaign so that every range and forest user should be looking for it.

The Strategy:

An active county program to keep knapweeds from reproducing on state and county roads would help stop most of the new infestations. Cost-share control programs with the known acreage on private land would not cost much at this point. An important project to complete is an extensive county-wide survey and mapping effort. This would yield information concerning all of the priority weeds.

## Dalmatian Toadflax Management

Dalmatian Toadflax is another range/pasture invader that is posing a serious threat to Baker County lands. There are scattered infestations around the county which need to be dealt with. Toadflax has an extensive root system and its waxy leaf makes this an extremely difficult plant to control.

The Strategy:

Toadflax is moving into Baker county along Highway 7 from Grant County. At present plants are encountered in and around the Sumpter area and have the potential to takeover the Sumpter Valley Dredge tailings. Cooperation and coordination will be required from Sumpter area residents if this weed is to be controlled.

The old Melhorn Mill site in Halfway is currently being sprayed to stop toadflax. This infestation should remain a top priority.

The gravel pit below Huntington along the Snake River Road and the surrounding range supports the largest known area of toadflax in the county. The gravel area itself must be kept clear of toadflax to avoid spreading the problem to new areas. A cooperative program with the B.L.M. and the private landowners needs to be developed to stop the toadflax from further spread.

## Yellow Starthistle Management

Yellow starthistle has been the target of various levels of attack for a number of years. At this time it would appear that it is not possible to pursue complete eradication of yellow starthistle in Baker County.

The Strategy:

A containment area (approximately 110 sections) has been developed encompassing the known area where yellow starthistle is being found and an action plan has been formulated with the landowners and area federal land managers to: a) reduce the economic impact of yellow starthistle within the containment zone and, b) stop the spread out of this zone. The remainder of the county should be considered an eradication zone for yellow starthistle.

An integrated approach to controlling yellow starthistle will be necessary within the containment zone, which will include some seeding of more competitive species of
grass, grazing management, herbicide use and biological controls. The Weed District, Keating SWCD, BLM, ODA, and the affected landowners should devise an effective containment agreement that would address equipment, livestock, hay and dried plants movement to avoid seed dispersal to other areas.



Rush Skeletonweed Management

There is an explosion of rush skeletonweed occurring in the Panhandle of Baker County. An Extensive inventory has included sighting of this invasive weed over a gross area of more than 70,000 acres.

Skeletonweed is of particular concern because of its ability to spread rapidly over long distances and to degrade rangelands rapidly. The population center is near the junction of the Snake River and the Powder River. Plants are being discovered in Eagle Valley, Pine Valley, Dry Creek, North Pine Creek and Oxbow.

The Strategy:

Field surveys need to occur and be followed by chemical treatment of each plant or group of plants. This plant should not be pulled because of its ability to re-sprout vigorously.

A containment area boundary (approximately 120 sections) has been drawn where sightings have occurred. Area residents are being alerted to this new weed threat and aggressive action taken at all known sites.

## BLUE PRINT FOR BUILDING ACTION ITEMS

The noxious weed program will build upon the following principles:

STEP #1 - Awareness, Education, and Training

Awareness is when people responsible for supporting, implementing, or taking part in a weed management program realize there is a weed problem. When people recognize leafy spurge, spotted knapweed, and other undesirable plants as problems, they have weed awareness.

Education about the impacts noxious weeds have on natural resources, wildlife, and the economy occurs after people are made aware of weeds. Training takes place after people become aware and realize that noxious weeds are detrimental to our natural resources, but need assistance in how to manage the weeds effectively.

STEP #2 - Funding and Program Justification

To increase funding and justify our management plan, we need to:

1. Demonstrate the impacts of that noxious weeds are bringing to Baker County.
2. Establish an operating budget for the entire program.
3. Designate who performs which parts of the program.



STEP #3 - Inventory (Zoning and Weed Mapping)

Mapping may be the single most useful part of our noxious weed control plan. We must "Know what is out there", if we expect to manage the land successfully. A map can be an aerial photograph, drawing, topography map, road map, section or county map, or property map. A good inventory and mapping system:

1. Defines the problem
2. Brings awareness
3. Helps monitor program effectiveness
4. Helps develop prevention and integrated weed management action plans
5. Tells about the land and the weeds on it

6. Provides a historical weed infestation record
7. Provides data to evaluate weed management options

STEP #4 - PREVENTION AND EARLY DETECTION

Prevention, early detection, and eradication of early detected noxious weed species are the most practical means of weed management. Prevention is best accomplished by ensuring that new weed species' seed or vegetative reproductive plant parts are not introduced into an area.

STEP #5 - Planning and Plan Implementation

There at least seven reasons why weed management planning works:
1. It improves our weed control knowledge
2. It saves time and money
3. It forces us to evaluate all factors of weed control
4. It helps us visualize the total weed program
5. It prioritizes control efforts
6. It creates a historical record-keeping system
7. It enables us to participate in federal, state, county, or other weed control projects.

Keeping accurate records of the details of each treatment in prioritized units insures that your planning is accurately translated into action.

STEP #6 - Monitoring and Evaluation

Monitoring means repeated, systematic observation. Monitoring is "determining the truth" or observing the results about how the program is working. For building awareness, continuing education, implementing training, funding and justifying the program, and being able to plan and to modify the plan, you must know what you are doing.



Evaluation is relating information obtained from monitoring relative to a goal. The purpose of evaluation is to answer the questions:

A. Does the weed management program come as close to accomplishing the goal as is possible with the resources at hand?

B. Is the goal still desirable and realistic?

STEP #7 - Record System

A record system will help identify factors that influence success such as herbicides, application rate, temperature, moisture conditions, growth stage of weeds, and wind. Being extremely busy most of the year and no one can remember all the critical details involved in a successful noxious weed control effort. But records can. They can make the difference between success and failure.

# Backpack Sprayer Calibration

## *No Math Version!!*

**Step 1:** Establish a calibration plot that is exactly: 18.5 feet wide x 18.5 feet long
**Step 2:** Spray the calibration plot uniformly with water, noting the number of seconds required: Time Required to spray plot = _____ seconds.
**Step 3:** Spray into a bucket for same number of seconds.
**Step 4:** Measure the number of ounces of water in the bucket:
Volume sprayed = _____ ounces
**Step 5:** The number of ounces collected from the bucket is equal to the number of gallons per acre the sprayer is delivering: Gallons Per Acre (GPA) = _____

## *Adding the Correct Amount of Herbicide to Tank for Liquid Herbicide Formulations*

**Step 6:** Record sprayer output in gallons/acre (calculated from Step 5).
Output (volume) = _____ GPA
**Step 7:** Determine volume of full spray tank.
Tank volume = _____ gallons
**Step 8:** From the herbicide label determine amount of herbicide concentrate to apply per acre.
_____ Herbicide per Acre (quarts or pints)
**Step 9:** Determine the amount of herbicide to add to each gallon using the chart below.
**Step 10:** Calculate the amount of herbicide to add to each tank.
_____ Amount of herbicide/gallon x _____ number of gallons in a tank =
_____ Total amount of herbicide to add to a tank.

| **Spray Volume** | **Amount of Herbicide to Add to Each Gallon Recommended Herbicide Rate/Acre** | | | | |
|---|---|---|---|---|---|
| Gal. / A | 1 pint | 1 quart | 2 quarts | 3 quarts | 4quarts |
| 15 | 6 tsp | 2 fl oz. | 4 fl oz. | 6.25 fl oz. | 8.5 fl oz. |
| 20 | 5 tsp | 10 tsp | 3.25 fl oz. | 4.75 fl oz. | 6.33 fl oz. |
| 30 | 3 tsp | 6 tsp | 2 fl oz. | 3.25 fl oz. | 4.25 fl oz. |
| 40 | 2.33 tsp | 4.75 tsp | 1.66 fl oz. | 2.33 fl oz. | 3.25 fl oz. |
| 50 | 2 tsp | 3.75 tsp | 1.25 fl oz. | 2 fl oz. | 2.5 fl oz. |
| 60 | 1.66 tsp | 3.25 tsp | 6.33 tsp | 1.66 fl oz. | 2 fl oz. |
| 70 | 1.33 tsp | 2.75 tsp | 5.5 tsp | 1.33 fl oz. | 1.75 fl oz. |
| 80 | 1.25 tsp | 2.33 tsp | 4.75 tsp | 7.25 tsp | 9.5 tsp |
| 90 | 1 tsp | 2 tsp | 4.25 tsp | 6.33 tsp | 8.5 tsp |
| 100 | 1 tsp | 2 tsp | 3.75 tsp | 5.75 tsp | 7.66 tsp |
| 120 | 0.75 tsp | 1.5 tsp | 3.0 tsp | 4.75 tsp | 6 tsp |

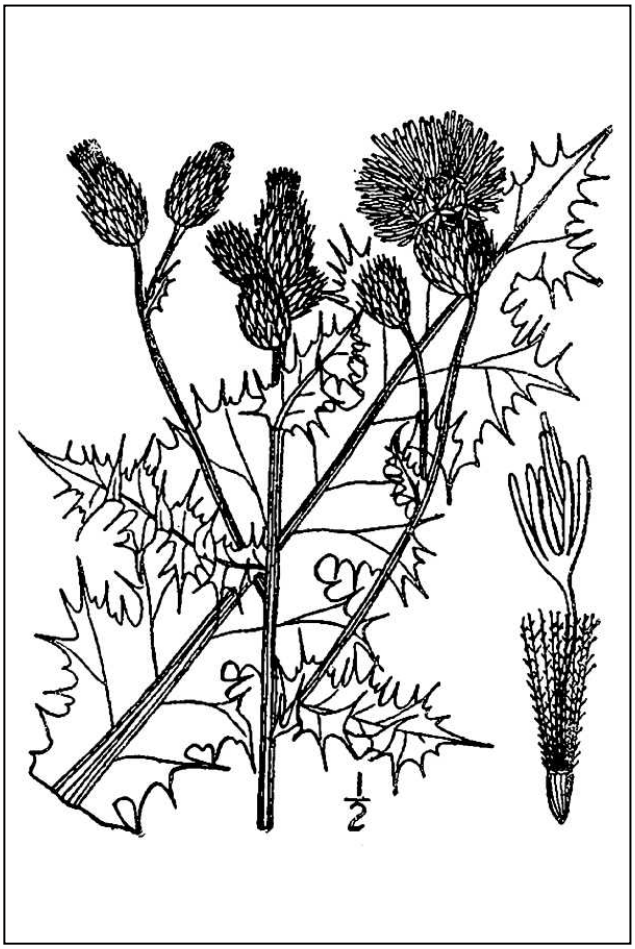
**Example:** Assume that the calibration of your sprayer (Steps 1 – 5) yields an output of 30 GPA and your spryer holds 3 gallons. Your herbicide label for the target weed species dictates a herbicide application rate of 1 pint/acre. Go to the chart and read across from 30 Gal. / A to the 1-pint column – the amount of herbicide to add per gallon is 3 tsp in the chart. Since your sprayer holds 3 gallons of total solution, you would add 9 tsp of herbicide in addition to the water in each tank.

Liquid Conversions:

| | | |
|---|---|---|
| tsp = teaspoons | TBS = tablespoons | fl oz. = fluid ounces |
| 3 teaspoons = 1 tablespoon | 8 fl ounces = 1 cup | |
| 2 tablespoons = 1 fluid ounce | 1 cup = 16 tablespoons | |

Attachment 7.3

# Common Control Measures




*Cirsium arvense*
*Canada thistle*

# For Invasive Plants of the Pacific Northwest Region

Prepared by: Linda Mazzu
*USDA Forest Service, Region 6*
*Invasive Plants EIS Team*
Updated: June 30, 2005

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## *Introduction*

This document summarizes methods commonly used to control some of the most invasive species in the Pacific Northwest. Please use it as a 'starting point' for developing treatment alternatives to meet your objectives. It is not intended as the only document to use in making your determinations; there are too many treatments options available to discuss them all in one place. Use the reference materials and Internet links included to keep up-to-date with ever changing practices in the treatment of invasive plants, as success stories are shared throughout the region and the west.

Invasive plant management requires the integration of prevention measures as well as early detection and rapid response strategies using the treatments found in this guide. One of the best ways to manage invasive plants is through prevention. While the focus of this guide is on invasive plant treatments, the reader can find more information on prevention in the USDA Forest Service Guide to Noxious Weed Prevention Practices (USDA, 2001).

The information in this guide is organized by species. Discussions on manual, mechanical, biological, cultural, prescribed burning, and herbicide treatments are usually included in each species discussion. If no information was found, then it was noted as such. All sources and authorities on invasive plant management were sought including studies describing the biology of species, websites of weed control boards and county extension sites, websites from universities and entities such as The Nature Conservancy. All successful approaches found were summarized even if from outside this country.

The following describes the categories of treatments included. In most cases, using a combination of treatments was considered more effective than using a single method. Because of this, the development of weed management plans for projects is recommended. Various definitions of treatment categories are found in the literature; the categories used were those defined in the FEIS [49]. The categories may not be defined the same in other publications.

Manual: With new, small infestations, hand pulling can be the easiest and quickest method. Even larger populations can be controlled with hand pulling if the workforce is available and continual maintenance occurs. The Bradley Method is one sensible approach to manual control of invasive plants. [17, 22] This method consists of hand weeding selected small areas of infestation in a specific sequence, starting with the best stands of native vegetation (those with the least extent of infestation) and working towards stands with the worst infestation. Initially, new satellite populations (sometimes referred to as 'spotfires') that occur singly or in small groups should be eliminated from the extreme edges of the infestation. The next area to work on are those with a ratio of at least two natives to every invasive. As the native plants stabilize in each cleared area, work can then continue deeper into the center of more dense patches.

Hand digging with shovels, weed wrenches or covering with plastic are also considered manual techniques in this document.

Mechanical: Traditional methods of mowing and cutting were the most common methods found in the literature. Other options do exist, though. Steaming or foaming equipment, for example, are being used more often with success. Therefore, creative solutions for treatments should always consider newer technology.

See http://tncweeds.ucdavis.edu/index.html for more information.

Biological: The effectiveness of biological controls is briefly summarized for each species. Details for each species of biocontrol are not provided, but through the references given, ample information can be found. To introduce any of the biological control agents in your state, first coordinate with your state agency to determine if the state introduced ample biocontrols in your area already or if you should obtain a permit for a new introduction. To obtain a permit you must complete an application through your APHIS_PPQ State Plant Health Office. You can get information and applications on line at http://www.aphis.usda.gov/ppq/weeds.

Cultural: Livestock grazing (considered by some a biological control) and such agricultural methods as plowing and disking (considered by some to be mechanical controls) were summarized in the document when found in the literature. Appropriate areas for these techniques may be limited, but they could be important tools. The planting of competitive species (considered by some to be a cultural technique) is discussed under the restoration/monitoring sections.

Prescribed Fire: Prescribed burning can be an effective tool in invasive plant control, especially in combination with other techniques. The Fire Effects Information System [2] has a wealth of information not only on fire ecology for some of the species, but also other management methods.

Chemical: Damage to non-target vegetation is a major concern with most control methods, but it is most often associated with herbicide use. It is important when selecting a herbicide to find the one that is most effective with the least unintentional impact to non-target species. Herbicide selection should be tailored to the species and the situation. Careful application will minimize effects to non-target species.

The chemicals listed for each species were found in the literature. Confirmation of their effectiveness was made through a variety of phone calls to contacts from the Oregon Department of Agriculture, various county weed coordinators, and researchers. If a chemical was recommended by only one source, its citation was listed.

Restoration/Monitoring: Restoration through revegetation should be a major component of all treatment strategies, especially where control treatments of aggressive species have left newly disturbed bare ground. If any information unique to a species regarding monitoring or restoration was found, it was included in the discussions. A regional revegetation policy does exist and regional revegetation guidelines are being developed that recommend species for use.

Local native species are always preferred, but use of other desirable species such as non-native species that do not persist could be used as an interim step. A combination of native and

desirable non-natives could be an initial mix for revegetation. A fast growing desirable non-native such as sterile wheatgrass can germinate quickly and start filling in bare ground until a slower to germinate native species can start competing effectively.

**** This document is expected to be updated occasionally as new species sections and new information on treatments are added.**

**** While other herbicides may be effective on these species, only those approved through the Region Six6 Invasive Plants EIS have been included in this document.**

## Some Tips to Consider

- Always follow an integrated pest management approach (IPM) when tackling an invasive plant problem. IPM does not merely focus on the eradication of an invader but instead attempts to understand what makes it spread and focuses on reducing that spread through a combination of prevention, early detection/rapid response, treatment, and restoration options. The main goal is to find the most effective methods with the least risk.
- Integration and perseverance are key to successful vegetation management programs [38]. It is very unlikely that one method will do the trick. A combination of methods is usually the most effective for most aggressive species.
- Don't expect a single treatment to do the trick for any species. Return visits and continued management are part of the process.
- Never underestimate the power of a group to manually tackle difficult species. For example, English ivy control in Portland or knapweed pulling in the Wenatchee area. Not all species can be successfully controlled with only manual treatment, but some can.
- Be creative. Try techniques not usually used. The use of steam, hot foam, and propane torching are becoming popular solutions under the right conditions.
- Always, always, **follow the Label when using herbicides**. If you plan to apply herbicides yourself, go through application certification training at the state or federal level. There is a lot to keep track of when applying herbicides such as determining application rate, amount applied, applicator calibration and proper times to apply.
- Talk to your local authorities. County weed coordinators, state coordinators or local university folks may have spent the most recent time on the species that you are concerned with.
- Plan ahead for revegetation. First assess the need for revegetation. It may not always be necessary if a healthy native population is already in place. Not every inch of bare ground needs to be revegetated. If revegetation is needed, make sure you have materials available to seed or plant treated sites as soon after treatment as possible.
- The planting of competitive desirable species can sometimes be the most effective method of control available for an invasive species.
- Establish a method to monitor treatment progress and overall effectiveness.

## Prioritizing Treatments

The following table suggests a decision process for prioritizing treatments. This is especially important when budgets and staff time are limited. Focusing efforts on the wrong species or the wrong portion of an infestation can be ineffective and frustrating.

The first step in prioritizing treatments is to understand where infestations are located, where they are spreading from and where infestation spread may be heading. Up-to-date inventories will help with this step as well as a working knowledge of ground disturbing activities in the vicinity of populations. For example, knowing where a species is located throughout a watershed will help to alleviate treatments focused downstream or downslope of a spreading infestation or activity that may cause spread through ground disturbance or movement of seed. Also, finding out where new satellites or 'spot fires' will also focus treatment efforts.

### *Decision Matrix for Prioritization for Treatment*

| Priority | Description | Treatment – choice based on site-specific conditions |
|---|---|---|
| Highest Priority for Treatment | * Eradication of new species (focus on aggressive species with potential for significant ecological impact including but not limited to State listed high priority noxious weeds). See www.natureserve.org for an invasive species assessment protocol.<br>* New infestations (e.g. populations in areas not yet infested; "spot fires"; any State or Forest priority species). | 1. Manual/mechanical - isolated plants or small populations.<br>2. Herbicide treatment if manual/mechanical is known to be ineffective or population too large.<br>3. Remove seed heads. This is an interim measure if cost/staff is an issue. |
| Second Priority for Treatment | * Areas of high traffic and sources of infestation (e.g. parking lots, trailheads, horse camps, gravel pits)<br>* Areas of special concerns: (e.g. botanical areas, wilderness, research natural areas, adjacent boundaries/access with national parks) | 1. Manual/mechanical - isolated plants or small populations.<br>2. Herbicide treatment if manual/mechanical is known to be ineffective or population too large.<br>3. Remove seed heads. This is an interim measure if cost/staff is an issue. |
| Third Priority of Treatment | * Containment of existing large infestations of State-listed highest priority species or Forest priority species – focus on boundaries of infestation.<br>* Roadsides – focus first on access points leading to areas of concern. | 1. Manual/mechanical - isolated plants or small populations in spread zones.<br>2. Herbicide treatment for larger populations along perimeter. |

## *Decision Matrix for Prioritization for Treatment*

| Priority | Description | Treatment – choice based on site-specific conditions |
|---|---|---|
| Fourth Priority of Treatment | * Control of existing large infestations of State-listed and Forest second priority species | 1. Disperse biocontrol agents on large infestations<br>2. Livestock grazing<br>3. Mechanical<br>4. Herbicide application |
| Fifth Priority of Treatment | * Suppression of existing large infestations – when eradication/control or containment is not possible. | 1. Biocontrol on large infestations<br>2. Livestock grazing<br>3. Mechanical<br>4. 4. Herbicide application along perimeters |

**Eradication:** Attempt to totally eliminate an invasive plant species from a Forest Service unit, recognizing that this may not actually be achieved in the short term since re-establishment/re-invasion may take place initially. **Contro**l: Reduce the infestation over time; some level of infestation may be acceptable. **Contain**: Prevent the spread of the weed beyond the perimeter of patches or infestation areas mapped from current inventories. **Suppress**: Prevent seed production throughout the target patch and reduce the area coverage. Prevent the invasive species from dominating the vegetation of the area; low levels may be acceptable.

The following table summarizes those herbicides approved in the Region Six Invasive Plants EIS and their properties that may be useful in treating invasive plants when using an integrated pest management approach.

## *Comparison Table of Proposed Chemicals**

| Chemical/Brand Names/Action | Properties | General Uses/Known to be Effective on:** | Comparisons/Issues *** |
|---|---|---|---|
| Chlorsulfuron/ (Telar,Glean,Corsair)/ *Sulfonylurea-Interferes with enzyme acetolactate synthase w/ rapid cessation of cell division and plant growth in shoots and roots.*<br><br>Aerial spraying prohibited by FEIS. | Glean -Selective pre-emergent or early post-emergent<br>Telar – Selective pre- and post-emergent.<br><br>Chlorsulfuron can be used for many annual, biennial and perennial broadleaf species. | Use at very low rates on annual, biennial and perennial species; especially whitetop, dyers woad, toadflaxes, hounds tongue and perennial pepperweed.<br><br>Safe for most grasses. | Some soil residual. Potential for offsite movement through runoff or wind erosion is substantial in conditions that favor these actions.<br>Damage to some aquatic plants possible at peak concentration.<br>Offsite drift may cause damage to sensitive species up to 900'. |
| Clopyralid/ (Transline)/ *Synthetic auxin -Mimics natural plant hormones.*<br><br>Contains hexachlorobenzene. | A highly translocated, selective herbicide active primarily through foliage of broadleaf species. Little effect on grasses. | Particularly effective on Asteraceae, Fabaceae, Polygonaceae, Solanaceae. Some species include knapweeds, yellow starthistle, Canada thistle, hawkweeds. | Not as persistent as picloram, but problems still exist. Can persist from one month to one year. More selective than picloram.<br>Potentially mobile depending on site specific conditions.<br>Off site drift may cause damage to sensitive species up to 300'. |
| Glyphosate/ (RoundUp, Rodeo, Glypro, Aquamaster etc.)/ *Inhibits three amino acids and protein synthesis.* | A broad spectrum, non-selective translocated herbicide with no apparent soil activity. Translocates to roots and rhizomes of perennials. | Low volume applications are most effective.<br>Control for purple loosestrife, herb Robert, English ivy, reed canarygrass and other weeds common in wetland and riparian habitats. | Rain within 6 hours of application may reduce effectiveness.<br>Complete control may require re-treatment.<br>Off site drift damage to sensitive species up to 100' possible.<br>Not mobile in the environment.<br>Will not kill seeds or inhibit germination.<br>Surfactants can be toxic to aquatic species.<br>Aquatic formulations can be used near water. |

## *Comparison Table of Proposed Chemicals**

| Chemical/Brand Names/Action | Properties | General Uses/Known to be Effective on:** | Comparisons/Issues *** |
|---|---|---|---|
| Imazapic/ (Plateau)/*Inhibits the plant enzyme acetolactate, which prevents protein synthesis.* | Selective against some broadleaf plants and some annual grasses. | Use at low rates can control leafy spurge, cheatgrass, medusa head rye, and hounds tongue. Useful in grassland prairie habitat restoration because it is selective against annual grasses. | Off site drift may damage sensitive species up to 50' possible; over 100' if aerially applied. Even very tolerant non-targets could be damaged directly. Some damage to aquatic plants at peak concentrations. |
| Imazapyr/ (Arsenal, Chopper, Stalker)/ *Inhibits the plant enzyme acetolactate, which prevents protein synthesis.*<br><br>Aquatic labeled Habitat may be available after further risk assessment. | Broad spectrum, non-selective pre- and post-emergent for annual and perennial grasses and broadleaved species. | Most effective as a post-emergent. Has been used on cheatgrass, whitetop, perennial pepperweed, tamarisk, other woody species, spartina. | High potential for leaching. Highly mobile and persistent. Residual toxicity up to several years. May be actively exuded from the roots of legumes, likely as a defense mechanism by these plants. |
| Metsulfuron methyl/ (Escort)/ *Sulfonylurea - Inhibits acetolactate synthesis, protein synthesis inhibitor, block formation of amino acids.*<br><br>Aerial spraying prohibited by FEIS | Selective against broadleaf and woody species. Most sensitive crop species in the Lily family. | Use at low rates to control such species as houndstongue, perennial pepperweed, dyers woad, sulfur cinquefoil. Safest sulfonylurea around non-target grasses. | Potentially mobile in water or through wind erosion. Damage to some aquatic plants possible at peak concentrations. Off site drift may cause damage sensitive plants up to 500'. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachlorobenzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Use at low rates to control such species as knapweeds, Canada thistle, yellow starthistle, houndstongue, toadflaxes, St. Johnswort, sulfur cinquefoil and hawkweeds. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets. One application may be effective for 2 or more years. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |

## *Comparison Table of Proposed Chemicals**

| Chemical/Brand Names/Action | Properties | General Uses/Known to be Effective on:** | Comparisons/Issues *** |
|---|---|---|---|
| Sethoxydim/ (Poast)/ *Inhibits acetyl co-enzyme, a key step for synthesis of fatty acids.* | A selective, post-emergent grass herbicide. | Will control many annual and perennial grasses. | Potentially mobile, but degrades rapidly. Off site drift up to 50' possible. |
| Sulfometuron methyl/ (Oust)/ *Sulfonylurea - Inhibits acetolactase synthase, a key step in branch chain amino acid synthesis.*<br><br>Aerial spraying prohibited by FEIS | Broad spectrum pre- and post-emergent herbicide for both broadleaf species and grasses. | Used at low rates as a pre-emergent along roadsides. Known to be effective on canary reedgrass (but not labeled for aquatic use), cheatgrass and medusahead. | Offsite drift may cause damage sensitive plants up to 900'. Highly mobile by water or by wind erosion. Substantial damage has occurred to croplands in arid and wet regions. Damage to some aquatic plants possible at peak concentration |
| Triclopyr/ (Garlon, Pathfinder, Remedy)/ *Synthetic auxin - Mimics natural plant hormones.*<br><br>Only selective application methods permitted by FEIS. | A growth regulating selective, systemic herbicide for control of woody and broadleaf perennial weeds. | Little or no impact on grasses. Effective for many woody species such as scotch broom. Also effective on English ivy, Japanese knotweed. | Garlon 4 (ester compound) is toxic to fish and aquatic invertebrates. Amine formulations may be used near or over water. Offsite movement by water possible. Off site drift may damage sensitive plants up to 100'. |

** This table is a brief summary of some of the attributes of these herbicides. More information is provided in the species write ups or more information can be found from the references given.*

***Please note: The information on effectiveness by species (third column) contains examples of just some of the species the herbicides can treat.*

**** Issues listed in this table and in following species-specific tables were identified in Forest Service Risk Assessments prepared by Syracuse Environmental Research Associates, Inc. Risk assessments are available on the Region 6 Invasive Plant EIS website: www.fs.fed.us/r6/invasiveplant-eis.*

## *Acroptilon repens - Russian knapweed*

### Ecological Characteristics of Note

Russian knapweed is a creeping perennial that reproduces from seed and vegetative root buds [66]. It forms dense, monotypic colonies from widely spreading horizontal roots; roots can extend 14 square yards radially and up to 23 feet deep within two growing seasons [2]. Russian knapweed can survive 75+ years through its root system. Several allelopathic compounds have been isolated from the species; allelopathy plays an important role in Russian knapweed ecology. A single Russian knapweed plant can produce about 1,200 seeds per year. Seedheads generally remain closed at maturity and the heavy seeds lose their pappus bristles at maturity, making wind dispersal unlikely. Ballistic dispersal may be more important; mature achenes can dehisce and launch over distances roughly equal to the height of the plant when the flower head sways in the breeze [2].

### Management

Keys to controlling Russian knapweed are 1) stressing the plant and causing it to expend nutrient reserves in its root system, 2) eliminating new seed production and 3) controlling its vegetative spread by planting competitive species and/or isolating the infestation so as not to spread root fragments to other locations during treatment [2]. The most effective control is to prevent its establishment. The healthier the plant community, the less susceptible it will be to Russian knapweed invasion [17].

Manual: Hand pulling Russian knapweed is very difficult, but can be effective for small infestations during the establishment year only. Pull the plants when the soil is wet and before seeds have formed. Remove all plant parts from the site [67].

Mechanical: Cutting or mowing reduces the current year growth and will eliminate seed production, but will not kill the roots of this species. Cutting and mowing several times annually will control the existing topgrowth and could cause re-emerging plants to be smaller in size and lower in vigor. Unless repeated frequently, the cut plants recover vigorously the following year. Cutting or mowing 3 times a year (spring, summer, fall) stresses plants and forces them to use nutrient reserves stored in the root system [2].

Biological: A gall-forming nematode has been released at limited sites in Colorado, Montana, New Mexico, Oregon, Utah, Washington, Wyoming, Alberta and British Columbia. It has not been found to be readily spread long distances without assistance [67].

Cultural: Discing or plowing produces broken root fragments that spread quickly and resprout. As with cutting or mowing, if done frequently, some reduction in vigor could occur. Livestock will graze Russian knapweed, but it is usually avoided. It can be poisonous to horses [17]. Grazing provides only a negligible effect on vigor and viability of the root system [67].

Prescribed Fire: Very little study has been done on using fire as a control agent for these species. What has been done shows it is not effective [2]. Based on results from other control methods,

one can expect that burning would not control Russian knapweed and may even promote its spread locally [17].

Chemical: In most situations, Russian knapweed cannot be effectively managed by herbicide alone. Chemical control has proven more difficult than for other knapweed species [2, 17, 66, 67].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexachlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17] | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Apply during bud stage or in the fall. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachlorobenzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply during bolting, budding or in the fall. | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 to 12 months to reseed since picloram is persistent in the soil. More mobile than clopyralid. Can move offsite through surface or subsurface water. Can be relocated through livestock urine |
| Metsulfuron methyl (Escort) [67] | Selective for broadleaf and woody species.<br><br>Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Extremely potent. Most sensitive species in the Lily family. | Timing is critical. Apply from bloom to post-bloom stages; earlier applications do not work as effectively. Can also apply in the fall [67] | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Potentially mobile in water or through wind erosion. Damage to non-target terrestrial and some aquatic plants (at peak concentrations) more possible than animals. |

Chemical: In most situations, Russian knapweed cannot be effectively managed by herbicide alone. Chemical control has proven more difficult than for other knapweed species [2, 17, 66, 67].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Chlorsulfuron (Telar, Glean) [66,67] | Glean- Selective pre-emergent or early post emergent; controls many annual, biennial and perennial broadleaf species. Telar – Selective for broadleaf species both pre- and post-emergent [7] | Off site drift up to 900' possible. Safe for most grasses. | Timing is critical. Apply from bloom to post-bloom stages; earlier applications do not work as effectively. Can also apply in the fall [66, 67] | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Some soil residual. Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |
| Imazapic (Plateau) [67] | Selective for broadleaf plants and some grasses. | Off site drift up to 50' possible. Over 100' if applied aerially. | Apply before bloom stage. | Backpack or wick to minimize drift. | Even very tolerant non-target species are likely to be damaged. Some damage to aquatic plants at peak concentrations could occur. |
| Glyphosate (many formulations)[17] | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Apply during bud stage (only controls top growth; abundant regrowth from roots systems will occur). | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: While competitive plantings are usually necessary, such plantings or the resurgence of species in the seedbank, may be hindered by residual allelopathic compounds present in the soil [17]. Aggressive monitoring at least three times per year will help to track treatment success or prevent new infestations in potential areas [2].

## *Brachypodium sylvaticum – False-brome*

### Ecological Characteristics of Note

False-brome is an invasive perennial bunch grass that can rapidly invade a variety of environments including open and understory habitats. Although it is not rhizomatous, it forms coalescent clumps and can resprout from stem or root fragments when cut. False-brome reproduces rapidly from seed. It has been suggested that *B. sylvaticum* does not maintain a persistent (longer than 1 year) seed bank in soils, but this is not yet confirmed in North America [44, 46, 47].

### Management

Manual: Hand removal may effectively control small infestations, but care must be taken to remove all root fragments to prevent resprouting [45, 47].

Mechanical: The Institute for Applied Ecology and the Eugene District BLM conducted trials that include spraying with super heated foam. Hot foam reduced the cover of false-brome from 44 percent to 7 percent in one year, although seedlings remained and Himalayan blackberry seemed to fill in behind. [46] Repeated mowing may benefit control efforts by exhausting the seed bank and forcing the plants to send up new shoots that are more likely to take up herbicide [47].

Cultural: In Europe, false-brome is absent from heavily grazed sites, so grazing may eventually eliminate it. Grazing before seed set may benefit control efforts by exhausting the seed bank and forcing the plants to send up new shoots that are more likely to take up herbicide [47].

Prescribed Fire: Burning appears to be ineffective. False-brome is frequently found in recently burned sites and it reported to resprout within 2 weeks of a burn. [45, 47] burning before seed set may benefit control efforts by exhausting the seed bank and forcing the plants to send up new shoots that are more likely to take up herbicide [47].

Chemical: [48]
A pilot study to control this species at the Oregon State University Research Forests was conducted in fall of 2002 using the herbicides Plateau (imazapic), Accord (glyphosate), the combination of Accord and Plateau and the combination of Accord and Oust (sulfometuron methyl) along with other herbicides not included under the Region Six Invasive Plant Program. [49] Treatments with Accord, Accord + Plateau, and Oust + Accord reduced false-brome >90 percent after one year of treatment. Treatment with Plateau alone was ineffective. The following table is based on this pilot project with only one post-treatment data collection completed.

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use* | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations, but Accord was used for pilot study) | Broad spectrum, non-selective and systemic. | Offsite drift up to 100'. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Late fall. | Backpack sprayer with six nozzle spray boom if necessary. | Complete control may require re-treatment. Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |
| Accord + Imazapic (Plateau) | Imazapic is selective for broadleaf plants and some grasses. Glyphosate is non-selective. | Offsite drift up to 50'. Over 100' if applied aerially. Reduced native plant cover. | Late fall. | Backpack sprayer with six nozzle spray boom if necessary. | With imazapic even very tolerant non-target species are likely to be damaged. Damage to some aquatic plants possible at peak concentrations. |
| Sulfometuron methyl (Oust) + Accord | Broad spectrum pre- and post-emergent herbicide for both broadleaf and grasses. Glyphosate is non-selective. | Offsite drift may damage sensitive plants up to 900'. Reduced native plant cover. | Late fall. | Backpack sprayer with six nozzle spray boom if necessary. Aerial spraying not permitted under FEIS. | Highly mobile by water or by wind erosion. Damage to some aquatic plants possible at peak concentrations. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: Experimental studies of reestablishment of native species after removal of false brome are currently being conducted. A study done by the Institute for Applied Ecology and Eugene BLM found that seeding with blue wildrye and mulching resulted in relatively high establishment of the native grass. Mulching with blue wildrye straw appears to be an effective way to establish the species, inhibit the establishment of false-brome and increase survivorship of blue wildrye seedlings [46].

## *Cardaria draba – Whitetop, Hoary Cress, Heart-podded Hoary Cress; Cardaria pubescens – Hairy Whitetop, Globe-podded Hoary Cress; Cardaria chalepensis – Lens-podded Hoary Cress*

### Ecological characteristics

All three species are long-lived, deep-rooted perennials that reproduce by seed and by propagation from rhizomes [59]. Plants flower in early spring and fruit about one month later, but can produce a second crop of seeds in late summer if conditions permit [60]. *C. draba* and *C. chalepensis* can self-pollinate [17] and produce up to 4800 seeds each year [60]. Seeds are dispersed by wind, water, vehicles, and in hay and crop seed. Seeds remain viable in the soil up to three years. Once established, infestations spread rapidly through the extension of lateral roots that produce numerous vegetative buds. The hoary cresses can regenerate from severed root segments only 1/2 inch long if they are near the soil surface. They are toxic to livestock [17].

### Management

Control of hoary cresses is difficult because the majority of the plants biomass is located below ground [59]. Integration of a variety of approaches is most likely to be successful [17].

Manual: Diligent hand pulling or grubbing can control small infestations, but plants must be completely removed within 10 days after emergence throughout the growing season for two to four years [60]. Intact or damaged roots left behind after control efforts can resprout [17].

Mechanical: Mowing to ground level during flowering can limit seed production and reduce biomass but does not provide effective control on its own. Mowing followed a month later by herbicide can be effective [60], but it is important to time the mowing to coincide with full flower [17].

Biological: No natural enemies for use as biocontrol agents are currently available [60].

Cultural: Flooding or planting competitive legumes can be useful [60], but these are not appropriate techniques for natural areas. The hoary cresses are most invasive in agriculture when they are irrigated. In less disturbed settings without irrigation, and when other species are competing (particularly perennial shrubs such as roses and wild snowberry) they are relatively easily controlled. Sheep will eat *C. draba*, especially the seedlings, but cattle that eat it may have tainted milk [17]. *Cardaria* root systems can be exhausted through repeated cultivation, but again, repeat treatments should occur within ten days of weed re-emergence for complete elimination of the weeds [17]. Again, any root fragments left behind will resprout.

Prescribed Fire: Information regarding whitetop species response to fire is lacking [60, 17], but it is thought that fire is unlikely to damage belowground perennating tissues and there is some suggestion that fire may break seed dormancy in *Cardaria draba* [60].

Chemical: Herbicides can effectively control whitetop species but more than one application will be required [59, 60, 62]. The different species of whitetop have different levels of susceptibility to herbicide, with *C. draba* being the most resistant [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Metsulfuron (Escort) [60, 17] Considered very effective [63] | Selective for broadleaf and woody species. Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Extremely potent. Most sensitive species in the Lily family. | Apply from pre-bloom to bloom stage or to rosettes in the fall [17]. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Potentially mobile in water or through wind erosion. Damage to non-target terrestrial and some aquatic plants (at peak concentrations) more possible than animals. |
| Picloram (Tordon) Restricted Use Herbicide Contains hexachloro-benzene | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Winter to spring from rosette to prebloom [65]. | Backpack or wick to minimize drift. | Wait 6 to 12 months to reseed since picloram is persistent in the soil. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |
| Chlorsulfuron (Telar, Glean) [62, 65]. | Glean-Selective pre-emergent or early post emergent; controls many annual, biennial and perennial broadleaf species. Telar – Selective for broadleaf species both pre- and post-emergent [7]. | Off site drift up to 900' possible. Safe for most grasses. | Apply from pre-bloom to bloom stage or to rosettes in the fall [17]. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Some soil residual. Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |
| Sulfometuron methyl (Oust) + Accord | Broad spectrum pre- and post-emergent herbicide for both broadleaf and grasses. | Offsite drift may damage sensitive plants up to 900'. Reduced native plant cover. | Apply during early stages of growth [17]. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Highly mobile by water or by wind erosion. Damage to some aquatic plants possible at peak concentrations. |

Chemical: Herbicides can effectively control whitetop species but more than one application will be required [59, 60, 62]. The different species of whitetop have different levels of susceptibility to herbicide, with *C. draba* being the most resistant [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Apply during early flowering [62]. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

## *Carduus nutans – Musk or Nodding Thistle and Carduus acanthoides – Spiny Plumeless Thistle*

### Ecological Characteristics of Note

"Musk thistle" in the United States and Canada includes a complex of closely-related species of the *Carduus nutans* group [17] but only two are weedy [54]. Species in this group are tall (up to six feet) biennial, winter annual or annual herbaceous tap-rooted thistles that reproduce by seed [55, 17]. Hybrids have been reported between *C. nutans* and *C. acanthoides*, with some suggestion that hybrid vigor may confer them an advantage over the parent species [54, 17]. Musk thistle begins flowering in early June and continues for up to seven weeks, while spiny plumeless thistle begins flowering about two weeks later and continues until frost kill [54, 55]. Florets on the same head are self-compatible. Seed maturity and dispersal occur within 7 to 10 days of flowering, and seed production can be as great as 11,000 seeds per plant. Most seeds are not dispersed long distances, and studies have shown that 80 percent of seeds are deposited within 40 meters of the parent. Seeds remain viable in the soil up to ten years, and appear to require one year of dormancy before germination under natural conditions [17]. Musk thistle seedlings recruit in the fall after flowering plants have died, while spiny plumeless thistle seedlings recruit in either the spring or fall [54, 55]. Plants of all ages overwinter as rosettes [17].

### Management

Manual: Hand-pulling [3], cutting or mowing can provide control if repeated over a period of years [17]. Effective control is obtained when cutting is done with a sharpened shovel at the base of the bud and the top of the root crown. If only the terminal bud is destroyed, the side buds can develop into leaders and set seed. Effective control requires cutting (or preferably chopping the root crown) at the onset of blooming. Treatment before plants are fully bolted results in regrowth. Repeated visits at weekly intervals over the 4 to 7 week blooming period provide most effective control because not all plants bloom simultaneously and it is important to cut them after flowers are fully open, but before seed set

Mechanical: Mowing of musk thistle within 2 days of full flowering in the terminal heads eliminated production of germinable seed from all mowed stalks. Delay of treatment until 4 days after full flowering resulted in production of germinating seed [17].

Cultural: Livestock avoid both musk and spiny plumeless thistle [55, 3], and grazing appears to favor musk thistle species rather than control them [55, 17]. Musk thistle species are pioneer species favored by abandoned fields and overgrazed pastures. One Nature Conservancy area reported that populations decreased rapidly after grazing was removed and natural succession began to take place [17].

Biological: Several specialized insects attack *Carduus* in Europe, and all prefer musk thistle [54]. Two species of weevil and one gall fly have been released in the United States for the biological control of musk thistles. However, recent observations of impacts to native thistles, including some rare species, and crops have raised concerns about the continued use of the weevils for biocontrol [55, 3, 17]. A more specific seed head gall fly was introduced in the mid-

1980s in response to increasing concern about effects of the weevils on non-target species. This seed-feeding fly is not currently established in the U.S. [55].

Prescribed Fire: Prescribed burns are not recommended for control of musk thistle because responses to fire have been variable, with several cases suggesting that the plants may not be killed and colonization may be enhanced [4, 17]. In tallgrass prairie habitat, fire may provide the indirect benefit of increasing the competitive ability of native plants, but on sites where native grasses are not vigorous, fire has favored musk thistle establishment [4]. The only suggested technique using fire is the untested idea of individually burning rosettes with a hand torch in order to achieve temperatures high enough to kill the root crown [17].

Chemical: Although the biology, ecology, history, introduction, and control of both thistles are quite similar, plumeless thistle is more tolerant of herbicides and requires a higher rate of application [55]. Chemical control of all types is most effective in the rosette stage and least effective after plants have bolted and begun to flower [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use* | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexa-chlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae [7] Some effects on Apiaceae, Solanaceae, Violaceae [17] | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Apply up to bud stage [7] | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. |
| Picloram | Selective, systemic for many annual and perennial broadleaf and woody species. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4] | Apply in the fall before bolting | Backpack or wick to minimize drift. | Gives good control in cool dry autumn and non-targeted veg is less susceptible. Gives best residual control but this also presents > risk to non-target species. |

Chemical: Although the biology, ecology, history, introduction, and control of both thistles are quite similar, plumeless thistle is more tolerant of herbicides and requires a higher rate of application [55]. Chemical control of all types is most effective in the rosette stage and least effective after plants have bolted and begun to flower [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use* | Issues/Concerns |
|---|---|---|---|---|---|
| Chlorsulfuron (Telar, Glean) | Glean -Selective pre-emergent or early postemergentcontrols many annual, biennial and perennial broadleaf species.<br><br>Telar – selective for broadleaf species both pre- and post – emergent [7]. | Off site drift up to 900' possible. Safe for most grasses. | Apply to actively growing plants. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Extremely potent.<br><br>Damage to non-target terrestrial and some aquatic plants at peak concentrations. |
| Metsulfuron (Escort) | Selective for broadleaf and woody species.<br><br>Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Extremely potent. Most sensitive species in the Lily family. | Apply to actively growing plants. | Backpack or wick to minimize drift.<br><br>Aerial spraying not permitted under FEIS. | Potentially mobile in water or through wind erosion.<br><br>Damage to non-target terrestrial and some aquatic plants (at peak concentrations) more possible than animals. |
| Glyphosate (many formulations) [3] | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses.<br><br>Adheres to soil which lessens leaching or uptake by non-targets. | Apply from rosette stage or prior to flower. | Backpack or wick to minimize drift. | Provides some control.<br><br>Repeated applications necessary.<br><br>Aquatic formulations can be used near water.<br><br>Rain within 6 hours reduces effectiveness. |

Chemical: Although the biology, ecology, history, introduction, and control of both thistles are quite similar, plumeless thistle is more tolerant of herbicides and requires a higher rate of application [55]. Chemical control of all types is most effective in the rosette stage and least effective after plants have bolted and begun to flower [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use* | Issues/Concerns |
|---|---|---|---|---|---|
| Triclopyr [3] (various Garlon formulations; consisting of salts and ester) | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ecto-mychorrizal growth. | Apply from rosette stage or prior to flower | Backpack or wick to minimize drift. | Garlon 4 (ester formulation) is more toxic to fish and aquatic inverts. Offsite movement by water possible. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: Re-establishment of competitive, desirable plant cover is imperative for long term control, especially in areas without a residual understory of desirable plants [2].

## *Centaurea biebersteinii (C. maculosa) – Spotted Knapweed*

### Ecological Characteristics of Note

Spotted knapweed reproduces entirely by seed. This species generally lives up to nine years or longer. It can produce up to 4,000 seeds per square foot. The majority of seeds are viable and can remain viable for up to 8 years. Seeds may germinate over a wide range of soil depths, moisture content and temperature. Plants may stay in the rosette stage for multiple years before bolting. Typically, the species bolts for the first time in May during its second growing season and flowers in July/August. Seeds are shed immediately and can be dispersed up to 3 feet from the plant through dehydration and expelling through the bracts. Of course, seed can be dispersed much farther on vehicles and trains. Spotted knapweed seeds germinate in either spring or fall [2, 3, 17].

### Management

Manual: Hand pulling/digging before seed production may be effective for small populations. The entire root crown must be completely removed. However, the effects of soil disturbance on knapweed seed germination are not well documented [17].

Mechanical: In stands with little other vegetation, this may be possible if mowing occurs just after most flowering has ended, but before seeds have matured. This would make regrowth unlikely since moisture levels late in the season are probably too low for continued growth, but would offer a possible advantage of reducing reserves for flowering the following year [17]. It is considered moderately effective [8]. Mowing combined with mulching may increase effectiveness. Mowing may cause low growing forms.

Biological: A variety of biological control agents have been established. None of these, alone or in combination effectively control populations. Studies suggest that given sufficient time certain biological control agents could reduce the density and aggressiveness of spotted knapweed. However, on a shorter timeline, they do not effectively eradicate populations unless integrated with other control techniques [10].

Cultural: Long term grazing by sheep and goats has been found to control spotted knapweed. Cultivation may be effective, but application may be limited in most treatment areas. Plowing soils under to 7 inches, allowing 4 to 6 weeks for re-germination and then repeating for one growing season has been successful. Herbicide application may make cultivation more effective for large infestations [10].

Prescribed Fire: Prescribed burning alone is probably not effective for controlling spotted knapweed and may cause increases. Studies have shown that moderate increases occur after fire. Fire may be useful in conjunction with herbicides under the right conditions by reducing old stem densities. A fuel model has been developed for this species. The fire severity depends on the amount of dry knapweed stems and the amount of fine grass fuels [2].

Chemical (for spotted knapweed) [3, 4, 7, 8, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexa-chlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17]. | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Up to the bud stage. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexa-chlorobenzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Late spring prior to flower stem elongation | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 to 12 months to reseed since picloram is persistent in the soil. More mobile than clopyralid. Can move offsite through surface or subsurface water. Can be relocated through livestock urine |
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Actively growing in bud stage. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration Issues: The allelopathic chemical, -catechin,, may reduce recovery potential as its presence in the soil may hinder the resurgence of natives. Also dormant seeds may germinate and re-infest an area. Replanting is preferred over allowing natural recovery. A native or less persistent species such as sterile wheatgrass is preferred [17].

An integrated approach would involve late-fall cultivation, followed by a dormant seeding of grasses. The next spring requires treatment by herbicide at the point of first emergence with another reduced herbicide treatment or mowing in mid-summer [9].

## *Centaurea diffusa – Diffuse Knapweed*

### Ecological Characteristics of Note

Diffuse knapweed reproduces entirely by seed and is a prolific seed producer. A single plant can produce up to 18,000 seeds. Under favorable conditions (high soil moisture), it has a biennial life cycle, but additional years are required to attain flowering size in less favorable conditions. The plants must reach a critical size in order to flower. Under favorable conditions a plant will bolt in May of its second growing season and flowers in July/August. Seeds mature by mid- to late August. Seeds germinate in both early spring (primarily) and fall. In the fall, diffuse knapweed breaks off at ground level and disperses widely as a tumbleweed [2, 17].

### Management

A successful management program should set a goal of <5 percent knapweed cover. This is the assumed density of the weed in its native range [17]. A cumulative stress approach is necessary (i.e. a combination of treatments).

Manual: For small infestations, hand pulling before seed set is effective if done three times in one year [17].

- Dig rosettes in the spring.
- Pull mature and immature plants in early summer before seeds form.
- Pull and bag (to remove seed from area) remaining plants in mid to late summer.
- All of the infestation must be pulled. All of the taproot must be removed. Pulling only portions of a large infestation will not be effective.

Mechanical: Mowing could actually increase populations of diffuse knapweed.

Biological: At least nine biological control agents are established in parts of the U.S. None of these, alone or in combination, effectively control populations. They may prove useful as part of an integrated program to weaken plants therefore making them more susceptible to other treatments [17].

Cultural: Deep plowing may be effective where feasible because knapweed seeds will not germinate below 3 cm. Shallow plowing could actually increase diffuse knapweed. Grazing is not an effective control method for diffuse knapweed. It is generally unpalatable and the spines can injure livestock [17].

Prescribed Fire: Fire may be effective in controlling this species. Low-severity fire may only top-kill diffuse knapweed. Dry soil conditions associated with burns may discourage re-infestation as moisture is the limiting factor for seed germination. Re-seeding of desirable species may be necessary. A fuel model developed for spotted knapweed may be useful to managers planning to burn fields infested with diffuse knapweed. Using prescribed fire to reduce big sagebrush in semiarid grasslands may expose sites to invasion by diffuse knapweed [2].

Chemical (for diffuse knapweed) [3, 4, 7, 8, 17, 52].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexa-chlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17]. | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Up to the bud stage. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexa-chlorobenzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Late spring prior to flower stem elonga-tion | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 to 12 months to reseed since picloram is persistent in the soil.<br>More mobile than clopyralid. Can move offsite through surface or subsurface water.<br>Can be relocated through livestock urine. |
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Actively growing in bud stage. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Monitoring: Conduct monitoring 2 or 3 times per year (spring, summer and fall) [17].

Restoration Issues: The allelopathic chemical, cnicin, may reduce recovery potential as its presence in the soil may hinder the resurgence of natives. Also dormant seeds may germinate and re-infest an area. Replanting is preferred over allowing natural recovery. A native or less persistent species is preferred [17].

## *Centaurea pratensis (C. jacea x nigra, C. debeauxii) – Meadow Knapweed*

### Ecological Characteristics of Note

Meadow knapweed is a fully fertile hybrid between brown and black knapweed. It is a perennial with a taproot when a seedling; mature plants develop a cluster of somewhat fleshy roots below a woody root crown. Flowering peaks in July/August, but occasional flowers can be found west of the Cascades into November/December, particularly on damaged plants [19].

### Management

Manual: Hand pulling is difficult due to the species' tough perennial root crown. The plants usually will not come out easily and will require digging [34].

Mechanical: Repeated mowing may suppress the species' ability to produce seed, but in some cases will only lower the blooming height [51]. Such mowing must be done before any seeds are formed, to avoid spreading the seeds. The season of growth and flowering may also be prolonged. This may be to an advantage in herbicide programs [35].

Cultural: Little information is available on palatability. Regrowth after mowing may also be an advantage when combined with grazing [35]. In pastures where treated with herbicide, fertilizer should be added to encourage grass vigor and competitiveness. Repeated cultivation as with spotted knapweed may be useful in some areas.

Prescribed Fire: No information could be found specific to this species, but burning effectiveness is most likely similar to spotted knapweed.

Chemical (for meadow knapweed) [3, 4, 7, 8, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexa-chlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17]. | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Up to the bud stage.<br><br>Two applications per season; one in spring, one in fall is also proving effective. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water.<br><br>Worked very well for this species in elk habitat. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexa-chlorobenzene | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Late spring prior to flower stem elongation | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 10 12 months to reseed since picloram is persistent in the soil.<br>More mobile than clopyralid. Can move offsite through surface or subsurface water.<br><br>Can be relocated through livestock urine |
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Actively growing in bud stage. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

An integrated approach of herbicide treatment combined with mowing or pulling has potential for control. Various combinations of spraying herbicide first, then pulling or mowing are being tested by Washington State University [37].

## *Centaurea solstitialis – Yellow Star-thistle*

### Ecological Characteristics of Note

Yellow star-thistle typically begins flowering in late May and continues through September, sometimes into December or later. The time period from flower initiation to the development of mature viable seed is only 8 days. Infestations can produce 50-100 million seeds per acre. Two types of seeds can form, pappus bearing and non-pappus bearing. In either case, wind dispersal is not effective. Over 90 percent of seed fall within two feet of a plant. Non-pappus bearing seed can be retained in the flower head for a considerable amount of time, even into the winter. Over 90 percent of seed are germinable one week after seed dispersal. Seeds may stay viable from six to twelve years [17].

### Management

Manual: Manual removal is most effective with small patches or in maintenance programs where plants are sporadically located. This usually occurs with a new infestation or in the third year or later in a long-term management program. It is important to detach all above ground stem material. Leaving even a two inch piece of stem can result in recovery if leaves and buds are still attached at the base of the plant. The best time for manual removal is after plants have bolted but before they produce viable seed (early flowering) [21].

The Bradley method [22] of manual control can work on a larger population. Start removing plants at the outward edge of the population and working towards the interior. The technique requires repeated visits, but ensures that no new seeds are produced and soil disturbance is minimized. This method can control relatively large populations of less than 40 acres [21].

Mechanical: Early summer tillage will control yellow starthistle provided that roots are detached from the shoots. Repeated cultivation may be necessary in the same season when rainfall stimulates additional germination between tillage. Conduct tillage before seeds are produced. Appropriate use of this technique is probably limited in areas with many non-target species.

Mowing can be useful but timing is critical. Mowing early growth stages results in increased light penetration and rapid regrowth. If stem branches are below the mowing height, flowers could still develop. Mowing could also reduce biocontrol efforts, injure late growing forb species and reduce fall/winter forage. If conducted before viable seed production it may still be considered effective.

Biological: Six insects have become established for yellow starthistle control in the western US. These include three species of weevils and three species of flies. Only two have had any significant effect on reproduction in California; the hairy weevil and the peacock fly. The combination of these two insects reduced seed production by 43 to 76 percent. Although this level of suppression would not ensure long term management, it will certainly help in combination with other treatments. A more successful biocontrol program will likely require the introduction of plant pathogens or other insects capable of damaging roots, stems and foliage [17].

Cultural: Grazing could be effective if properly timed. Early grazing would favor light penetration and stimulate growth of yellow starthistle. Late season grazing would allow heavy seed production since cattle and sheep would avoid the spiny heads. Grazing in May or June may be effective depending on effects to native vegetation. Short duration, intensive grazing (for only 3 to 5 days) may be most effective. Goats are becoming more popular as the grazing tool of choice since they will eat the plant during its spiny phase [17, 21].

Prescribed burning: The ideal burning time is similar to the ideal mowing time (early flowering before seedset). Unfortunately early to mid-summer burning may not be feasible in some places due to climatic or environmental conditions. It may be best used after herbicide treatment (such as with clopyralid) in the first year. This would suppress legumes and stimulate grasses making a second year fire more effective in promoting species diversity.

Chemical (for yellow starthistle) [3, 4, 7, 8, 17, 21].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline) * considered most effective [17]<br><br>Contains hexachlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17]. | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | January through May. Most effective on seedlings and rosettes. Will work in bolt or bud but at higher concentrations. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. |
| Picloram (Tordon) * most widely used in the West [17]<br><br>Contains hexachlorobenzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Late winter to spring in rosette through bud stage. | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 10 12 months to reseed since picloram is persistent in the soil.<br>More mobile than clopyralid. Can move offsite through surface or subsurface water.<br><br>Can be relocated through livestock urine |

Chemical (for yellow starthistle) [3, 4, 7, 8, 17, 21].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations). | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Works best on seedlings. Will not control plants germinating after application, so use on mature plants is better for long term management. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |
| Triclopyr (various Garlon formulations; consisting of salts and ester). | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ectomychorrizal growth. | Works best on seedlings. Will not control plants germinating after application, so use on mature plants is better for long term management. | Backpack or wick to minimize drift. Only selective treatments allowed by standards. | Only provides control during year of application. Garlon 4 (ester formulation) is more toxic to fish and aquatic inverts. Offsite movement by water possible. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: Revegetation with desirable and competitive plant species can be the best long-term sustainable method. Unfortunately, few studies have been conducted on the restoration of yellow starthistle using a wide diversity of species, particularly natives. Perennials such as big bluegrass and thickspike wheatgrass provide a native alternative to non-native persistent species such as crested wheatgrass.

## *Chondrilla juncea – Rush Skeletonweed*

### Ecological Characteristics of Note

Rush skeletonweed can produce by either seed or vegetatively. It is a somewhat long lived perennial which can produce seed without fertilization. This self fertilization produces clones resulting in well-adapted biotypes that can dominate an area. Three biotypes are known in the Pacific Northwest, with varying flowering times. Mature plants can produce 1500 flower heads with the capability of producing 20,000 seeds. Seeds can be wind dispersed up to 20 miles. Vegetative spread is possible from shoot buds found along lateral roots, and from shoot buds found near the top of the main tap root. Vegetative spread is also possible when a root fragment, as deep as four feet down, is left in the ground. When the plant stem or root is mechanically injured, vegetative growth is initiated [23].

### Management [23]

Manual/Mechanical: Since any mechanical damage to plants stimulates new growth resulting in satellite plants, such methods are not recommended. Frequently mowing rush skeleton weed plants infested with gall mites may decrease the rate of spread for the species.

Biological: Several biological controls have been released in the west. Most are very specific to biotype and are therefore only effective in specific areas. The gall mite is most effective against all biotypes. Rush skeletonweed still remains the dominant species, though, even with this biological control. The plant pathogen, rust fungus, is well established and is effective on the early flowering biotype.

Cultural: Continual grazing may decrease populations when seed production is prevented, but rotational grazing can increase population densities.

Chemical (for rush skeleton weed) [7, 23}: Rush skeletonweed is a deep rooted, rhizomatous perennial considered tolerant to herbicides. Therefore, an aggressive follow up program with repeated applications will be necessary. Difficult to apply because of small leaves.

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexachlorobenzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17] | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Apply to rosette in the late fall or up to early bolting in spring. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water.<br><br>Plants less than five years old respond better to herbicides. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachlorobenzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply from late fall to early spring | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 to 12 months to reseed since picloram is persistent in the soil.<br>More mobile than clopyralid. Can move offsite through surface or subsurface water.<br>Can be relocated through livestock urine.<br>Plants less than five years old respond better to herbicides. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

## *Cirsium arvense – Canada Thistle*

### Ecological Characteristics of Note

Canada thistle produces an abundance of seeds that are easily dispersed by the wind. Most seeds germinate within a year, but some remain viable in the soil for twenty year or more. Vegetative reproduction is aided by a fibrous taproot capable of sending out lateral roots as deep as 3 feet below ground, and from which shoots sprout up at frequent intervals. It also readily regenerates from root fragments less than an inch in length. The species is usually dioecious [3].

### Management

Canada thistle management programs should be designed to kill established clones since the species spreads primarily by vegetative expansion of the root system. Prevention of seed production is also an important part of a management program [53]. It takes at least two growing seasons to determine whether a particular control method is effective. Remove or treat populations before they flower and set seed [17].

Manual: The only manual technique found was hand cutting of flower heads using the same leaf and stem criteria described below under mechanical. Although not a control method per se, this technique would suppress seed production [3]. Smothering Canada thistle with boards, sheet metal or tar paper can kill plants.

Mechanical: Mowing may only be effective in rare cases where it can be repeated at monthly intervals. This intensity is not recommended in natural areas, where it would likely damage native vegetation, but may be practical along roadsides [53]. Mowing just twice a year, in mid-June and September may reduce or contain Canada thistle. When mowing, cut high enough to leave >9 leaves per stem, or > 20 centimeters of bare stem tissue, as mature Canada thistle leaves and stems independently inhibit development of shoots from rootbuds.

Biological: Overall, this method provides little or no control on Canada thistle populations, although some agents weaken and kill individuals. Most biocontrols are not adequately synchronized with its life cycle in North America. Management that delays flowering, such as mowing or burning, may help to synchronize a more susceptible stage with the biocontrol agent's life cycle. At least three agents may be needed for effective control [17].

Cultural: Little information is available on the effectiveness of grazing. Although sheep and goats have been known to eat young plants, livestock grazing has not been proven and is most likely a contributor to thistle establishment in overgrazed situations.

Tilling also may be effective in unique cases. Deep tilling repeated through the season until early August will ensure new shoots do not produce flower stalks. Tilling in mid- to late July, applying herbicide in mid-August and tilling again after three weeks has been successful in Canada.

Prescribed Fire: Above ground parts will be killed, but below ground parts will survive even severe fires. There is abundant evidence that post-fire establishment of Canada thistle is common where seed source is available [2].

Results are mixed on the use of prescribed fire as a management tool. Prescribed burns may be effective at stimulating growth of native species and thereby discouraging the growth of this invasive. It may be best if timed to emulate the natural fire regime of a site. Late spring burns may discourage the species, yet early spring burns may encourage it. Dormant season burning may be preferred because it stimulates growth of native vegetation, but may not be as effective as late spring burning [2]. Annual burns for several years may be required.

Chemical (for Canada thistle) [3, 4, 7, 8, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline)<br><br>Contains hexachloro-benzene. | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17] | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Apply at basal rosette stage after the most leaves have emerged. Fall applications will reduce spring regrowth. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. Contains hexachlorobenzene. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachloro-benzene. | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply at basal rosette stage after the most leaves have emerged. Fall applications will reduce spring regrowth. | Backpack or wick to minimize drift. | Wait 6 to 12 months to reseed since picloram is persistent in the soil.<br>More mobile than clopyralid. Can move offsite through surface or subsurface water.<br>Can be relocated through livestock urine. |
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | As above. Fall is the best season since translocation to root is highest then. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

Chemical (for Canada thistle) [3, 4, 7, 8, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Chlorsulfuron (Telar, Glean) | Glean -Selective pre-emergent or early postemergent; controls many annual, biennial and perennial broadleaf species. Telar – selective for broadleaf species both pre- and post – emergent [7] | Off site drift up to 900' possible. Safe for most grasses. | Could apply at bud-bloom stage or to fall rosettes. | Backpack or wick to minimize drift. Aerial spraying not permitted under standards. | Primarily suppressed regrowth and secondarily reduces the number of root buds. Extremely potent. Damage to non-target terrestrial and some aquatic plants at peak concentrations. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Some considerations for use of herbicide include [17]:

- Different ecotypes respond differently to the same herbicide, so what is effective in one locale, or on one clone, may not be effective in another.
- Vary herbicides used at a site to prevent clones tolerant to one herbicide from becoming dominant. Select alternative herbicides with a different mode of action to minimize chances for tolerance to build.
- In many habitats, Canada thistle goes dormant shortly after native species, so there is only a limited window to apply herbicides when native species will not be affected.
- Herbicide absorption is enhanced in late summer and fall, when plants are in the rosette stage as shoot-to-root translocation is greatest at this time.

Monitoring: The best time to annually monitor sites is just before or during the blooming period, which corresponds with periods with 14-18 hours of daylight. [17]

## *Cynoglossum officinale – Hounds Tongue*

### Ecological Characteristics of Note

Houndstongue is a biennial or short-lived perennial species, which forms rosettes in the first year and flowers in the second. It flowers between May and July. It has a thick branching taproot, extending to depths >40 inches. It often occurs in dense stands. Seedlings are usually clustered around parent plants in densities of up to 405 seedlings per square foot. Estimates of total seed number per plant range from 50 to more than 2,000. Its spiny husk and protruding barbs enable long distance dispersal to occur. Seed viability in the soil is relatively short compared to other invasive plants. Seed can remain viable above ground on plants for up to two years. Houndstongue is most abundant in areas with more than 10 percent bare ground. Germination starts in late winter and early spring [2]. A relationship between burrs on cattle and houndstongue density in paddocks was shown by De Clerck-Floate in 1997 [29].

### Management

Manual: Surface cultivation, digging and hand pulling are considered ineffective means of control because plants are capable of regenerating from the root crown. Hand pulling can reduce the size of populations up to 85 percent, though, if roots are completely removed [2].

Mechanical: Severing the root crown 1 to 2 inches below the soil surface with a spade and removing top growth can be effective in controlling small infestations when done before flowering. Mowing at ground level can reduce re-growth by 60 percent as well as seed production in some cases [18]. Plowing is said to control houndstongue, but may not be appropriate in most areas.

Biological: Biological controls are being screened for possible use. One is approved in Canada. A native bacteria is being tested at Montana State University as an effective biological control as well. Spraying the plant with this bacteria interferes with its production of chlorophyll, weakening it so it will not resprout the following year [18].

Cultural: No references to grazing as a management method were found, most likely due to the poisonous nature of the plant. Proper livestock grazing that promotes full recovery of desirable grass species and litter accumulation was recommended [2].

Prescribed Fire: In some ecosystems re-establishing historic fire regimes can be effective at controlling invasive species, but more research is needed regarding the potential of prescribed burning to control houndstongue [2].

Chemical (for houndstongue) [2, 3, 4, 7, 8, 17, 18].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Metsulfuron (Escort) | Selective for broadleaf and woody species.<br><br>Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Extremely potent. Most sensitive species in the Lily family. | Mid-June or during active growth. Reapplication may be needed the first year to prevent seed production. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Potentially mobile in water or through wind erosion. Damage to non-target terrestrial and some aquatic plants at peak concentrations. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachloro-benzene | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply at basal rosette stage after the most leaves have emerged. Fall applications will reduce spring regrowth. | Backpack or wick to minimize drift. | Wait 6 to 12 months to reseed since picloram is persistent in the soil. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |
| Chlorsulfuron (Telar, Glean)[2] | Glean-Selective pre-emergent or early post emergent; controls many annual, biennial and perennial broadleaf species. Telar – Selective for broadleaf species both pre- and post-emergent [7] | Off site drift up to 900' possible. Safe for most grasses. | Apply to rosettes, or 6 to 11 inch bolts to prevent seed production completely. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |
| Imazapic (Plateau)[20] | Selective for broadleaf plants and some grasses. | Off site drift up to 50' possible. Over 100' if applied aerially. | Apply before bloom stage. | Backpack or wick to minimize drift. | Even very tolerant non-target species are likely to be damaged. Some damage to aquatic plants at peak concentrations could occur. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: Houndstongue seedlings have a comparatively low growth rate and are not strongly competitive. Interspecific competition can severely reduce the dry weight of first and second year plants. Therefore, revegetation can effectively control houndstongue re-introduction, although more research is needed.

Prevention is extremely important with houndstongue. The cleaning of cattle and equipment or clothing used for treatments when moving from infested to non-infested areas is very effective in reducing introductions [2].

## *Cytisus scoparius – Scotch Broom*

### Ecological Characteristics of Note

Scotch broom can reproduce vegetatively or by seed. Bushes can produce up to 60 seed pods per bush by their second year. Only about 45-50 percent of the seeds produced will actually germinate. Seed can remain viable up to 80 years if stored correctly and will germinate when shade is removed and ground disturbed [53]. Initial growth is rapid for the first 4 to 5 years. Broom plants can grow over a meter tall in the first year. Soil disturbance while treating will encourage sprouting [17].

### Management [17]

Manual: Hand pulling may be used to destroy seedlings or plants up to 1.5 meters tall. It is most easily accomplished after a rain when the soil is loose when the root system can be removed in its entirety. This will also minimize soil disturbance which encourages germination. As with hand pulling, hand digging or hoeing can be effective, but care must be taken to remove all roots. Hoeing may be used to expose and desiccate roots and will minimize the damage to roots of desirable vegetation. Use of a weed wrench is effective on mid-size plants.

Mechanical: Cutting using various tools or mowers is most effective when done as plants are flowering, but before seed set. Clipping low to the ground is best. At this stage, the reserve food supply in the roots is nearly exhausted. Brooms will most likely still resprout with this method, so repeated treatments will be needed. Return visits in the fall and winter will be necessary.

Biological: Three biocontrols may be present on scotch broom; a twig mining moth, a seed weevil and a shoot tip leaf tying moth. One was accidentally released in the 1920s, one was purposely released in the 1970's and one in the 1980's. While some predation has been noted, none have been very effective. They may slow the spread, but do not reduce existing populations significantly.

Cultural: In some areas of California, the use of angora and Spanish goats has shown promise for effective control. In the Cleveland National Forest, goats were herded for firebreak management of brush species over 79,000 acres. Desirable vegetation in weed treatment areas would need to be fenced, especially woody vegetation to keep goats from eating it, though. Sheep are more selective than goats, but proper management to avoid soil compaction and movement of seed is important. Cattle grazing may not be effective, since it may be considered unpalatable and is slightly toxic.

Prescribed fire/flaming: Flaming during the winter months using a propane torch has been shown to be effective for smaller plants. Tiger torches used for tar roofing projects have been used. Flaming would reduce soil disruption caused by other manual or mechanical removal techniques.

Broadcast burning has been used, but is only effective in combination with other techniques such as herbicides. Burning is best followed by herbicide treatment of stumps, subsequent burning to exhaust the seed bank and underground reserves and revegetation with other fast growing native

shrubs. Herbicides could also be used before burning to desiccate the plants so they would burn more readily.

Chemical (for scotch broom) [7, 8, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Triclopyr (various Garlon formulations; consisting of salts and ester) | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ectomychorrizal growth. | Late spring during active growth. If too early, spring sap flow may wash off chemical. | Paint cut stumps or incised stem within 5-20 minutes of cutting. Broadcast spraying not permitted under FEIS. | Garlon 4 (ester formulation) is more toxic to fish and aquatic inverts. Offsite movement by water possible. |
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Most effective when applied from flowering through first hard frost. | Backpack or wick to minimize drift. | Provides some control.<br><br>Repeated applications necessary.<br><br>Rain within 6 hours reduces effectiveness. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachloro-benzene. | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply to young plants during active spring growth. Moderately effective. | Backpack or wick to minimize drift. Use on cut stumps caused 'flashback' through roots between treated and non-target plants [17] | Wait 6 to 12 months to reseed since picloram is persistent in the soil. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

## *Elytrigia repens var. repens – Quackgrass*

### Ecological Characteristics of Note

Quackgrass is an aggressive, cool season grass which spreads both by seed and rhizomes. An extensive network of rhizomes can form that competes strongly with cultivated crops, native grasses and forbs as well as native woody species where it forms dense stands. Because it is a cool season grass it will grow early in the spring, therefore suppressing species that grow later in the season. Its rhizomes secrete ethylacetate extracts, which may be allelopathic. It is an early successional species which supposedly will not tolerate shade; although the Nature Conservancy has not documented any evidence on their preserves that decreases in abundance have occurred over time. Primary rhizome growth occurs once in the spring and again in the fall [17].

### Management

There has been a great deal of attention on the control of quackgrass in croplands, but little published material exists on the control of this invasive in wildlands.

Manual: Pulling by hand is usually not effective because root pieces which break off in the ground can produce new plants, possibly more than were at the original site [56].

Mechanical: In midwestern prairies, mowing and raking significantly reduced quackgrass biomass and prevented flowering the following growing season [2]. Mowing is recommended when conditions are too wet for tilling to reduce seed production [17].

Cultural: Tilling breaks up rhizomes and forces plants to use reserves to regenerate. It can also spread the species in some cases. It will most likely take multiple years. Care should be taken not to spread rhizome parts. In the spring tilling will need to be repeated when top growth reaches 5 centimeters [17]. Tillage is most effective in warm, dry weather when root systems can be exposed to dry out. In the fall, tillage exposes roots to freezing temperatures which can also aid in control. Close grazing before tillage improves control [57]. Fabric mulches may be effective in some settings. Also, a layer of 80-pound grade roofing paper has been useful as a permanent barrier on areas such as driveways or permanent borders [56].

Prescribed burning: Results vary with the use of prescribed burning. Some report that burning is not effective. Others say burning on a repeated or biennial schedule for several years has been effective in some cases [17]. Late spring fires generally reduce quackgrass cover, flowering and biomass, while early spring fires can increase these [2]. Fall burns might also help reduce undesirable cool season grasses [17].

Integrated: The predominant theme in the literature for this species is the use of a combination of techniques. Some references point to a combination of mowing, burning and chemical application [2]. Others promote a multi-year integrated plan using tillage, patch mowing and herbicides [58].

Chemical: (for quackgrass) [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which prevents leaching or uptake by non-targets. | Apply in spring or fall during active growth.<br><br>Early spring would be best to avoid effects on warm season grasses. | Backpack or wick to minimize drift | Complete control may require re-treatment. Rain within 6 hours reduces effectiveness. Aquatic formulations can be used near water. Careful application is imperative since this species mingles with natives and desirable vegetation. Could be used in a degraded situation; treat then plow up, then re-seed. |
| Sethoxydim (Poast)<br><br>not as effective as glyphosate | Selective for post emergent grasses | Off site drift up to 50' possible. | Apply in spring or fall during active growth.<br><br>Early spring would be best to avoid effects on warm season grasses. | Backpack or wick to minimize drift | Potentially mobile, but degrades rapidly. Will impact native grasses. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

## *Euphorbia esula – Leafy Spurge*

### Ecological Characteristics of Note

Leafy spurge emerges in early spring. Stem elongation is very rapid as daily temperatures increase from May through June. As the growing season progresses, seedlings may appear to die, but their underground parts persist and adventitious shoots develop. It is the adventitious shoot that matures into a flowering shoot. Flowering forms on the main axis from May through July with flowering and seed development again occurring for a short time in the fall, usually from auxiliary branches. Seeds may remain dormant for 5 to 8 years following maturity. Seed dispersal is by explosive dehiscence up to 4 meters from the plant. Seeds can also float and disperse along waterways. Vegetative reproduction occurs from both crown and root buds that can overwinter. Seedlings have a remarkable capacity for vegetative reproduction and can develop root buds with 7 to 10 days of emergence. Roots have been excavated to a depth of over 4 meters [17].

### Management

Manual/Mechanical: Repeated mowing or hand cutting may be used as a control of seed production, but it must be used in conjunction with herbicides for adequate control of stand expansion. Repeated mowing or cutting is necessary in a single season. A single cutting will stimulate the development of lateral branches and flowering. Repeated mowing could reduce the competitive ability of desirable species, though [17].

Biological: Research is being conducted on at least fifteen insects as possible biological control agents. Some success has been found with the flea beetle combined with fall herbicide treatments.

Cultural: Grazing by domestic goats or sheep may help control leafy spurge. However favorable results are directly related to the grazing regime. Season long grazing by goats is more effective than rotational grazing, for example [2]. Multi-species grazing has been advocated for control of leafy spurge. This method could only be used when long term grazing is a possibility. Usually, in the first two years, sheep are grazed on an area with dense spurge. Starting in year three, cattle can be moved in. At year five, monitoring and maintenance grazing can be established [40].

In any case an integrated approach is most likely to be successful when treating leafy spurge. A combination of mechanical and chemical may produce the most effective results.

Chemical (for leafy spurge) [2, 7, 17]

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching/uptake by non-targets. | Most effective when applied in spring to prevent flowering and repeated in early fall. | Backpack or wick to minimize drift. | Provides some control.<br><br>Repeated applications necessary.<br><br>Rain within 6 hours reduces effectiveness. |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachloro-benzene. | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply in late spring when flowers and seeds are developing If needed also in early fall after stems have developed. | Backpack or wick to minimize drift. | Does not inhibit the germination of leafy spurge seed.<br>Wait 6 to 12 months to reseed since picloram is persistent in the soil.<br>Can move offsite through surface or subsurface water.<br>Can be relocated through livestock urine. |
| Imazapic (Plateau)[20] | Selective for broadleaf plants and some grasses. | Off site drift up to 50' possible. Over 100' if applied aerially. | Apply during the fall. | Backpack or wick to minimize drift. | Even very tolerant non-target species are likely to be damaged.<br>Some damage to aquatic plants at peak concentrations could occur. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods for control were found in the literature.**

## *Geranium robertianum – Herb Robert*

### Ecological Characteristics of Note

Herb Robert is a shade tolerant, low growing geranium described as a winter or spring annual, a biennial and even as a perennial. It spreads entirely by seeds. The root structure is shallow. Each flower produces 5 seeds capable of being ejected 15-20 feet. With adequate moisture, seeds begin germinating soon after dispersal. New seedlings appear several times throughout the growing season, which is from early spring to late fall and even into early winter. It has the ability to overwinter as seeds or as a rosette. Disturbance is not a requirement for the establishment of this species and it can become dominant in the understory of a forest community [23].

### Management

Manual: Hand pulling is quick and easy, due to the shallow roots, but stems are brittle, so care must be taken to get the entire plant. This method is probably the most effective, but care must be taken not to pull desirable vegetation since the plant will mingle with natives [23].

Biological: Although one species of aphid is known from its native range to feed specifically on the species, biocontrol may not be a true option because of the economic value of other ornamental geraniums.

Chemical (for herb Robert) [23].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Treat at low rates early in the season. | Backpack or wick to minimize drift<br><br>Has been used with or without a surfactant effectively. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water.<br><br>Careful application is imperative since this species mingles with natives and desirable vegetation. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods for control were found in the literature.**

## *Hedera Helix – English Ivy*

### Ecological Characteristics of Note

English ivy reproduces vegetatively and by seed, which is dispersed primarily by birds. New plants grow easily from cuttings or from stems making contact with the soil. Compounds in English ivy are somewhat toxic and include glycosides that cause vomiting, diarrhea, nervous conditions and dermatitis in sensitive individuals.

### Management

Manual: Effective for small areas or when a large volunteer workforce is available.

- Remove from trees first. Cut the vines at shoulder height and ankle height and strip away from tree. Next pull up roots as much and as deep as possible. Keep extending the pulled area around the base of the tree until at least six feet is cleared [12].
- When pulling ground ivy get all the roots you can as well. Use a shovel to extract root mats. Do not leave pulled plants on the ground as they can continue to grow [13].
- Use crews to roll 'ivy logs' pulling a line of ivy, rolling and pulling again. On slopes use the cookie cutter method, removing ivy for a three foot circle. Plant with a native tree species [12].
- Return annually. The second year should require only about 10 percent of the first year's effort [12].
- At the very least, clip any branches with blossoms to prevent the spread of seed by birds [53].

Mechanical: String trimming prior to herbicide application was recommended.

Biological: No biological controls are currently available.

Chemical (for English ivy) [3, 8, 11, 12, 13, 14].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Triclopyr (various Garlon formulations; consisting of salts and ester) | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ectomychorrizal growth. | Any time as long as temps are above 55 degrees. Fall and winter minimize impacts. | Paint cut vines. Backpack spray to minimize drift. | Application rates vary (15-30%) of Garlon 4 [3]. Effectiveness varied. Possibility of absorption to the host tree depending on thickness of bark. Could be used on string trimmed ground growth depending on size of infestation. Garlon 4 (ester formulation) is more toxic to fish and aquatic inverts. Offsite movement by water possible. |

Chemical (for English ivy) [3, 8, 11, 12, 13, 14].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic. | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Any time as long as temps are above 55 degrees. Fall and winter minimize impacts. | Broadcast at diluted rate or paint on cut vine at full strength. If spraying on leaves, the waxy cuticle on leaf must be broken at the leaf edge. | Provides some control.<br><br>More effective after string trimming.<br><br>Rain within 6 hours reduces effectiveness. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods of control were found in the literature.**

Restoration: After treating English ivy, rake disturbed areas and seed or plant cleared areas with natives or sterile wheatgrass [15]. Or mulch cleared areas with 8" thick mulch.

## *Hieracium aurantiacum – Orange Hawkweed, Hieracium pretense* – Meadow or Yellow Hawkweed, Hieracium vulgatum – Common Hawkweed

### Ecological Characteristics of Note

These hawkweeds are perennials with shallow fibrous root systems and rhizomes. They can reproduce by seed or vegetatively. Orange and yellow hawkweeds also produce stolons that can produce new plants. Yellow or meadow hawkweed can also develop new plants from the root buds [18]. Although, most populations begin from seed, these species will then aggressively spread through rhizomes or stolons. In a new site, less than 2 percent of the plants come from seedlings. Once established, vigorous stolon growth quickly expands the colony, forming dense patches with as many as 3,200 plants per square yard [24].

### Management

Manual: It is possible to control small infestation by carefully digging out rosettes. Any breakage of the shallow roots and rhizomes must be avoided. Even a small piece left in the soil may develop into a new plant. Anything removed must be taken off site and either burned or put in a refuse pile. Some authorities do not recommend manual removal at all [18].

Mechanical: Mowing is considered ineffective. Cultivating and rotating in an annual crop works in agricultural situations, but this method has little application on Forest Service lands. Mechanical control procedures are generally not successful since any disturbance to the plant can stimulate the growth of new plants from fragmented roots, stolons and rhizomes. Such disturbance can re-distribute the hawkweeds and increase the rate of spread [18].

Biological: No biological controls are currently available for release on the hawkweeds. The magnitude and complexity of these species suggests that biological control may not be successful.

Chemical (for hawkweeds) [7,18].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Clopyralid (Transline) w/ soluble nitrogen fertilizer | Selective, systemic for particularly: Asteraceae, Fabaceae, Polygonaceae, [7] Some effects on Apiaceae, Solanaceae, Violaceae [17]. | Off site drift may cause damage to sensitive plants up to 300'. Little effect on grasses. | Apply after most basal leaves emerge but before buds form. Fall treatments may also be helpful, but research is limited. | Backpack or wick to minimize drift. | Less persistent than picloram. More selective than picloram. Potentially mobile in water. Contains hexachlorobenzene. **Adding fertilizer enhances the competitive ability of desirable species.** |
| Picloram (Tordon) Restricted use pesticide<br><br>Contains hexachloro-benzene | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply after most basal leaves emerge but before buds form. Fall treatments may also be helpful, but research is limited. | Backpack or wick to minimize drift. | Wait 6 to 12 months to reseed since picloram is persistent in the soil. More mobile than clopyralid. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods of control were found in the literature.**

Restoration: After herbicide treatment, applying soluble nitrogen fertilizer can be effective in increasing the competitive abilities of grass. Fertilizing, when applied within 1 to 2 weeks of herbicide treatment is an important tool for restoring bare ground more quickly after the hawkweeds die back [18, 37].

## *Hypericum perforatum – St. Johnswort*

### Ecological Characteristics of Note

St. Johnswort is a taprooted perennial weed which reproduces by seeds and short runners. The taproot may reach depths of 4 to 5 feet. Lateral roots grow 2 to 3 inches beneath the soil surface but may reach depths of 3 feet. Flowering begins in May and continues through September. Developing capsules become very sticky and contain 400 to 500 seeds. Seeds may remain viable in soil for up to 10 years [18].

### Management [18, 30]

Manual: Hand pulling or digging of young plants in small, isolated infestations may be effective. Repeated treatments will be necessary because lateral roots can give rise to new plants. Pulled or dug plants must be removed from the area and burned to prevent vegetative regrowth.

Mechanical/Prescribed Burning/Cultural: Mowing is ineffective, but may discourage the spread of the plant if done before seeds form. Burning may increase the density and vigor of this species. Livestock avoid this species which can make them sensitive to sunlight, so grazing would select for the increase of this species.

Biological: Four biocontrols are currently recommended in Montana. Several have been released in the Pacific Northwest since the late 1940's. Effectiveness varies by climactic conditions. The insects are more effective in areas with a Mediterranean climate rather than cool and damp since the native range of the species has a similar climate [25]. The Klamath weed beetle (*Chrysolina quadrigemina)* has had good success and another beetle (*C. hyperici*) is better adapted to wetter sites. *Agrilus hyperici*, a root boring beetle has become established in eastern Washington and northern Idaho.

Chemical (for St. Johnswort)[7,18,20, 50].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Metsulfuron methyl (Escort) [20] | Selective for broadleaf and woody species.<br><br>Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Most sensitive species in the Lily family. | Apply after plants have fully emerged and are in active growth. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Potentially mobile in water or through wind erosion. Damage to some aquatic plants possible at peak concentrations |
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexa-chlorobenzene | Selective, systemic for many annual and perennial broadleaf herbs and woody plants. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply in early growth stage before bloom. | Backpack or wick to minimize drift. | One application may be effective for 2 or more years. Wait 6 to 12 months to reseed since picloram is persistent in the soil. More mobile than clopyralid. Can move offsite through surface or subsurface water. Can be relocated through livestock urine |
| Glyphosate/ (many formulations.)/ *Inhibits three amino acids and protein synthesis.* | A broad spectrum, non-selective translocated herbicide with no apparent soil activity. | Off site drift damage to sensitive species up to 100' possible Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | In spring/summer, when plants are growing rapidly. | Backpack or wick to minimize drift. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

## *Ilex aquifolium – English Holly*

### Ecological Characteristics of Note

With this dioecious species, female trees must grow within the pollinator range of the male trees. Birds usually spread the seed of this species and it also vegetatively reproduces by suckering or layering, where branches root into the ground.

### Management

Mechanical: It was very difficult to find removal techniques for English holly. The ones listed are from Australia and New Zealand [32, 33]. Mechanical removal of branches is required for safe access to the holly stems. It is recommended that lower unlayered branches be removed to above head height. After this is accomplished all layered branches (those with roots underground) should be removed from the stem and carefully pulled out of the ground. Having moist soils will make this easier to accomplish. Be sure to clear the leaf litter away from the base of the trees to ensure that no buried branches have been overlooked. All branches removed must not be left on the ground as they will re-root.

Mechanical removal is combined with chemical treatments in New Zealand and Australia.

Chemical (for English holly) [32, 33].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | In spring/summer, when plants are growing rapidly. | Paint along horizontal cut stump. Drilling and injecting into the stem is used in NZ and Australia; please check label! Frilling of bark and painting. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.
*Tordon is used in NZ and Australia, using cut stump, injection or frilling, which is not permitted on the label in the US.*
*Garlon may be useful for this species, given it is a woody plant..*

**No other methods of control were found in the literature.**

## *Lathyrus latifolius – Everlasting Peavine*

### Ecological Characteristics of Note

This pea has a sprawling and climbing nature. It has escaped from gardens and is probably still valued as a garden specimen by some.

### Management

Manual/Mechanical: Grubbing can be done using a spade or shovel to loosen the soil and dig up the root system. Re-sprouting may occur if the entire root system is not removed. Rotary or string trimming can cut back flowering, but the plant will re-grow after trimming.

Chemical (for everlasting peavine) [36].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | In spring/summer, when plants are growing rapidly. | Backpack or wick to minimize drift | Rain within 6 hours reduces effectiveness.<br><br>Some formulations can be used over water.<br><br>Complete control may require re-treatment. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods of control were found in the literature.**

## *Lepidium latifolium – Perennial Pepperweed*

### Ecological Characteristics of Note

Perennial pepperweed produces dense stands with stems reaching up to 3 feet in height, up to 8 feet in wet areas. Its dense cover blocks sunlight from reaching the soil, thus suppressing the growth of other plants. Roots are enlarged at the soil surface in a woody crown and can extend at times into the water table. Roots as deep as 3 meters have been observed. The species is a prolific seed producer, capable of producing more than six billion seeds per acre. Seeds lack a hard cover, therefore viability may be short. Shoots flower and fruit in late spring and continue throughout much of the summer. Seeds either fall from the pod or can remain in pods until the following season. In addition to seeds, the species can spread by rhizomes which may grow to a length of ten feet [17, 18].

### Management

With the exception of continual flooding, no non-chemical treatments have been found to effectively control this species.

Biological: No biological agent is approved for perennial pepperweed. The risk is too great of releasing a control that would attack a valuable crop.

Cultural: Grazing may be effective by cattle, sheep or goats. There is potential for poisoning, which is currently being evaluated [17].

Chemical (for perennial pepperweed) [7, 17, 18].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Metsulfuron (Escort) plus surfactant | Selective for broadleaf and woody species.<br><br>Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Extremely potent. Most sensitive species in the Lily family. | Apply during bud to early bloom stage. | Backpack or wick to minimize drift. Aerial spraying not permitted under standards. | Potentially mobile in water or through wind erosion. Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |

Chemical (for perennial pepperweed) [7, 17, 18].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Chlor-sulfuron (Telar, Glean) plus surfactant | Glean-Selective pre-emergent or early post emergent; controls many annual, biennial and perennial broadleaf species. Telar – Selective for broadleaf species both pre- and post-emergent [7]. | Off site drift up to 900' possible. Safe for most grasses. | Apply during bud to early bloom stage. | Backpack or wick to minimize drift. Aerial spraying not permitted under standards. | Some soil residual. Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |
| Imazapyr/ (Arsenal) | Broad spectrum, non-selective pre- and post-emergent for annual and perennial grasses and broadleaved species. | Off site drift may cause damage to sensitive plant species up to 500'. | Apply during bud to early bloom stage. | Backpack or wick to minimize drift. | High potential for leaching. Highly mobile and persistent. Residual toxicity up to several years. Can leak from roots of targeted species to non-targeted species. |
| Glyphosate (many formulations)<br><br>For sites near water. | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Apply during bud to early bloom stage. Best if done after early season mowing. | Backpack with adjustable spray nozzle. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

An integrated method of early mowing and herbicide treatment can be effective. This strategy involves mowing stems at the flowerbud stage, followed by a herbicide application to resprouting stems when translocation patterns favor accumulation below ground [17].

Restoration: To successfully manage perennial pepperweed, competitive vegetation must be established immediately after its control to prevent re-invasion [18].

## *Linaria vulgaris – Yellow Toadflax, Linaria genistifolia ssp. dalmatica – Dalmation toadflax*

### Ecological Characteristics of Note

A toadflax plant may have a taproot as deep as one meter. Horizontal roots may grow to several meters long and can develop adventitious buds that may form independent plants. Once established both species can suppress other vegetation mainly be intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials. Seeds can remain dormant for up to ten years. Both are quick to colonize open sites and are capable of adapting growth to a wide variety of environmental conditions.

### Management [17]

Manual: Hand pulling can be very effective if staff or volunteers are available for persistent treatment. Pulling teams in nature preserves can easily eliminate plants in early June or when flowers are first emerging. This makes locating the species easy. Plants can be removed in large infestations to avoid a mulching effect on desirable species, but they can also be left on the ground in smaller infestations. By the third year in one study, plants were noticeably smaller and lower in vigor. It can take up to ten years for total control.

Cutting toadflax stands in the spring or early summer is an effective way to eliminate plant reproduction. However, the long dormancy of toadflax seeds requires that the process be repeated annually for up to ten years.

Mechanical: Mowing can reduce reserves, but is only a temporary solution since it does not reduce rhizome growth.

Biological: Five insects have been approved by APHIS for release. One species, a shoot and flower feeding beetle is primarily found in Canada where it was accidentally released. It has reduced total seed production in some stands. *Calophasia lunula,* a defoliating moth was released in several western states including Washington and Oregon. It failed to establish in most sites, but is widely distributed in eastern Washington. Cold temperatures may effect this species. Two small root boring moths had little effect. Some seed weight reduction was noted, but root mining in the winter resulted in doubling of stem production. A seed eating weevil *(Gymnaetron antirrhini)* can also reduce seed production and is now established in both Oregon and Washington. None of these species are considered highly effective.

Cultural: Intensive cultivation can be successful if repeated every 7 to 10 days, but may not be applicable in most areas. Grazing does not control any toadflax species.

Prescribed Burning: Prescribed burning is not effective since it does not impact root buds or buried seed.

Chemical (for toadflaxes) [7, 17, 20].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Picloram (Tordon)<br><br>Restricted Use Herbicide<br><br>Contains hexachloro-benzene | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply to actively growing toadflax in the spring before bloom or in late summer or fall during regrowth. | Backpack or wick to minimize drift. Fall applications at lower rates are especially effective when made shortly after the first killing frost. | Wait 6 to 12 months to reseed since picloram is persistent in the soil. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |
| Chlorsulfuron (Telar, Glean) | Glean-Selective pre-emergent or early post emergent; controls many annual, biennial and perennial broadleaf species. Telar – Selective for broadleaf species both pre- and post-emergent [7] | Off site drift up to 900' possible. Safe for most grasses. | Apply to actively growing toadflax in the spring or fall. | Backpack or wick to minimize drift. Aerial spraying not permitted under FEIS. | Some soil residual. Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |
| Imazapic (Plateau)[20] | Selective for broadleaf plants and some grasses. | Off site drift up to 50' possible. Over 100' if applied aerially. | Apply during the fall. | Backpack or wick to minimize drift. | Even very tolerant non-target species are likely to be damaged. Some damage to aquatic plants at peak concentrations could occur. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: The recovery potential of areas that have been cleared of toadflax is very high. Communities that are in good condition may recover without replanting of desirable species as long as follow up control visits are conducted annually. However, replanting can help accelerate recovery. [17]

## *Lythrum salicaria – Purple Loosestrife*

### Ecological Characteristics of Note

Purple loosestrife has an extended flowering season from June to September. A mature plant may have as many as thirty flowering stems capable of producing an estimated two to three million seed per year. It also readily reproduces vegetatively at a rate of about 1 foot per year. [3]

### Management

Manual: Hand-removal is only recommended for small populations or isolated stems. Pull before seed is set. The entire rootstock must be pulled out. Remove uprooted plants and broken stems from the area since they can resprout. Winter pulling has been found by some to be most effective. [16]

Biological: Biological control is considered the most likely candidate for effective long term control of large infestations. As of 1997, three agents have been approved by APHIS. [3]

Chemical (for purple loosestrife) [7, 8, 16, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Apply to actively growing plants at full flowering stage. | Backpack with adjustable spray nozzle or cut and paint stems. | Spray may take several times per season. For cut and paint, cut stems high, below inflorescence, so that plant will keep growing and absorb more. A PVC applicator can be designed to wipe stem and cut. Also, a glove technique using nitrile or latex gloves on both hands covered with a fleecy, cotton glove can be used to wick up the top 1/3 of a plant after flowerheads are removed.[16] Rain with 6 hours reduces effectiveness. Surfactants can be damaging to aquatic species. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods of control were found in the literature**

## *Phalaris arundinacea – Reed Canarygrass*

### Ecological Characteristics of Note

Reed canarygrass is a robust, cool season, sod-forming perennial that produces culms through creeping rhizomes. The species is morphologically variable and more than ten infraspecific categories (varieties, subspecies, forms and races) have been described. It is very tolerant of freezing temperatures and begins to grow early in the spring, therefore it can outcompete many other species. Reed canary grass is rarely fully eradicated and requires yearly, if not monthly attention.

Some debate exists on whether this species is native or a descendent of non-native cultivars or the vigorous result of crosses between cultivated varieties and native strains. Early botanical collections from the inland Pacific Northwest predated settlement of the area by people of European descent. Cultivars have been widely introduced for forage and erosion control [17].

### Management [17]

Manual: Removal by hand pulling is practical only for small stands and requires a large time commitment. It can be effective if done over the entire population 2 to 3 times per year for five years. Covering populations with black plastic may work as long as shoots are not allowed to grow beyond the plastic. It may take over two years to be effective, though, and re-seeding will be necessary.

Mechanical: Mowing or cutting can be effective, but again must be done multiple times in one year.

Biological: No biocontrol agents for reed canarygrass are currently known.

Cultural: Discing and plowing can be effective especially after herbicide treatment but may not be appropriate in most situations. Grazing may be effective but the palatability of the reed canarygrass is questionable.

Prescribed burning: Fire may be effective in highly productive wetlands where a healthy seed bank of fire adapted species will readily colonize after burning. Lower quality areas may still be burned, but a more frequent cycle (every two to three years) may be required. The timing of burns is important. Early spring burns only accelerate growth, while late spring burns can weaken stands. Late autumn burns can also be beneficial.

Biological: No biocontrols have been identified for this species.

Chemical (for reed canarygrass) [8, 17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Apply in early spring when just sprouting and before other wetland species germinate. | Backpack with adjustable spray nozzle.<br><br>Application followed in two to three weeks by prescribed burning has been effective. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |
| Sulfometuron methyl (Oust) | Broad spectrum pre- and post-emergent herbicide for both broadleaf species and grasses. | Offsite drift may damage sensitive plants up to 900'. | Apply to pre-emergent or early post-emergent plants. | Backpack with adjustable spray nozzle. Aerial spraying not permitted under FEIS. | Highly mobile by water or by wind erosion. Substantial damage has occurred to croplands in both an arid and wet regions.<br><br>Damage to some aquatic plants possible at peak concentrations. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

## *Polygonum cuspidatum – Japanese Knotweed*

### Ecological Characteristics of Note

Seeds do not appear to be a significant method of reproduction for this species in the United States. The primary mode is through extensive rhizomes which can reach 15-20 meters in length. Dispersal can occur when rhizome fragments are washed downstream. Rhizomes can regenerate even if buried up to 1 meter deep and have been observed growing through two inches of asphalt. Shoots generally begin to emerge in April and growth rates exceeding 8 centimeters per day have been recorded [17].

Note: Hybridization is occurring. The treatments suggested are specifically for Japanese knotweed only. More literature review is needed for hybrid management or giant knotweed management.

### Management [17, 39]

Manual: Digging out the rhizomes of this species is effective for small infestations or in environmentally sensitive area where herbicides cannot be used. It is extremely labor intensive and tends to spread the rhizome fragments and promote disturbance so it is not highly recommended. All plant parts should be removed from the site.

Mechanical: Cutting may be effective if done repeatedly. Every 2-3 weeks from April through August will reduce rhizome reserves. It does not come highly recommended. Hand cutting or weedeater/mowing have been used.

Covering, particularly in conjunction with cutting, may be useful in smaller stands. Several layers of black plastic or shade cloth weighted down by blocks, mulch or stones may work. This should be done either after cutting or when plants are fully grown for the season since this species is capable of emerging up through asphalt. No reports of successful long term control using covering have been found.

Biological: Biocontrols are still being researched in this species native habitat in Japan.

Cultural: Goats are reported to eat knotweed and in some limited circumstances may be an option similar to intensive mowing. They will eat desirable vegetation; therefore exclosures will need to be installed.

**No other methods of control were found in the literature.**

Integrated approach: Cutting or pulling in combination with herbicide is most effective since the manual/mechanical treatments will encourage the plant to send up new shoots. The more shoots per linear foot of root, the more likely you will be able to physically pull them out, exhaust their reserves or kill them with herbicide (see next page).

Chemical (for Japanese knotweed) [7, 8, 17, 27].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Cutting and injection: Most effective in fall when leaves are translocating to rhizomes. Could follow a prior cut in late spring or early summer. Foliar spray: When plants are 1 -2 meters tall. Best if following a prior cut in spring. | 1. Cut and paint stems. Cut between first and second internode then deliver into 'well' created. 2. Stem injection (check label)** below first or second node [27]. 3. Backpack with adjustable spray nozzle. On young plants; may take more applications than other methods. | Complete control may require re-treatment. Rain within 6 hours reduces effectiveness. Aquatic formulations can be used near water. Low concentrations (<5%) may be most effective since higher concentrations can topkill the plants too fast to get the herbicide down to the roots (check with Mt. Baker – Snoqualamie on this or Portland area Nature Conservancy). |
| Triclopyr (various Garlon formulations; consisting of salts and ester) | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ectomychorrizal growth. | Most effective in fall when leaves are translocating to rhizomes. Could follow a prior cut in late spring or early summer [27] | Cut and paint stems. Cut between first and second internode then deliver into 'well' created [27] | Garlon 4 (ester compound) is toxic to fish and aquatic invertebrates. Amine formulations may be used near or over water. Offsite movement by water possible. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.
** Stem injection is approved on a limited number of labels.

## *Potentilla recta – Sulfur Cinquefoil*

### Ecological Characteristics of Note

Sulfur cinquefoil is a long-lived, taprooted perennial herb that typically flowers from late May to mid July. It reproduces primarily through seed; a single plant can produce thousands of seeds annually and it can be spread by roots if they are moved by tillage or on soil-moving equipment [41]. Seeds are dispersed primarily by wind from late summer through fall. Seeds appear to remain viable in the soil for more than four years, though studies specifically addressing seedbank persistence are lacking. In western North America, sulfur cinquefoil invades native forest, shrub and grassland plant communities as well as disturbed habitats that typically harbor weeds [17]. It can dominate a site within 2 to 3 years. New shoots can develop annually from the outer portion of the main root allowing a plant to live for extended periods as long as 20 years [2].

### Management

Manual: Hand-digging may effectively control small infestations if the root crowns are completely removed [41, 17].

Mechanical: Mowing is not an effective control method [41, 17].

Biological: There are no approved biological controls for *P. recta*. Due to the plant's close genetic relationship to native *Potentilla* species and to cultivated strawberries, finding a host specific biocontrol agent for *P. recta* is difficult [17].

Cultural: Grazing appears to be ineffective in controlling sulfur cinquefoil, as the plant can still flower and produce seeds even when heavily grazed. Improper cattle grazing of infested areas may accelerate sulfur cinquefoil dominance if grasses and forbs are selectively removed. Ingestion of seed heads or attachment of seeds to the bodies or hooves of animals during grazing of infested sites may lead to establishment of new colonies if seeds are deposited in uninfested areas with grazing migration .[17] Tilling followed by seeding with desired vegetation may be effective in agricultural settings but is not practical for most natural areas [17].

Prescribed Fire: Prescribed fire used alone does not appear to be effective, and may in fact increase sulfur cinquefoil recruitment. The use of prescribed fire as part of an integrated approach has not yet been studied [17].

Chemical: Sulfur cinquefoil will re-establish within three to four years of herbicide treatment, so repeated applications are needed for long-term control [43].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use* | Issues/Concerns |
|---|---|---|---|---|---|
| Picloram (Tordon) *considered most effective [17] | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | In fall or spring prior to late bud stage [20]. | Backpack or wick to minimize drift. Broadcast spray may be necessary for large infestations. | Picloram is preferred because its residual activity will inhibit new plants from establishing from the seed bank [17] Wait 6 to 12 months to reseed since picloram is persistent in the soil. Can move offsite through surface or subsurface water. Can be relocated through livestock urine. |
| Escort (metsulfuron) [41] | Selective for broadleaf and woody species. Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. Extremely potent. Most sensitive species in the Lily family. | Apply after plants have fully emerged and are in active growth [20]. | Backpack or wick to minimize drift. Broadcast spray may be necessary for large infestations Aerial spraying not permitted under FEIS. | May cause short term grass injury. Potentially mobile in water or through wind erosion. Damage to non-target terrestrial and some aquatic plants at peak concentrations possible. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Restoration: If sulfur cinquefoil populations are reduced (i.e. by herbicide, hand-digging), native plants are usually able to rapidly recolonize sites if sufficient native seed is still viable in the soil. Seeding of native species under adequate environmental conditions, reducing grazing pressure, and continued spot herbicide re-treatments, will result in a more rapid and stable restored native plant community [17].

## *Rubus discolor – Himalayan Blackberry*

### Ecological Characteristics of Note

Canes of Himalayan blackberry can grow to lengths of up to 7 meters in a single season. Once first year canes have arched over and hit ground, daughter plants can develop where cane apices have rooted. Canes produce berries in the second year and then die, senescence commencing near the middle or at the apices of canes without daughter plants. Canes can continue to grow in the center of thickets adding to their impenetrable mass. The root crown can be up to 20 centimeters in diameter from which many lateral roots can grow. Depths of 90 centimeters and lengths up to 10 meters have been documented [17].

Thickets can produce 7,000 to 13,000 seeds per square meter. Dispersed seed remains viable for several years with germination increasing after the first year. Seeds germinate mainly in the spring. Plants growing in shade do not produce seed and germination is reduced, but still occurs, where full sunlight is not available [17].

### Management [17]

Manual: Best if the massive root crown is fully dug out. This method works best where native vegetation is an issue and/or where a large workforce of volunteers is available. After digging out root crowns, return in a year and remove new plants. Typically about ¼ of the original amount should remain. This method can be effective over several years, especially if desirable vegetation that provides shade is planted [28]. The Bradley method would also work with this species [22]. This method would be useful to destroy seedlings and young plants up to 1 meter tall. For plants up to 4 meters tall, a claw mattock is effective for removing root crowns.

Mechanical: Mowing may have limited use where ground is flat and free of obstacles. Mowing or cutting of canes may have advantages over herbicides since these techniques will not stimulate adventitious root growth. Mechanical removal is best used as a first step to reduce above ground biomass before root crown removal.

Biological: The USDA will not support the introduction of insects as controls due to the risk these species may pose to commercially important blackberry species. The state of Oregon is researching options that may be less risky.

Cultural: The use of goats has proven effective in some areas of California. Grazing of goats must be combined with fencing of native vegetation to avoid impacts on these species. Sheep and cattle grazing have shown to reduce the amount of daughter plants arising from new canes.

Prescribed Fire: Used alone this method will not prevent resprouting from root crowns. Burning is best followed by stump herbicide treatment, subsequent burning to exhaust the seedbank and underground reserves and revegetation with fast growing native species.

Chemical (for Himalayan blackberry) [7, 17].
Herbicide treatments, in general, should be applied in conjunction with other treatments such as mechanical or prescribed fire. All the following could be applied after an earlier season cutting. Chemicals would suppress or weaken materials for burning, but can also stimulate the development of adventitious roots [17].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Most effective in fall when canes are actively growing and after berries have formed. | Backpack with adjustable spray nozzle. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |
| Triclopyr (various Garlon formulations; consisting of salts and ester) | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ectomychorrizal growth. | Most effective in fall when canes are actively growing and after berries have formed. | Cut and paint stems or backpack with adjustable spray nozzle where non-targets are not an issue. | Garlon 4 (ester compound) is toxic to fish and aquatic invertebrates. Amine formulations may be used near or over water. Offsite movement by water possible. |
| Picloram (Tordon) [7]<br><br>Restricted Use Herbicide<br><br>Contains hexachloro-benzene | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets. | Apply in late spring after leaves are fully developed. Could stimulate development of adventitious roots. | Backpack or wick to minimize drift. Reapplication will be required as regrowth occurs [7]. | Wait 6 to 12 months to reseed since picloram is persistent in the soil.<br>Can move offsite through surface or subsurface water.<br>Can be relocated through livestock urine. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

Integrated techniques are the most probable for success. A scenario where mechanical removal of large biomass in the summer, followed by hand removal of canes and roots, then herbicide treatment of new growth in the fall/winter may be most effective and least impacting to non-target species. The sowing of such fast growers as sterile wheatgrass will reduce erosion possibility in the winter. Mixing in native seed or planting woody species for shade development will help to develop competition with the species.

## *Senecio jacobaea – Tansy Ragwort*

### Ecological Characteristics of Note

Tansy ragwort is considered a biennial species. Under extremely favorable conditions, though, this species may behave like an annual. If conditions are poor or the plant is damaged, it may be induced into a mono- or polycarpic perennial habit. Polycarpic perennial plants often have large, woody rootstocks and more than one flowering stalk. Dispersal of the seed though not usually long distance (up to around 9 meters), can vary depending on climatic conditions. Seeds can remain viable in the soil for several years and as deep as 25 centimeters. The species also regenerates vegetatively, usually, but not always due to damage [17].

### Management

Manual: Hand pulling is effective if done when soils are moist and the hole left behind is mulched. This method is usually used after a population has been brought under control. Plants must be mature enough to bloom, at which point stems are firm and not easily broken. Because the primary root grows toward one side, the technique that works best is to tug firmly from one side and if the plant does not come out, move to the opposite side [53].

Mechanical: Mowing is the most commonly used technique. It is most effective if done prior to flowering when the plant has exhausted its reserves, but before seeds have started to develop. Mowing can prevent flowering, but may also increase rosette density [17]. Mowing may also force tansy ragwort to keep growing as a perennial [23].

Biological: Although an effective part of a long-term management strategy, the biocontrols in place will decline as the ragwort declines. Because of the ability for seed to remain dormant, they could effectively 'outwait' the decline of the biocontrol [17]. The most effective biocontrol is when all three of the agents (cinnabar moth, ragwort flea beetle and seed fly) are used in combination [8]. Biological control is not recommended for infestations found in Idaho, eastern Washington or eastern Oregon because insects are ineffective in these areas [31].

Grazing: Sheep appear to be unaffected by the toxicity of tansy ragwort. Sheep could be allowed to graze the plants before they bolt as a pretreatment to cattle grazing.

Chemical** (for tansy ragwort) [7].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Metsulfuron (Escort) plus surfactant | Selective for broadleaf and woody species.<br><br>Safest of the sulfonylureas on grasses. | Off site drift may cause damage to sensitive plants up to 500'. | Apply to actively growing plants. | Backpack or wick to minimize drift.<br><br>Aerial spraying not permitted under FEIS. | Potentially mobile in water or through wind erosion.<br>Damage to non-target terrestrial and some aquatic plants at peak concentrations possible.<br>Most sensitive species in the Lily family. |
| Picloram (Tordon)<br><br>Contains hexachloroben zene. | Selective, systemic for many annual and perennial broadleaf and woody species. Systemic. | Off site drift may cause damage to sensitive plants up to 1000'. Also can leak out of roots to non-targets [4]. | Apply up through flowering stage. Fall application after rains have initiated seed germination have also proven effective. | Backpack or wick to minimize drift. | Wait 6 to 12 months to reseed since picloram is persistent in the soil.<br>Can move offsite through surface or subsurface water.<br>Can be relocated through livestock urine. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.
* **Most publications state that 2,4-D or dicamba are the most effective chemicals to use.*

## *Taeniatherum caput-medusae – Medusahead rye*

### Ecological Characteristics of Note

Medusahead germinates in the fall. Roots begin to grow immediately and continue to grow through the winter. Germination may be delayed by dryness or cold temperatures, but this species still occurs sooner than cheatgrass or bluebunch wheatgrass. Germination increases with temperature. Flowering and seed formation occur in May and June. Seed reach maximum viability in July. Medusahead can effectively remove soil moisture which is also an advantage over other species. Plant density once established may range from 500 plants per square foot in scablands to 2000 plant per square foot in valley bottoms. Established populations form stem mats up to 12 centimeters thick which decompose slowly. The dense litter cover enhances medusahead germination and may exclude cheatgrass. It also contributes to high fire danger in the summer [17].

### Management [17]

Cultural: Heavy spring grazing by sheep during the green stage of medusahead has been reported to assist in control.

Prescribed Burning: Controlled burning in early June successfully controlled infestations in northern California. Burning in late May and early June meant that medusahead seed was still immature while associated annuals had cured, thus promoting a light by intense fire to arrest seed development. Single burns resulted in nearly complete elimination of medusahead for the next several years.

Chemical (for medusahead) [26].

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Imazapic (Plateau)[26] | Selective for broadleaf plants and some grasses. | Off site drift up to 50' possible. Over 100' if applied aerially. | Early season post emergence. | Backpack or wick to minimize drift. | Even very tolerant non-target species are likely to be damaged. Some damage to aquatic plants at peak concentrations could occur. |
| Sethoxydim (Poast) [26] | Selective for post emergent grasses | Off site drift up to 50' possible. | Fall soon after growth begins. | Backpack or wick to minimize drift. | Potentially mobile, but degrades rapidly. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

**No other methods of control were found in the literature**

Restoration: The planting of the native, *Elymus elymoides*, successfully established in non-native annual grasslands with or without prior treatment. Success is dependent upon the current mix of species.

## *Tamarisk ramosissima, T. parviflora - Tamarisk or Salt Cedar*

### Ecological Characteristics of Note

There is some dispute regarding the correct taxonomy of the deciduous tamarisk that have escaped and become invasive in western North America. Other species have been noted in the literature, but these two are the most commonly used for plants with 5-parted flowers and plants with 6-parted flowers, respectively [17]. Tamarisk is an aggressive, woody invasive that has become established over as much as a million acres. It is such a species of concern that control legislation has been passed in Congress (the Salt Cedar Demonstration Act) and statewide strategic plans, such as for the state of New Mexico, have been developed.

Tamarisk is a relatively long lived plant that can tolerate a wide range of environmental conditions. It produces massive quantities of small seeds and can propagate from buried or submerged stems. It can displace native woody species such as cottonwood, willow or mesquite, especially when timing and amount of peak water discharge, salinity, temperature and substrate texture have been altered by human activities. The species consumes large quantities of water and is tolerant of highly saline environments [17]. Tamarisk has a deep, extensive root system; it has a primary root that grows with little branching until it reaches the water table, at which point secondary root branching is profuse. Tamarisk plants may flower in their 1$^{st}$ year, but most begin to reproduce in the 3rd year or later. A large plant may bear several hundred thousand seeds in a single growing season. While prolific, the seeds produced are short lived and do not form a persistent seedbank [2].

### Management

Manual: Due to its extent and woody nature, manual methods such as pulling are not typically used. Handpulling has been used to control new tamarisk plants around isolated desert springs in national parks after the larger plants have been killed [17].

Mechanical: Mechanical methods such as cutting, using chainsaws, scraping with a bulldozer, using a brush claw or root plowing are being used throughout the West, mostly in combination with other methods [17]. A single cutting of tamarisk is ineffective, because the species resprouts vigorously. Cutting in combination with herbicide treatment can be effective. Cutting can reduce consumption of ground water through reduction of transpiring leaves.

Biological: A biological control program has been studied for tamarisk since the 1980's; several species are in various stages of experimental development. Biocontrol releases have not been fully approved due to concern of how quickly defoliation may occur, which could affect the federally listed southwest willow flycatcher [17].

Cultural: Cattle may graze large amounts of tamarisk, but are ineffective in the long term [2].

Prescribed fire: Prescribed fire can be used to thin dense tamarisk infestations prior to application of herbicides. Results are variable and dependent on season and herbicide used. Dense stands can burn hot with erratic fire behavior [2].

Chemical: [2, 17] The efficacy of herbicides is greatly enhanced when combined with other methods and/or revegetation. Heavy infestations may require thinning through prescribed burning or mechanical removal prior to herbicide application.

| Herbicide | Selectivity | Effects to Natives | When to Apply | Method to Use * | Issues/Concerns |
|---|---|---|---|---|---|
| Imazapyr/ (Arsenal) | Broad spectrum, non-selective pre- and post-emergent for annual and perennial grasses and broadleaved species. | Off site drift may cause damage to sensitive plant species up to 500'. | Apply during winter when plants are dormant and not moving large amounts of water from the roots. | Foliar - Backpack or wick to minimize drift. Aerial application has been used. | High potential for leaching. Highly mobile and persistent. Residual toxicity up to several years. Can leak from roots of targeted species to non-targeted species. |
| Glyphosate (many formulations) | Broad spectrum, non-selective and systemic | Off site drift up to 100' possible. Most likely to kill non-targets including grasses. Adheres to soil which lessens leaching or uptake by non-targets. | Apply during winter when plants are dormant and not moving large amounts of water from the roots. | Backpack with adjustable spray nozzle, cut stump, carpet roller. | Complete control may require re-treatment.<br><br>Rain within 6 hours reduces effectiveness.<br><br>Aquatic formulations can be used near water. |
| Triclopyr (various Garlon formulations; consisting of salts and ester) | Selective, systemic for woody and broadleaf species. Will remain in plants until they die. Growth regulating. | Little or no impact on grasses. Off site drift up to 100' possible. Could inhibit ectomychorrizal growth. | Apply during winter when plants are dormant and not moving large amounts of water from the roots. | Backpack with adjustable spray nozzle, cut stump, basal bark or carpet roller. | Garlon 4 (ester compound) is toxic to fish and aquatic invertebrates. Amine formulations may be used near or over water. Offsite movement by water possible. |

* Usually the most conservative method(s) of application is listed. Others may be acceptable.

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# Attachment 7.4

**Jason Yencopal**
01/06/2011 05:03 PM

To: "Audie Huber" <Audiehuber@ctuir.com>, "Carolyn Templeton" <Carolyn.Templeton@ferc.gov>, "Carl Stiff" <cbstiff@wildblue.net>, "Colleen Fagan" <Colleen.E.Fagan@state.or.us>, "GRIFFIN Dennis"
cc: Heidi Martin/Baker County@Baker County, Jason Yencopal/Baker County@Baker County
Subject: Stakeholder Update Mason Dam Hydroelectric Project

Stakeholders,

Attached is an update with where we are at and where we are heading. If I may be of any help please let me know.

Sincerely,
Jason

Stakeholder Updates of January 6 2011b.pdf

January 6, 2011

Subject: Mason Dam Hydroelectric Project Update

Dear Stakeholders:

I appreciate your understanding as I have had to set up a temporary office. The County Courthouse had a flood in November in which most of the Courthouse Departments had to be relocated. I am now able to get back to some sort of normalcy.

Since our May 20th meeting, there has been come agency contact changes. Colleen Fagan with Oregon Department of Fish and Wildlife (ODF&W) has accepted a new position. Ken Homolk, ODF&W's hydropower program leader in Salem will be the new contact. The Forest Service has a new Whitman Distric Ranger, Jeff Tomac. I also wanted to remind everyone that Paul DeVito with the Oregon Department of Environmental Quality accepted a new position (midyear 2010) and Steve Kirk is now the main contact.

For the main update I will be summarizing the August 18, 2010 update that focused on the three following issues and add to it:

1. Transmission line route
2. Dissolved oxygen in the Powder River below Mason Dam
3. Fish entrainment and mortality through Mason Dam

Transmission Line Route

The preferred transmission line route is a 0.83 mile long, 12.47 kV over head line with 40 ft tall poles that would follow Black Mountain Road. This route would consist of the following segments:

Segment 1: 150 ft long, across open space at the base of the dam
Required Tree Clearance: None

Segment 2: 500 ft long, through sparse trees to Black Mountain Road
Required Tree Clearance: 40 ft wide by 500 ft long corridor through sparse trees

Segment 3: 1900 ft long, along Black Mountain Road, crossing the road as necessary to minimize tree clearance.
Required Tree Clearance: A few trees

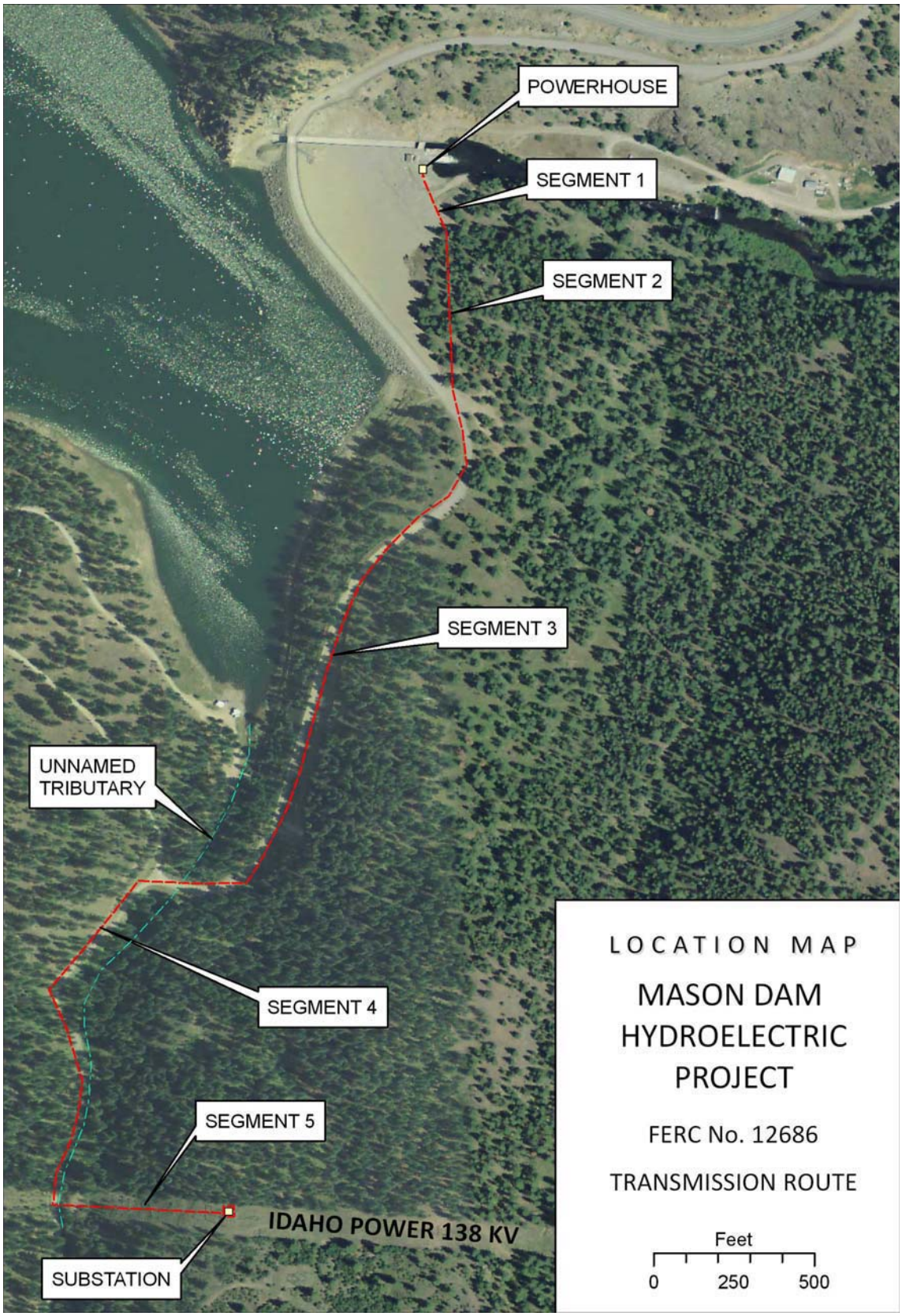
Segment 4: 1300 ft long, on the west side of Black Mountain Road to the Idaho Power Corridor
Required Tree Clearance: A few trees on the northern end of the segment and a 20 ft wide by 900 ft long corridor on the southern end of segment

See Figure 1 for a map.

Dissolved Oxygen

Baker County developed a DO Compliance Plan in October and submitted for stakeholders to comment on.

**Figure 1.**


POWERHOUSE
SEGMENT 1
SEGMENT 2
SEGMENT 3
UNNAMED TRIBUTARY
SEGMENT 4
SEGMENT 5
IDAHO POWER 138 KV
SUBSTATION
LOCATION MAP
MASON DAM HYDROELECTRIC PROJECT
FERC No. 12686
TRANSMISSION ROUTE
Feet
0
250
500

Fish Entrainment and Turbine Mortality

Baker County originally proposed to screen the intake in lieu of conducting an entrainment study. Our understanding after the May 20th 2010 meeting was that the entrainment would not change from the addition of the hydroelectric project but the mortality would. Thus a turbine and valve mortality analysis would be done to satisfy the entrainment requirement that was waived by the agencies. We understand that the agencies have some existing projects that would benefit the resources of upper Powder River basin habitat and we would encourage these projects be submitted to the County to be discussed and incorporated in future plans.

Recent Progress

Baker County developed four plans for stakeholder review and comments. These plans include:

- -Erosion and Sediment Control Plan
- -Revegetation/Noxious Weed Management Plan
- -Bypass Flow Plan
- -DO Compliance Plan

We have received comments back on these plans from the Oregon Department of Environmental Quality and Oregon Department of Fish and Wildlife. We will continue to modify these plans based on the comments received.

Baker County is also working on the License Application to continue to develop this valuable energy resource.

A tentative timeline is to provide updates to the plans mentioned above in the next couple of weeks and at the latest have a license application by March.

We hope to dry out here at the Courthouse and continue to work together with all of you on the Mason Dam Hydroelectric Project.

## Nicholas E Josten

**From:** jyencopal@bakercounty.org
**Sent:** Wednesday, October 20, 2010 3:03 PM
**To:** Audie Huber; Carolyn Templeton; Carl Stiff; Colleen Fagan; GRIFFIN Dennis; Emily Carter; Fred Warner; Gary Miller; Ken Anderson; Kenneth Hogan; GRAINEY Mary S; Mike Gerdes; Micheal Hall; Randy Joseph; KIRK Steve; Quentin Lawson; LUSK Rick M; Robert Ross; Shawn Steinmetz; Susan Rosebrough; Thomas Stahl; Timothy Welch; GRIFFIN Dennis; Joseph Hassell; Carl Merkle; lgecy@ecowest-inc.com; ted@tsorenson.net; gsense@cableone.net
**Cc:** hmartin@bakercounty.org; jyencopal@bakercounty.org
**Subject:** Mason Dam Plan Review
**Attachments:** Baker County Bypass Flow Plan Oct_20_2010_plusattachments_ap.pdf; Baker County DO Compliance Plan Oct_20_2010_plusattachments_ap.pdf; Baker County Erosion and Sedi...t_20_2010_plusattachments_ap.pdf

Dear Stakeholders,

Based on the PLP comments received and with FERC's recommendation, Baker County has developed plans that cover: Erosion and Sediment control, Bypass flow, DO compliance, and Noxious Weed management. Baker County would like to provide the agencies the following plans at this time. Attached are the Erosion and Sediment Control Plan, Bypass Flow Plan, and DO Compliance Plan. Comments on these plans will be due November 22nd, 2010. The Noxious Weed Management Plan is being reviewed by the Baker County Weed Department and will be distributed after their review, with comments from stakeholders due at a later date.

Thank you for your time and consideration. If I may be of any help please let me know.

Sincerely,
Jason

(See attached file: Baker County Bypass Flow Plan Oct_20_2010_plusattachments_ap.pdf)(See attached file: Baker County DO Compliance Plan Oct_20_2010_plusattachments_ap.pdf)(See attached file: Baker County Erosion and Sedi...t_20_2010_plusattachments_ap.pdf)

Oregon
Theodore R. Kulongoski, Governor

Department of Environmental Quality
Eastern Region Bend Office
475 NE Bellevue Drive, Suite 110
Bend, OR 97701-7415
(541) 388-6146
FAX (541) 388-8283

November 23, 2010

Jason Yencopal
Baker County
1995Third Street
Baker City, OR 97814

RE: ODEQ Comments to the DO Compliance Plan (October 2010)
Mason Dam Hydroelectric Project (FERC No. P-12686)

Dear Mr. Yencopal:

The Oregon Department of Environmental Quality is submitting comments on the October 2010 Dissolved Oxygen (DO) Compliance Plan for the Mason Dam proposed hydroelectric project, FERC No. P-12686. These comments have been prepared to assist Baker County in refining the DO compliance plan prior to the License Application.

**General Comments**

The draft DO compliance plan lacks the detail necessary to insure that the applicant will comply with state water quality standards. In general, there is a lack of detail regarding system design and the procedures to implement the tiered approach. The following comments address specific issues.

**Specific Comments**:

I. Introduction: Add the following sentence: "The ODEQ may require modifications to the DO Compliance Plan as it deems appropriate to assess and confirm water quality compliance."

1.0 Purpose and Scope: Please provide reference to the Oregon Administrative Rules that specify the DO criteria applicable to the Powder River. Also include a description of the designated fish use for the stilling basin and downstream of the stilling basin with the applicable DO criteria. Oregon Department of Fish and Wildlife has designated the still basin as "redband trout rearing" and the Powder River immediately downstream of the stilling basin as "redband trout spawning" (personal communication with Colleen Fagan, ODFW)

Provide a summary description of the proposed seasonal operations relative to the seasonal DO criteria.

4.0 Responsibilities: Provide assurance that the approved Quality Assurance Project Plan (QAPP) for collection of the DO data will be followed and any changes in monitoring activities that do not conform to the QAPP will be reported to DEQ.

5.0 Procedures: Provide a more complete description of the tiered approach for DO compliance including; 1) decision process for changing compliance actions, 2) schedule of decision process for taking corrective actions to comply with DO, and 3) consideration of adaptive management to revise tired approach based on DO compliance monitoring data.

5.1: Include a detailed description of the Draft Tube Aeration system with design specifications.

5.1.1 Draft Tube Aeration: the text states: "... that once it is open will allow air to enter the system through the venture effect..." Do you mean venturi effect?

5.1.2 Rock Weirs: Include an analysis of potential impacts to sediment erosion and sediment geomorphology that supports the designated fish use and associated water quality criteria.

5.1.3.1 Bypass Flow: Provide a description of the corrective action procedures and reporting schedules.

5.2 Monitoring: Provide additional information regarding the locations selected for monitoring DO. Since the proposed project is required to meet the DO criteria for trout rearing in the stilling basin, DEQ recommends monitoring DO at the downstream boundary of the stilling basin and at one location downstream of the stilling basin and within the area of proposed rock weirs to monitor DO relative to the DO criteria associated with redband trout spawning.

6.0 Summary of Mitigation Measures: Provide a more complete summary of mitigation measures and adaptive management used to implement the mitigation measures. For instance, the text states: ...adjustments will be made to operation criteria if DO levels fall below the state water DO standard." What is the schedule for reporting the DO levels? What is the decision process and schedule for taking corrective action?

7.0 Attachments: DEQ recommends deleting Section 7.0. Details regarding the weir locations, weir design specifications and Draft Tube Aeration System should be included in Section 5.1.1 Draft Tube Aeration and Section 5.1.2 Rock Weirs.

If you have any questions or need any additional information regarding these comments, please contact me at (541) 633-2023 or by email at kirk.steve@deq.state.or.us.

Sincerely,

Steve Kirk
Eastern Region Hydroelectric Specialist
Oregon Department of Environmental Quality

Oregon
Theodore R. Kulongoski, Governor

**Department of Fish and Wildlife**
Northeast Region
107 20th Street
La Grande, OR 97850
(541) 963-2138

November 22, 2010

Jason Yencopal
Mason Dam Project Manager
1995 Third Street
Baker City, Oregon 97814

Subject: ODFW's Comments on Baker County's draft plans for the proposed Mason Dam Hydroelectric Project (FERC No. 12686).

Dear Mr. Yencopal:

Baker County has requested comments on draft plans associated with its efforts to install hydroelectric power at the existing Bureau of Reclamation's Mason Dam. Enclosed are ODFW's comments on Baker County's DO Compliance Plan, Bypass Flow Plan, Erosion and Sediment Control Plan, and Revegetation/Noxious Weed Management Plan.

**DO Compliance Plan**

3.0 - Baker County defines spawning as "the time that fish are spawning and fry are emerging and rearing". Baker County's definition includes spawning, incubation, emergence, and rearing. All four of these life history stages should be defined separately, particularly since the Oregon Department of Environmental Quality (DEQ) has separate dissolved oxygen (DO) standards for salmonid spawning use and salmonid rearing and migration use.

5.1.1.1 - Baker County indicates that a pipe will be attached to the draft tube with a valve that once it is open will allow air to enter the system through the venture effect and aerate the water. ODFW requests clarification on whether Baker County is referring to the Venturi effect.

5.1.2.2 - Baker County indicates that it will build rock weirs, as needed, across the Powder River in the 0.16 mile stretch downstream of the stilling basin, if agreed upon. Additional information is needed on the potential effects of these weirs on stream flows, fish passage, entrapment and stranding, and erosion. Upstream and downstream passage of all life stages of native migratory fish species, which include redband trout, needs to be provided throughout this stretch of the Powder River.

5.1.2.3 – According to Baker County, rock weirs would only be constructed if post-project monitoring reveals that DO concentrations drop below 95% saturation during spawning times at the DO monitoring station. Baker County, however, has not identified the proposed location of the DO monitoring station. Redband trout rearing occurs in the stilling basin with redband trout spawning likely occurring immediately downstream of the stilling basin. Therefore, ODFW believes DO monitoring for rearing should occur in the stilling basin at the first location where accurate readings can be taken, and monitoring for spawning should occur immediately downstream of the stilling basin.

5.1.2.4 – As proposed, weirs would be constructed one at a time until their number is sufficient to achieve the standard at the monitoring station. Additional information is needed on monitoring that will occur and how the project will be operated during weir construction to ensure water quality standards are met.

5.1.2.5 – ODFW believes that state water quality standard for DO will need to be met at the downstream end of the stilling basin. According to Attachment 7.1, however, three rock weirs would be placed within the 0.16 mile section of the Powder River downstream of the stilling basin. Therefore, the state standard for DO would not be met at the downstream end of the stilling basin. If DO standards cannot be met at the downstream end of the stilling basin with installation of rock weirs, ODFW recommends that other alternatives be investigated that would provide a reasonable assurance of compliance with state water quality standards. Further, how were locations and numbers of weirs determined?

5.1.2.8 – Baker County indicates upstream passage for small fish will be provided through large interstitial passages between boulders. Oregon's fish passage law (ORS 509.580 - 509.645) requires upstream and downstream passage at all artificial obstructions in those Oregon waters in which migratory native fish are currently or have historically been present. Additional information needs to be provided to demonstrate that upstream and downstream passage will be provided throughout the year for all life stages of native migratory fish. This should include a discussion of how interstitial spaces will be maintained. Rock weir designs should be provided to ODFW for review and approval. No construction should occur until ODFW approves rock weir designs.

5.1.2.9 – Construction is proposed for minimum flow periods. Construction will need to occur during ODFW's instream work window, unless a variance is requested and approved by ODFW.

5.2 – Insufficient information is provided to determine if monitoring will be sufficient to determine if the Project is in compliance with DEQ's water quality standards. A water quality monitoring plan should be developed in consultation with ODFW and ODEQ and included in this plan or the license application. The monitoring plan should include DO, TDG, and temperature monitoring.

7.3 – ODFW recommends that the Draft Tube Aeration System article be removed from the plan. Instead, Baker County should summarize it and other relevant literature on draft tube aeration within the DO Compliance Plan.

**Bypass Flow Plan**

This plan should include the minimum flows that this plan is intended to ensure will be maintained during construction and operation of the Project.

2.0 - More information on these references is needed including date and author so that they can be accessed by ODFW.

4.1 - Baker County indicates it will work with BOR and Baker Valley Irrigation District, but it fails to identify what they will be working on.

5.3.1 – Additional operations information is needed in this plan including emergency backup and notification components. ODFW should be notified of any emergencies as soon as possible.

5.4.1 – Additional information is needed on maintenance including procedures and timing.

6.2 – Additional information is needed to ensure identified minimum flows will be maintained below the project, including how and where they will be measured.

6.3 and 6.4 – These sections do not appear relevant to this plan. ODFW recommends they be removed.

**Erosion and Sediment Control Plan**

2.0 – Unclear what reference Baker County has identified. Additional information such as author, agency, and date should be provided.

3.3 – ODFW should also be consulted regarding revegetation of disturbed areas.

3.4 – Insufficient information is provided to determine adequacy of implementation schedule.

5.0 – Insufficient information is provided by Baker County for ODFW to determine what construction activities are planned for the Project, when these construction activities will occur, which BMPs will be implemented for each to control and manage erosion, dust, and soil movement, and how activities will be monitored. ODFW requests that Baker County elaborate on procedures.

5.2 – Who will be contracted to conduct weekly inspections and what information will they be collecting?

6.4 - When is tailrace construction proposed to occur?

6.5 – ODFW should be consulted on appropriate seed mixes to ensure no impacts to wildlife.

7.0 – These attachments should be removed from the plan. Instead, Baker County should summarize relevant sections and measures that will be implemented at this project.

**Revegetation/Noxious Weed Management Plan**

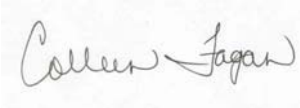
Baker County identifies the purpose of this plan is for the control and prevention of noxious weeds at the Mason Dam Hydroelectric Project. ODFW requests that the boundary for the plan be more clearly identified.

5.0 – Insufficient information is presented for ODFW to determine if implementation of this plan will result in control and prevention of noxious weeds. Proposed methods and monitoring for control and prevention of noxious weeds need to be included in the plan.

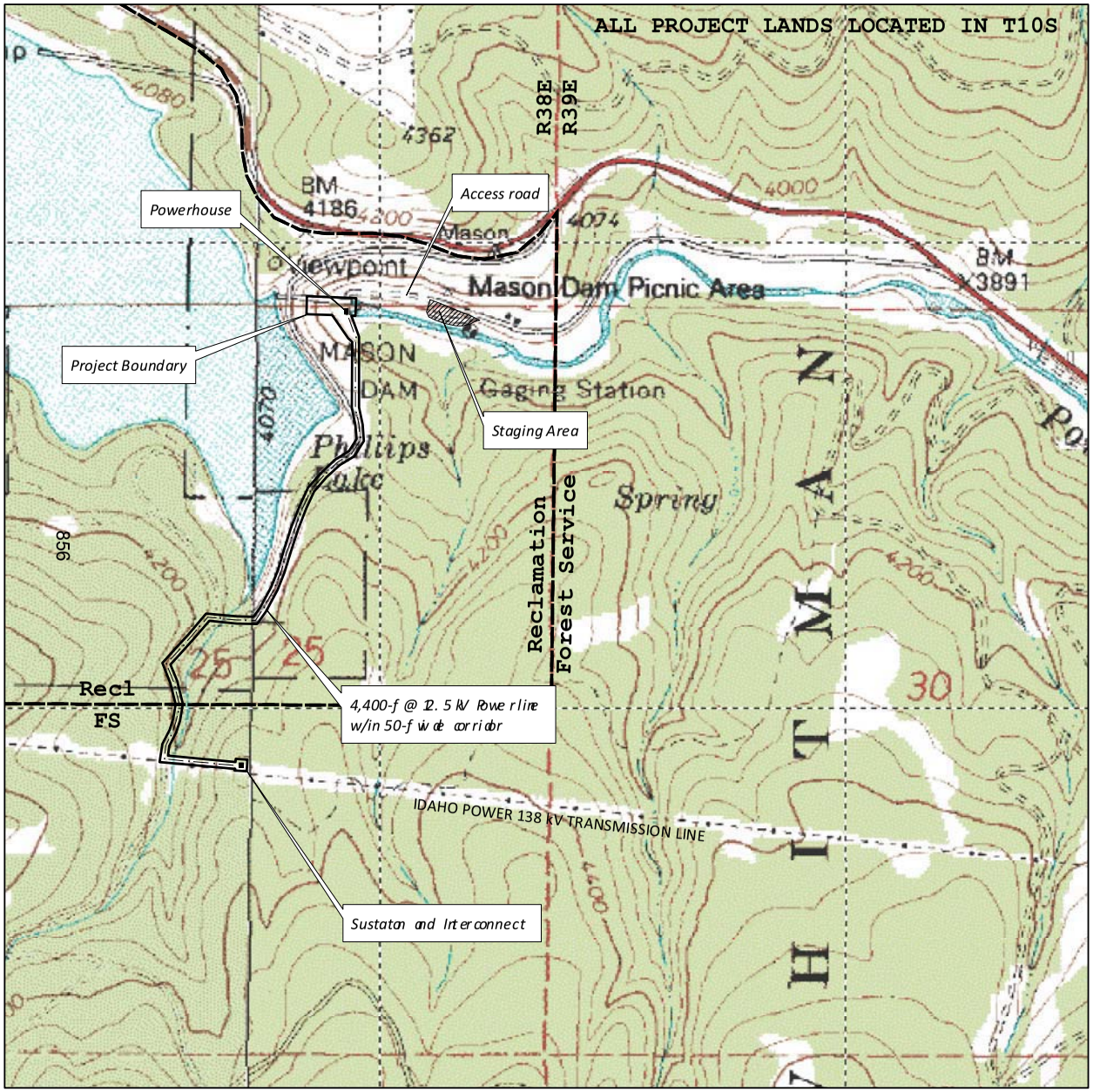
7.0 – ODFW recommends that the attachments be deleted from the plan. Instead, Baker County should clearly describe the efforts it will undertake to prevent the introduction and spread of noxious weeds as well as treatments that will be applied to decrease or eliminate noxious weed infestations. The majority of information included in these attachments is not relevant to this project.

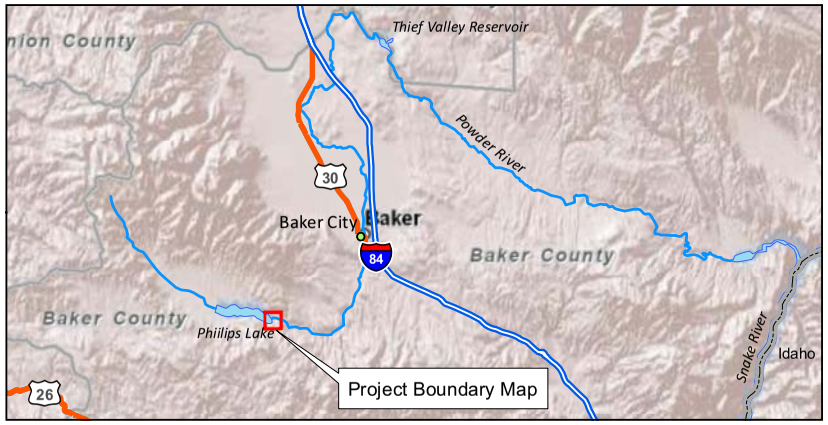
Thank you for the opportunity to review these draft plans. If you have any questions on these comments or need additional information, please contact me at (541) 962-1835 or colleen.e.fagan@state.or.us.

Sincerely,



Colleen Fagan
NE Region Hydropower Coordinator




*NOTES*
*1. ALL PROJECT LANDS LOCATED IN T10S, R39E, WILLIAMETTE MERIDIAN*

*2. ALL PROJECT FACILITIES LOCATED ON FEDERAL LANDS AS SHOWN*

# Attachment 7.5

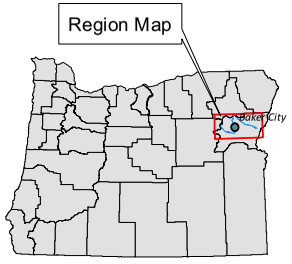



**EXHIBIT G-1**
**PROJECT BOUNDARY MAP**

**Mason Dam**
**Hydroelectric Project**

**FERC No. 12686**

0 0.125 0.25 Miles

UTM Zone 11N NAD 83