

# **APPENDIX D**

## **Herbicide Information and Project Design Feature Crosswalk**

## HERBICIDE INFORMATION SUMMARY AND PDF CROSSWALK

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Deschutes and Ochoco National Forest and Crooked River National Grassland  
PDF Information Incorporated by Beth Peer, Deschutes National Forest, Bend, Oregon  
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The following information is designed to aid in the understanding of herbicides used for invasive plant control. Any attempt to summarize the complex information about herbicides is prone to over-simplification and errors. The information in these tables should be used as an introduction to the herbicides, but should not be the sole source of information used for analysis purposes. It is important to refer to the respective risk assessments prepared by Syracuse Environmental Research Associates (SERA), Inc. and peer-reviewed literature for effects analysis information.

These tables have five columns labeled herbicide characteristics, basic hazard identification, risk characterization, label restrictions and information, and Project Design Features (PDF). Herbicide characteristics are general pieces of information about the herbicide and its use, often taken from the *Herbicide Handbook* (Weed Science Society of America 2002) or the respective risk assessments (SERA, Inc). Qualitative statements (e.g. highly water soluble) are based on information in charts on water solubility and soil mobility found at the end of the document. These categories are not absolute, but have been gleaned from a variety of sources. These charts (water solubility and soil mobility) need to be completed and updated, as they are a work in progress.

To better understand each herbicide, it is important to recognize the difference between the inherent risks from the chemical (i.e. hazard identification) from those risks associated with the intended use, which take into account application and exposure amounts (i.e. risk characterization). The hazard identification and risk characterization information is mostly taken from the respective risk assessments for each herbicide, prepared by SERA, Inc., as well as analysis results from the Region 6 Invasive Plant Program EIS (USFS 2005a). The R6 EIS already has conducted the analysis of effects from the hazard ID and risk characterization information. It need not be repeated. Standards added to the Deschutes and Ochoco Land and Resource Management Plans from the Invasive Plant ROD (USDA Forest Service 2005b) further reduce the potential risks listed in the risk characterization column. Project Design Features (PDF) (Section 2.4 of the DEIS) focus on reducing risks remaining after the application and exposure amounts are taken into consideration (i.e. risk characterization), along with compliance with label directions and new forest plan standards.

We have also included brief summaries of some label restrictions or information. Please note: the label restrictions column in these tables is not a comprehensive listing of all label requirements. The information is largely brief excerpts of *some* requirements from *some* formulations. Labels are also updated and revised periodically, so it is important to obtain and read the full label for complete information. Labels may be downloaded from the following website: [www.cmds.net/manuf/default.asp](http://www.cmds.net/manuf/default.asp).

This version of the table contains, for each herbicide, the priority target species for the Deschutes and Ochoco NFs and Crooked River NG. The herbicide became a first priority for the identified invasive plants based on efficacy of the herbicide on that species, as per recommendations from

the local State and County weed specialists. Environmental and seasonal variables, as well as infestations that contain several species, may require using a different herbicide in a given treatment area.

Herbicide grazing restrictions are summarized in the table on pages 35-36.

LOC used in the table=Level of Concern. The concentration in media or some other estimate of exposure above which there may be effects.

RfD = Reference dose. The RfD is a numerical estimate of a daily exposure to the human population, including sensitive subgroups such as children, that is not likely to cause harmful effects during a lifetime. RfDs are generally used for health effects that are thought to have a threshold or minimum dose for producing effects.

*The use of product names is for illustrative purposes only and is not intended as a recommendation for use or an endorsement of these products by the USDA Forest Service.*

Active Ingredient: **Chlorsulfuron** Trade Name(s): **Telar, Glean, Corsair**

Mode of Action: Acetolactate synthesis inhibitor Chemical family: Sulfonylurea

DES-OCH-CRNG target species: 1<sup>st</sup> priority: perennial pepperweed, whitetop, kochia  
 2<sup>nd</sup> priority: houndstongue, Dalmatian toadflax, butter ‘n eggs, Scotch thistle, Med. Sage, tansy ragwort, milk thistle

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Chlorsulfuron</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
SELECTIVE: controls broadleaf weeds some and grasses			Supplemental label for mix with clopyralid for control of yellow starthistle in Oregon	
Very high water solubility at pH 7; decreases to medium solubility at pH 5	Leaching, runoff	Rainfall post treatment: Off target movement and non-target effects.	Do not contaminate water	(17) precipitation
Moderate affinity for organic material, but adsorption to clay is low	High mobility in soils		Treatment of powdery, dry soil and light sandy soils when there is little likelihood of rainfall soon after treating may result in off target movement and possible damage to susceptible crops when soil particles are moved by wind or water.	(47) chlorsulfuron use on soils
In H2O, degraded by sunlight	Half-live in water is 1 month	Very low application rates; therefore, little potential to enter ground water		(16) drift (54, 55, 58) aquatic buffers
Degradation by soil microbes is slow	Half-life in field avg 40 days (range 4-6 wks); shorter at lower pH			(64, 65) botanical buffers

<b>Chlorsulfuron</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Low toxicity to soil microorganisms	Exposure far below level of concern		
In field, degraded primarily by hydrolysis, but rates are slow	Persistent		Residues may injure susceptible plants up to 4yrs after application in high pH soils	(64, 65) botanical buffers (69) sulfonylurea use near TES plants
Absorbed thru roots and foliage; active in soil as a pre-emergent			Do not apply thru irrigation system	
Resistant Biotypes may develop			Application should be based on IPM principles	
Maintains native perennial grasses				
Potent herbicide. Requires small amounts of AI to be effective.	May damage non-target plants and trees; Wind erosion concern	Adverse effects on some nontarget plants are plausible		no aerial application (12) application rate (64, 65) botanical buffers (69) sulfonylurea buffers
	Can cause body weight loss in mammals	Worker and public exposures below level of concern (LOC) except workers using ground broadcast applications, which is slightly above LOC at high application rate (0.14 lb/acre)	Do not apply in a way that will contact workers or other persons, either directly or through drift.	(12) application rate (15, 16) drift (11) personal protective gear
	Mild eye and skin irritant	Mild irritation to skin and eyes from exposures to high levels from mishandling	Only protected handlers may be in the area during application.	(12) application rates (11) personal protective gear
	May alter insulin production, cholesterol levels, and triglycerides at high doses	Exposures far below levels of concern		(12) application rates
does not bioaccumulate or bioconcentrate	No evidence of reproductive risk, malformations, cancer, or mutagenicity			(12) application rates

<b>Chlorsulfuron</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Can cause mild body weight loss in mammals and birds	Exposures well below levels of concern		
		No plausible risk to insectivorous species		
	Very low toxicity to fish, no effects to egg & fry	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers
	Very low toxicity to aquatic invertebrates	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers
	No data on effects to amphibians, fish used as a surrogate	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers (81) spotted frog buffers
	Aquatic plants are susceptible to chlorsulfuron, algae is less susceptible	Peak exposures could damage aquatic plants at typical and high application rates; algae may be damaged at high rates		(12) application rates (54, 55) aquatic buffers
	Low toxicity to bees or beetles	Exposure below level of concern		

Active Ingredient: **Clopyralid**

Trade Name(s): **Transline; Reclaim; Stinger**

Mode of Action: Plant growth regulator

Chemical family: Not known

DES-OCH-CRNG target species: 1<sup>st</sup> choice: true knapweeds (not Russian), thistles, tansy ragwort,  
 2<sup>nd</sup> choice: Russian knapweed

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Clopyralid</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Extremely SELECTIVE for broadleaves. Post emergent herbicide		Selectivity reduces threat to non-target plants	Avoid non-target contact with spray in treated areas	(64, 65) botanical buffers
Targets: knapweeds and families Asteraceae, Fabaceae, Solanaceae. Canada thistle; Does NOT affect conifers, grasses are tolerant			Supplemental label for control on tree plantations and forest sites	
High water solubility	0.01 % of that applied may reach stream after first significant rainfall	Contamination threat to water resources and non-target species	Do not contaminate water. Do not apply directly to water or to areas where surface water is present. Do not contaminate irrigation ditches.	(54, 55) aquatic buffers (27, 28) water intake buffer (17) precipitation
Photo degradation and hydrolysis do not occur	8-40 day ½ life in water			
Weakly adsorbed to soil	Very high mobility in soil		Users are advised not to apply where soils have a rapid to very rapid permeability throughout the profile (such as loamy sand to sand) and the water table is shallow.	(54, 55) aquatic buffers (43) low aquatic risk herb. (45) high porosity soils

<b>Clopyralid</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Degraded by soil microbes	Half-life in field avg 40 days (range 12-70 days)	Relatively rapid breakdown reduces potential for run-off or leaching		
	Low toxicity to soil organisms	Exposures far below level of concern		(12,13) application rate
Non-microbial degradation does not occur			Do not use hay or straw from treated areas for composting or mulching on susceptible plants	
Contaminated with hexachlorobenzene (HCB) (less than that in picloram)	HCB is a persistent carcinogen and it bioaccumulates	Exposure levels far below level of concern. Amount of HCB in Clopyralid does not present any substantial cancer risk.		(12) application rates
Clopyralid does not bioaccumulate or bioconcentrate	No evidence of reproductive risk, malformations, cancer, or mutagenicity	Exposures far below levels of concern		(12) application rates
	High acute doses cause depression of central nervous system in mammals	Exposures far below levels of concern		(12) application rates
	Chronic doses cause weight loss, thicken stomach lining in mammals	Exposures far below levels of concern		(12) application rates
	Low toxicity to birds	Exposures far below levels of concern		(12) application rates
		Chronic risk to insect-eating birds or mammals unknown		(12) application rates
	Slight skin and eye irritation		Avoid contact with skin and eyes or clothing. Avoid breathing spray mist. Applicators and handlers must wear long-sleeved shirt and long pants, waterproof gloves, shoes plus socks	(12) application rate (11) personal protective gear (26) public notification

<b>Clopyralid</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Potent herbicide. Requires small amounts of AI to be effective.	May damage susceptible non-target terrestrial plants	Adverse effects on some non-target plant species due to drift are likely under certain conditions		(15, 16) drift (64, 65) botanical buffers (13) application method
	Low toxicity to birds and mammals	Exposures below levels of concern	No grazing restriction	(12) application rates
	low toxicity to fish or aquatic invertebrates	Exposures very far below levels of concern		(12) application rates (54, 55) aquatic buffers
	No chronic tests to fish, or eggs and fry studies available; use surrogate	Exposures very far below levels of concern		(12) application rates (54, 55) aquatic buffers
	No data on effects to amphibians, fish used as a surrogate	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers (81) spotted frogs
	Aquatic plants and algae are not susceptible	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers
	Low toxicity to bees and earthworms	Exposures far below level of concern		(12) application rates



<b>Glyphosate</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	May cause transient population decrease or increase in some bacteria & fungi			
Does not bioaccumulate or bioconcentrate	No evidence of dose-related reproductive risk, malformations, cancer, or mutagenicity	All exposures for workers and public far below level of concern		(12) application rate (11) personal protective gear (26) notification
	May damage mucosal tissue, weight loss in mammals; mild liver toxicity	All exposures for workers and public far below level of concern	Applicators and other handlers must wear long-sleeved shirt and long pants, shoes plus socks, and protective eyewear.	(12) application rates (11) personal protective gear
	Mild to moderate irritant to skin and eyes.		Do not get in eyes or on clothing; Avoid breathing vapor or spray mist;	(12) application rates (15, 16) drift (11) personal protective gear
	Can cause diarrhea, weight loss in mammals; weight loss in birds at very high doses; some mortality to pregnant rabbits observed	Mortality to some large vegetation-eating mammals plausible at highest application rates only; some risk to insect-eating birds & mammals at high rate		(12) application rates
		Chronic risk to insect-eating birds at typical rate unknown; at highest rate, chronic risk to insect-eating birds and mammals unknown		(12) application rates
Surfactants (tallow amine or POEA) in non-aquatic use formulations very toxic to aquatic organisms	Low toxicity to fish; surfactant in some formulations much more toxic than glyphosate	Even aquatic formulation exceeds level of concern for <b>endangered fish</b> , with max risk assumptions; surfactant formulations may cause mortality at high application rate only		ROD standard (12) application method (43) aquatic labels/low aquatic risk (12, 44) surfactant buffer and application rate

<b>Glyphosate</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Low toxicity to aquatic invertebrates	Exposures below level of concern		(12) application rate (54, 55) aquatic buffers
	No malformations in amphibians; toxicity to amphibians is comparable to that of fish	at typical rate, all exposures below level of concern		(12) application rates, NPE application rate (54, 55) aquatic buffers (81) spotted frog
	Surfactants may be highly toxic to aquatic organisms		Do not apply (surfactant formulations) directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment.	(44) surfactant buffers (12) surfactant application rates (52) equipment rinsing (54, 55) aquatic buffers
	Aquatic plants and algae are susceptible to glyphosate; but it does not control submerged plants	Exposures below levels of concern; some algae growth stimulated at low concentrations	No restriction on the use of treated water for irrigation, recreation, or domestic purposes. If emerged weeds cover entire water body, treatment of aquatic weeds may result in oxygen depletion.	(12) application rates (28) water intake buffer (54, 55). aquatic buffer
	Low or no toxicity to bees, beetles, spider mites, wasps, isopods, earthworms, or snails.	Highest application rate may pose risk to some individual bees, but not likely to populations		(13) application rates (54, 55) aquatic buffers

Active Ingredient: **Imazapic**

Trade Name(s): **Plateau**

Mode of Action: acetolactate synthesis inhibitor

Chemical family: Imidazolinone

DES-OCH-CRNG target species: 2<sup>nd</sup> choice: field bindweed

3<sup>rd</sup> choice: leafy spurge, Dalmatian toadflax, butter ‘n eggs, medusa head

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Imazapic</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Selective against some broadleaves & some grasses				(64, 65) botanical buffers
Uptake by roots & leaves; active in soil as pre-emergent	May damage non-target plants and trees	Drift or runoff may cause some damage to susceptible species	Do not treat inside of irrigation ditches; conduct small test areas to determine risk to desirable trees and plants	(15, 16) drift (64, 65) botanical buffers (62) botanical buffers/adaptive management
Very high water solubility	Leaching, runoff		Do not contaminate water	(28) water intake buffer (43) low risk formulations (54, 55) aquatic buffers
Adsorbs to OM in soil	Moderately mobile in soils, leachable in coarse soils			
Degraded by soil microbes	Half-life avg. 120d		Treatment of areas that were previously treated with chlorsufl, metsulfuron methyl, sulfometuron or imazapyr may cause compound injury or death to desirable plants	(64, 65) botanical buffers (62) botanical buffers/adaptive management
No info on toxicity to soil microbes				

<b>Imazapic</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
In H2O, degraded by sunlight				
	Not irritating to skin, minimal irritation to eye	Mild eye irritation from mishandling; no exposure scenario exceeded RfD for workers or public except spill		(11) personal protective gear
Does not bioaccumulate or bioconcentrate	No adverse effects to mammal reproduction or development, not carcinogenic or mutagenic			
	Muscle, liver, & blood damage in dogs at high chronic doses	Exposures far below levels of concern		(12) application rates
	Low toxicity to birds	Exposures far below levels of concern		(12) application rates
		No plausible risk to insectivorous species		(12) application rates
	Low toxicity to fish, no effects to egg & fry	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers
	No data on effects to amphibians, fish used as a surrogate	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers (81) spotted frogs
	Aquatic plants sensitive, algae is not	Potential risk to aquatic plants at highest application rate only, no risk to algae		(12) application rates (54, 55) aquatic buffers
	Low toxicity to bees	Exposure far below level of concern		(12) application rates

Active Ingredient: **Imazapyr** Trade Name(s): **Arsenal, Chopper, Stalker,**

Aquatic Formulation: **Habitat**

Mode of Action: acetolactate synthesis inhibitor Chemical family: Imidazolinone

DES-OCH-CRNG target species: 2<sup>nd</sup> choice: reed canarygrass, ribbongrass

3<sup>rd</sup> choice: field bindweed, perennial pepperweed

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Imazapyr</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Non-selective				
Uptake by roots & leaves; active in soil as pre-emergent	May damage non-target plants; may be exuded into soil from roots of treated plants	Drift or runoff may cause some damage to susceptible species	Do not apply to irrigation ditches; prevent drift to desirable plants	(15, 16) drift (64, 65) botanical buffer
Very high water solubility			Do not contaminate water	(54, 55) aquatic buffer
Weakly bound to soil, but OM and lower pH increase adsorption to moderate levels	Moderately mobile in soils			
Photodegrades in H <sub>2</sub> O	Half-life in water 1-2 d		May be used in intermittent drainages, flood plains, and bogs when no water is present	(54, 55) aquatic buffer
Degrades by soil microbes	Half-life in soil 25-142 d; weed control for 3 mo-2yrs			
	Slight effect on soil microbes at high doses	Peak concentrations in soil well below level of concern		(12) application rates

<b>Imazapyr</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Mildly irritating to eyes and skin	Mild eye irritation from mishandling; no exposure scenario exceeded RfD for workers or public except spill		(11) personal protective equipment
Does not bioaccumulate or bioconcentrate	No adverse effects to mammal reproduction or development, not carcinogenic or mutagenic			
	No effects to birds or mammals even at high doses	Exposures all below level of concern		(12) application rates
		No plausible risk to insectivorous species		(12) application rates
	Low toxicity to North American fish	Exposures very far below levels of concern		(12) application rates
	No data on effects to amphibians, fish used as a surrogate	Exposures far below levels of concern		(12) application rates (54, 55) aquatic buffers (81) spotted frog
	Some aquatic plant species sensitive to imazapyr	Potential risk to aquatic plants at typical application rate, no risk to algae		(12) application rates (54, 55) aquatic buffers
	Low or no toxicity to bees	Exposure well below level of concern		(12) application rates

Active Ingredient: **Metsulfuron methyl** Trade Name(s): **Escort, Ally**  
 Mode of Action acetolactate synthesis inhibitor Chemical Family: Sulfonylurea  
 DES-OCH-CRNG target species: 1<sup>st</sup> choice: houndstongue, St. Johnswort, lesser burdock, Med. Sage  
 2<sup>nd</sup> choice: whitetop, kochia, pepperweed, Russian thistle, musk thistle

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<b>Metsulfuron methyl</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Selective for some broad-leaf and woody species; can damage conifers				(64, 65) botanical buffers
Resistant biotypes may develop			Manage herbicide resistance, use IPM	
Potent herbicide; uptake by roots & leaves	May damage non-target plants and trees; highly potent herbicide at low rates	Drift, runoff or wind erosion, may cause damage to susceptible species	This herbicide is injurious to plants at extremely low concentrations. Non-target plants may be adversely affected from drift and run-off. Do not use on irrigation ditches.	No aerial application (15, 16) drift (29) water intake buffer (64, 65) botanical buffer (54, 55) aquatic buffer
High water solubility	Runoff, leaching potential		Do not contaminate water; do not apply or rinse equipment near desirable plants;	(52) equipment rinsing (64, 65) botanical buffers (54, 55) aquatic buffers

<b>Metsulfuron methyl</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Low adsorption to clay, OM increases adsorption; active in soil as pre-emergent	Very high mobility in soils		Treatment of powdery, dry soil or light sandy soil when there is little likelihood of rainfall soon after treating may result in off target movement and possible damage to susceptible crops when soil particles are moved by wind or water.	(15) wind (17) precipitation
No photo degradation				
Slow microbial degradation at high pH, fast at low pH	Typical half-life 30 d (range 1-6 wks)			
	Short-term toxicity to soil microbes			(43) aquatic label & low risk herb
Degrades by hydrolysis			May be used in intermittent drainages, flood plains, marshes, and bogs when no water is present	(54, 55) aquatic buffers (12) application rates
	May alter insulin production, cholesterol levels, and triglycerides at high doses	Exposures well below levels of concern even at highest application rates		(12) application rates (11) personal protective gear
	Irritates skin and eyes	Mild eye irritation from mishandling; all exposures below levels of concern for workers and public	Applicator and other handlers must wear long-sleeved shirt, long pants, shoes plus socks	(11) personal protective gear
Does not bioaccumulate or bioconcentrate	No adverse effects to mammal reproduction or development, not carcinogenic or mutagenic			
	Can cause body weight loss in mammals & birds	Exposures well below levels of concern even at highest application rates		(12) application rates
		No plausible risk to insectivorous species		(12) application rates

<b>Metsulfuron methyl</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Low toxicity to fish, no effects to egg & fry	Exposures very far below levels of concern		(12) application rates (54, 55) aquatic buffers
	No data on effects to amphibians, fish used as a surrogate	Exposures very far below levels of concern		(12) application rates (54, 55) aquatic buffers (81) spotted frogs
	Can damage aquatic plants in acute exposures	Potential risk to aquatic plants at typical application rate, no risk to algae		(54, 55) aquatic buffers (12) application rates
	Low or no toxicity to bees	Exposure well below level of concern		(12) application rates (54, 55) aquatic buffers

Active Ingredient: **Picloram**

Trade Name(s): **Tordon 22K; Pathway**

Mode of Action: Plant growth regulator

Chemical family: Pyridicarboxylic acid or picolinic acid

DES-OCH-CRNG target species: 1<sup>st</sup> choice: Russian knapweed, field bindweed, leafy spurge, Dalmatian toadflax, butter ‘n eggs, sulphur cinquefoil

2<sup>nd</sup> choice: lesser burdock, true knapweeds, Canada thistle, Scotch broom, St. Johnswort

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<b>Picloram</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Selective: rate and season dependant; pre-emergent and soil active		Off-site drift of picloram may cause damage to susceptible plant species	Minimize drift and runoff	(15, 17) drift (46) soils (picloram and sulfo met) one app per year
Target: composite, legume, buckwheat, and parsley families. Less affected families: mustard, lily, figwort.				(64, 65) botanical buffers
High water solubility	Run-off, leaching potential;		Under some conditions, picloram may also have a high potential for runoff into surface water... Do not apply directly to water, to areas where surface water is present. Do no allow run-off or spray to contaminate wells, irrigation ditches or any body of water used for irrigation or domestic purposes.	(28) water intake buffer (54, 55) aquatic buffers (48) soils (picloram and sulfo met) (46) one app per year

<b>Picloram</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Photodegradation	Half-life in H2O is 2.6 days			
Weakly adsorbed to soils	Very high mobility in soils; leaching potential greatest in sandy soils with low OM	1-6% of application mobilized and reached drainage channels (monitoring results)	Picloram is known to leach through soil into ground water under certain conditions as a result of agricultural use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination.	(12) application rates (46) soils (picloram and sulfo met) (48) one app per year
Degraded slowly in soil by microbes	Half-life avg. 90 days (range 20-300 d)		NTE 2 qts/ac/growing season as a broadcast application	(46) soils (picloram and sulfo met) (48) one app per year
	Can inhibit microbial activity	Microbial activity inhibition likely at rates used by FS		(46) soils (picloram and sulfo met) (48) one app per year
Contaminated with hexachlorobenzene HCB (more than clopyralid)	HCB is a persistent carcinogen and it bioaccumulates	Exposure levels below level of concern. Picloram does not present any substantial cancer risk.		(13) application rates
Does not bioaccumulate or bioconcentrate	No adverse effects to mammal reproduction or development, not carcinogenic or mutagenic			
	Weight loss and increased liver weight in mammals following long term exposure to high concentrations	No exposures for workers or public exceeded levels of concern except spill		(12) application rates (11) personal protective gear

<b>Picloram</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Moderate eye irritant, can cause skin sensitization	Eye irritation and skin sensitization can occur with mishandling	Applicator and other handlers must wear long-sleeved shirt, long pants, shoes plus socks	(12) application rates (11) personal protective gear
	Low toxicity to mammals	Exposure to insect-eating mammals exceed acute levels of concern only at highest application rates		(12) application rates
	Almost nontoxic to birds	Exposures below levels of concern		(12) application rates
		Chronic risk to insect-eating birds or mammals unknown at typical and highest rates		(12) application rates
	Toxic to fish	Exposures exceed level of concern for listed fish at typical and highest application rate		(12) application rates (54, 55) aquatic buffers
	No data on effects to amphibians, fish used as a surrogate	Potential adverse effects to amphibians at typical and highest application rates		(12) application rates (54, 55) aquatic buffers (81) spotted frog
	Relatively nontoxic to bees	Exposures below level of concern even at highest application rates		(12) application rates

Active Ingredient: **Sethoxydim**

Trade Name(s): **POAST**

Mode of Action: Inhibits acetyl co-enzyme (ACE) Chemical family: Cyclohexanedione or cyclohexenone

DES-OCH-CRNG target species: 3<sup>rd</sup> choice: quackgrass, reed canarygrass, ribbongrass

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Sethoxydim</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Selective for annual and perennial grasses			Low likelihood of impacting non-target plants from drift	(64, 65). botanical buffers (15, 16) drift
Soil activity prevents germination of grasses				
Absorbed rapidly by foliage and roots. Systemic				
Broadleaf and sedges are tolerant			Some herbicide resistance can develop	
Very high water solubility	Leaching, run-off potential		Do not contaminate water.	(54, 55) aquatic buffers
Medium mobility in soil				
Photodegrades	Phytolysis in <4 hours in soil; <1 hr in water	Low soil persistence		
Degraded by soil microbes	5-25 day ½ life (avg is 5 days)	Rapidly degraded		
	Causes skin and eye irritation	Skin or eye irritation from mishandling.	Applicators and other handlers must wear coveralls over short-sleeved shirt and short pants; chemical resistant gloves and footwear, plus socks; protective eyewear; etc.	(11) personal protective gear
Does not bioaccumulate or bioconcentrate	Not mutagenic or carcinogenic			(12) application rates

<b>Sethoxydim</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Can cause liver and blood toxicity in chronic doses	All chronic exposures well below level of concern for workers and public		(12) application rates
	Decreased reproduction and maternal toxicity in high doses	All acute exposures below level of concern except for drinking water contaminated by accidental spill		(12) application rates
	Reproductive and neurological effects to small mammals at high doses	Exposures below levels of concern for mammals		(12) application rates
	Low toxicity to birds but reduced hatching for chronic exposures	Exposures below levels of concern except chronic dose for grass-eating bird at highest application rate		(12) application rates
		Chronic risk to insect-eating birds or mammals unknown at typical and highest rates		
	Highly toxic to fish due to petroleum inert	Exposure exceeds level of concern for federally listed fish at typical rate, and max exposure assumptions	This product is toxic to aquatic organisms. Do not apply directly to water or to areas where surface water is present.	(12) application rates (17) precipitation (54, 55) aquatic buffers
	No data on effects to amphibians, fish used as a surrogate	Plausible risk to amphibians		(12) application rates (55, 55) aquatic buffers salamander and mollusk
	Nontoxic to bees	Exposure below level of concern		(12) application rates

Active Ingredient: **Sulfometuron methyl** Trade Name(s): **Oust XP; DPX 5648**

Mode of Action: acetolactate synthesis inhibitor Chemical family: Sulfonylurea

DES-OCH-CRNG target species: 1<sup>st</sup> choice: medusahead  
 2<sup>nd</sup> choice: medusahead & quackgrass (when combined with chlorsulfuron)

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Sulfometuron methyl</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Non-selective Preemergent and post emergent.			If a surfactant is used, contact with tree foliage may injure or kill trees.	(12) application rates (12) NPE application rate (64, 65) botanical buffers
Target: annual and perennial broadleaf weeds, some grasses and some woody tree species			Do not apply more than 8 oz/ac/yr	(12) application rates
Potent herbicide; uptake by roots & leaves	May damage non-target plants and trees; highly potent herbicide at low rates	Drift, runoff or wind erosion, may cause damage to susceptible species	Potential for drift is an issue. Use weather and droplet size criteria	Standard 16 in R6 2005 ROD (no aerial application)
Only medium solubility in water; difficult to create high concentrations	May leach or runoff into water	Low application rates and microbe degradation pose little risk for water contamination	Do not treat dry or frozen soils, unless rainfall is anticipated	(15) wind (16) drift (17) precipitation (64, 65) botanical buffers

<b>Sulfometuron methyl</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
High mobility in soil			Treatment of powdery, dry soil and light sandy soils when there is little likelihood of rainfall soon after treating may result in off target movement and possible damage to susceptible crops when soil particles are moved by wind or water.	(12) application rates (48) soils (picloram and sulfo met) (46) one app per year
Degraded by microbes, light and hydrolysis	30 day ½ life in silt loam soils			
	Some growth inhibition to soil microbes in lab, but not demonstrated while in soil	Percolation could inhibit growth of microbes if lab results are relevant in the field		(48) soils (picloram and sulfo met) (46) one app per year
Does not bioaccumulate or bioconcentrate	Not mutagenic, carcinogenic			(12) application rates
	Reproductive and immune system effects to mammals at higher doses; very high doses cause neurotoxic effects	Exposures far below levels of concern		(12) application rates
	Irritating to skin and eyes at high doses	Mild irritation to skin and eyes from exposures to high levels from mishandling	Only protected handlers may be in the area during treatment	(12) application rates (11) personal protective gear (26) public notification
	Causes hemolytic anemia and weight loss in mammals	Exposures far below levels of concern		(12) application rates
	Slightly toxic to fish. Highly toxic to embryo hatch	Exposures very far below level of concern	Do not apply directly to water or where surface water is present	(12) application rates (54, 55) aquatic buffers
	Can cause malformations in amphibians	Exposures very far below level of concern		(12) application rates (54, 55) aquatic buffers
	Low toxicity to bee	Exposures well below level of concern		(12) application rates

Active Ingredient: **Triclopyr** Trade Name(s): **Garlon 4; Remedy; PathFinder;**  
 Aquatic formulation: **Garlon 3A**  
 Mode of Action: Plant growth regulator Chemical family: Pyridinecarboxylic acid  
 DES-OCH-CRNG target species: 1<sup>st</sup> choice: Scotch broom, Himalayan blackberry  
 2<sup>nd</sup> choice sulphur cinquefoil

Project Design Features 8 and 9 are applicable to all herbicide characteristics and risks: Herbicides would be used in accordance with label restrictions, except where more restrictive measures are required as described; Herbicide application will only treat the minimum area necessary to meet site objectives; Herbicide use would comply with standards in the Pacific Northwest Regional Invasive Plant Program – Preventing and Managing Invasive Plants ROD (2005), including standards on herbicide selection, restrictions on broadcast use of some herbicides, tank mixing, licensed applicators, and use of adjuvants, surfactants, and other additives.

<b>Triclopyr</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization* (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Selective for broadleaf and woody plants				
Target: Woody and herbaceous plants, especially root- or stem-sprouting species				Restricted to selective application methods by forest plan standard (R6 2005 ROD)
Absorbed thru roots, foliage and green bark.	Non-target plant effects possible; some bryophytes and lichens sensitive to triclopyr		Do not apply through any type of irrigation system.	
Two forms: salt (acid) (Garlon 3A) and ester (Garlon 4)	Ester form more toxic and volatile		Apply at cool temps with no wind. Combustible.	(15) wind
Salt formulation is highly soluble in water	Runoff, leaching		Do not contaminate water when cleaning equipment.	(52) equipment washing (28) water intake buffers (54, 55) aquatic buffers
Ester formulation has medium water solubility.	Less mobile			

<b>Triclopyr</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization* (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
Low adsorption to soils, varies with clay and OM content	Very high mobility in soils		The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.	(43) low risk herbicides R6 standard – application method
Degraded by photolysis in soil and water	½ life 2-6 hours in water			
Degraded by microbes in soil	½ life avg 30days in soils; range 10-46 days			
	Inhibits growth of soil fungi and bacteria	Transient inhibition in the growth of some bacteria or fungi might be expected		(13) application method
	Can cause severe eye damage		Applicators and other handlers must wear long-sleeved shirt and long pants; shoes plus socks; protective eyewear; chemical resistant gloves.	(11) personal protective gear
Does not bioaccumulate or bioconcentrate	Ester has much higher lipophilic tendency ( $K_{ow} = 10,233$ ) than salt ( $K_{ow} = 0.35$ )			
	Adverse effects to mammal reproduction or development only at doses that are maternally toxic		Except for lactating dairy animals, there are no grazing restrictions	(12) application rates
	Evidence for carcinogenicity is marginal (not convincing, but not entirely negative)			(12) application rates

<b>Triclopyr</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization* (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Effects to kidney are basis of risk to for acute and chronic exposures humans	At high application rates, chronic exposures to workers exceed level of concern; acute exposures do not exceed level of concern for workers. At high application rates, some acute and chronic exposures exceed level of concern for public. No exposures exceed level of concern at typical application rate.	Do not apply this product in a way that will contact workers or other persons, either directly or through drift.	(12) application rates drift (11) personal protective gear
	For wildlife, acute lethality only at very high doses, but effects to kidney and liver at lower doses	Acute exposures below level of concern at typical application rate, but exceed level of concern for grass and insect eating mammals		R6 standard – application method (12) application rates
	Primary effect from chronic doses is to the kidney	Using protective assumptions, chronic exposures exceed level of concern for grass-eating mammals. Risk from chronic exposure to contaminated insects unknown.		R6 standard – application method (12) application rates (11) personal protective equipment
	Formulations contain inerts that are neurotoxic (Garlon 3A = ethanol) (Garlon 4 = kerosene)	Exposures very far below level of concern; less toxic than triclopyr		(12) application rates (11) personal protective gear
	Ester more toxic to birds than salt form	Several scenarios exceed level of concern at typical and highest application rates for acute and chronic exposures		R6 standard – application method (12) application rates

<b>Triclopyr</b>				
<b>Herbicide Characteristics</b>	<b>Basic Hazard Identification</b>	<b>Risk Characterization* (SERA Risk Assess.)</b>	<b>Label Restrictions &amp; Information</b>	<b>Project Design Features</b>
	Salt/acid formulation low toxicity to fish; has aquatic use label	Exposures exceed level of concern for <u>federally listed</u> fish at typical rate, but not other fish even at highest application rate	(Garlon 3A) Permissible to treat flood plains, marshes, swamps, bogs etc. Permissible to treat non-irrigation ditch banks. When making application to banks or shorelines of moving water sites, minimize overspray to open water.	R6 standard –application method (12) application rates (54, 55) aquatic buffers (49) garlon4 buffer
	Ester formulation toxic to fish and aquatic invertebrates	Exposures exceed level of concern for <u>federally listed</u> fish at typical rate, but not other fish even at highest application rate	(Garlon 4) This pesticide is toxic to fish. Do not apply directly to water, to areas where surface water is present... Do not contaminate water when disposing of equipment washwaters.	(49) garlon4 buffer (12) application rates (52) equip. rinsing (54, 55) aquatic buffers
	Metabolite TCP much more toxic to fish than the salt form, about the same toxicity as ester	At typical application rate, no TCP exposures exceed level of concern. At highest application rate, chronic exposure exceeds level of concern		(12) application rates (54, 55) aquatic buffers
	Ester form much more toxic to aquatic plants and algae than salt form	Only <u>salt</u> form exceeds level of concern for aquatic plants; algae not at risk from either form		(13) application method (12) application rates (54, 55) aquatic buffers
	Ester formulation much more toxic to amphibians than salt formulation	At typical application rate, risk to amphibians from either form is low. At highest rate, exposure to run-off of either form could adversely affect responsiveness of tadpoles.		(13) application rates (54, 55) aquatic buffers (81) spotted frog
	Practically non-toxic to bees	Exposure exceeds level of concern only for highest application rates		(12) application rates (54, 55) aquatic buffers

\*Results of these risk characterizations are from scenarios where triclopyr is broadcast sprayed over a large area. A standard in each Forest Plan that was added by the Region Six Invasive Plant Program ROD (USDA Forest Service 2005) prohibits this type of application. Triclopyr is restricted to selective application methods only. Therefore, in practice, it is not plausible to create the exposures causing concern during use of triclopyr for invasive plant control in Region Six.

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**Water Solubility Chart**

<b>Solubility Class</b>	<b>Water Solubility (ppm=mg/L)</b>	<b>Examples</b>
Very High	3,000 – 1,000,000	chlorsulfuron, glyphosate, imazapic, imazapyr, picloram, sethoxydim,
High	300-3,000	clopyralid, metsulfuron methyl, 2,4-D
Medium	30-300	sulfometuron, triclopyr
Low	2-30	
Slight	0.5-2	
Immobile	<0.5	DDT (0.0012)

Adapted From Jay Davis, US Fish and Wildlife Service

**Mobility in Soil (Koc)**

<b>Mobility Class</b>	<b>Koc in Soil</b>	<b>Examples</b>
Very High	0-35	clopyralid, picloram, metsulfuron methyl, triclopyr
High	36-100	sulfomet., chlrosufluron,
Medium	100-1,000	imazapic, imazapyr, sethoxydim, atrazine
Low	1,000-3,000	glyphosate
Slight	3,000-10,000	Trifluralin
Immobile	>10,000	chlorpyrifos, DDT

Adapted from Jay Davis, US Fish and Wildlife Service.

Mobility class categories by S. Bautista and are general breakdowns, not a definitive classification.

**Grazing Restriction Table (Sources are Trade Name Labels for Specific Herbicides)**

<b>Livestock Use Restrictions by Herbicide*</b>			
<b>Herbicide</b>	<b>Brand Name</b>	<b>Restriction</b>	<b>Remarks</b>
Chlorsulfuron	Telar, Glean, Corsair, Landmark (oust + telar)	None	
Clopyralid	Transline, Redeem (Clopyralid + Triclopyr)	Redeem: Do not graze treated areas until poisonous plants are dry and no longer palatable to livestock. Withdraw livestock from grazing treated grass at least 3 days prior to slaughter.	See label for cropland grazing restrictions post treatment in pastures. Redeem: Herbicide application may increase palatability of certain poisonous plants.
Glyphosate	RoundUp, Rodeo, etc.	None	RoundUp: ingestion of this product or large amounts of freshly sprayed vegetation may cause temporary gastrointestinal irritation.
Imazapic	Plateau	Plateau: None. Plateau DG: Do not use on areas to be grazed.	
Imazapyr	Arsenal, Chopper, Stalker	Arsenal: none. Chopper: none. Stalker: none.	
Metsulfuron methyl	(Escort)/Sulfon ylurea	None.	

This table is not meant to be an inclusive or up-to-date list; please refer to product labels for the most accurate and inclusive information.

**Grazing Restriction Table (Sources are Trade Name Labels for Specific Herbicides)**

<b>Livestock Use Restrictions by Herbicide*(con.)</b>			
<b>Herbicide</b>	<b>Brand Name</b>	<b>Restriction</b>	<b>Remarks</b>
Picloram	Tordon	Tordon 101/22K/K: allow one week of grazing/feeding in non-exposure area before moving livestock onto broadleaf cropland. Tordon 22K: herbicide application may increase palatability of certain poisonous plants. Do not graze treated areas until poisonous plants are dry and no longer palatable to livestock. Meat grazing animals up to two weeks after treatment should be removed from treated areas 3 days prior to slaughter.	
Sethoxydim	Poast	None	
Sulfometuron methyl	(Oust)/Sulfonyl urea, & Landmark (oust + telar)	None	
Triclopyr	(Garlon, Pathfinder, Remedy)/Synthetic auxin, Redeem (Clopyralid + Triclopyr)	Forestry Garlon 4, Garlon 4, & Remedy: 2 quarts per acre or less, no restriction. If less than 25% of the grazing area is treated, there is no restriction. Slaughter: remove animals from treated area 3 days prior to slaughter. Garlon 3A: none. Remove animals from treated area 3 days prior to slaughter. Pathfinder II & Remedy RTU: 2.5 gallons per acre or less, no restriction. If less than 25% of the grazing area is treated, there is no restriction. Slaughter: remove animals from treated area 3 days prior to slaughter. Redeem: Do not graze treated areas until poisonous plants are dry and no longer palatable to livestock. Withdraw livestock from grazing treated grass at least 3 days prior to slaughter.	

\* This table is not meant to be an inclusive or up-to-date list; please refer to product labels for the most accurate and inclusive information

## Summaries of Herbicide Characteristics that Influence Their Potential Effects on the Soil Resource

### Picloram

Picloram has a typical half-life of 90 days. Field studies (Brooks et al., 1995; Nolte and Fulbright, 1997) have not noted substantial adverse effects from this herbicide on soil productivity and health under normal application rates (SERA, 2003-picloram). Although the application of Picloram at typical rates may change microbial metabolism on site in the short term, detectable effects to soil productivity that might be expected if soil microbial activity were substantially damaged have not been identified in the literature.

- Since picloram is toxic to microorganisms at low levels, toxic effects can last for some time after application.
- Long-term effects to soil microorganisms are unknown, but persistence in soils could affect soil microorganisms by decreasing nitrification (SERA, 2003-picloram).
- The persistence of picloram increases with soil concentration, thus increasing the likelihood that it becomes toxic to soil microorganisms in the short-term.
- Picloram applied at a typical application rate is likely to change microbial metabolism, though detectable effects to soil productivity are not expected.
- Substantial effects to soil productivity from the use of picloram over the last 40 years have not been noted (SERA, 2003d).
- Picloram has been studied on a number of soil invertebrates.
- Metabolites may increase toxicity for some soil microorganisms.
- Picloram has a typical half-life of 90 days.
- Picloram soil degradation rates vary in soil, depending on application rate and soil depth.
- Picloram is water soluble, poorly bound to soils that are low in clays or organics, has a high leaching potential, and is most toxic in acidic soil.
- Picloram should not be used on coarse-textured soils with a shallow water table, where groundwater contamination is most likely to occur (KSU, 2001; SERA, 2003d).
- Picloram percolation is highest in loam and sandy soils (SERA, 2003d; Herbicide Handbook, 2002). However, modeling results indicate picloram runoff (not percolation) is highest in clay soils.

### Sulfometuron methyl

This herbicide is the primary choice for control of medusahead, which is located most extensively on the finer textured soils of the CRNG, with some populations also located on the Lookout Mountain, Paulina and Sisters Ranger Districts.

- The typical half-life for sulfometuron methyl varies from 10 to 100 days, depending on soil texture and organic matter content in the mineral soil profile.
- Microbial inhibition in the short term is likely to occur at typical application rates and could be substantial in some cases, as indicated by the negative impacts that a formulation of sulfometuron methyl had a on the abundance of microorganisms and decreased soil nitrogen content on a Christmas tree farm (Arthur and Wang, 1999).
- Residues of these herbicides in the soil may alter the composition of soil microorganisms over an extended period of time on coarser textured and lower organic matter content soils with higher pH levels. Mobility of this herbicide following application also increases under these same characteristics.
- There are no studies on the effects of sulfometuron methyl on soil invertebrates.

- Sulfometuron methyl degradation occurs most rapidly at lower pH soils where rates are dominated by hydrolysis.
- Sulfometuron methyl mobility is generally greater at higher soil pH and lower organic matter content.
- Modeling results indicate sulfometuron methyl runoff is highest in clay and loam soils with peaks after the first rainfall. Sulfometuron methyl percolation is highest in sandy soils. Monitoring results generally support modeling results (SERA, 2003e; Herbicide Handbook, 2002).
- Sulfometuron methyl applied to vegetation at typical application rates would probably be accompanied by secondary changes to vegetation that affect the soil microbial community more certainly than direct toxic action of sulfometuron methyl on soil microorganisms (SERA, 2003e).

### **Metsulfuron methyl**

Metsulfuron methyl and chlorsulfuron are also members of the Sulfonylurea chemical type, although they exhibit less toxic effects on soil microorganisms than sulfometuron methyl.

The half-life of metsulfuron methyl is approximately 30 days and the herbicide has a short-term toxicity to soil microorganisms identified on the label. This herbicide is the primary choice for treating houndstongue. Studies on the effects of metsulfuron methyl on soil biota are limited to *Pseudomonas* species, though there are a few studies of insects that live in soil. The lowest observed effect concentration is 5 mg/kg, based on the *Pseudomonas* study. At recommended use rates, no effects are expected for insects.

- Effects to soil microorganisms appear to be transient (SERA, 2003c).
- Metsulfuron methyl degrades in soil, with a variable half-life up to 120 days.
- Half-life is decreased by the presence of organic matter though microbial degradation of metsulfuron methyl is slow.
- Non-microbial hydrolysis is slow at high pH but rapid at lower pH.
- Adsorption to soil particles, which affects the runoff potential of metsulfuron methyl, increased with increased pH and organic matter.
- Metsulfuron methyl has low adsorption to clay.
- Modeling results indicate that off-site movement due to runoff could be significant in clay soils.
- Metsulfuron methyl percolates in sandy soils (SERA, 2003c; Herbicide Handbook, 2002).

### **Chlorsulfuron**

The half-life of chlorsulfuron is approximately 40 days but has a very low toxicity to soil microbes identified on the label. This herbicide is the primary choice for perennial pepperweed and white top. Studies on the effects of chlorsulfuron on soil biota include lab and field studies on nematodes, fungi, populations of actinomycetes, bacteria, and soil microorganisms.

- No effects of chlorsulfuron were found for soil biota at recommended application rates, with the exception of transient decreases in soil nitrification (SERA, 2003a).
- The 'no observable effects concentration' for soil is 10 mg/kg, based on cellulose and protein degradation.
- Chlorsulfuron degrades in aerobic soil.
- Non-microbial hydrolysis plays an important role in chlorsulfuron breakdown, and hydrolysis rates increase as pH increases.
- Adsorption to soil particles, which affects the runoff potential of chlorsulfuron, is strongly related to the amount of organic material in the soil.
- Chlorsulfuron adsorption to clay is low.
- Chlorsulfuron is moderately mobile at high pH.

- Leaching is reduced when pH is less than six.
- Modeling results indicate that runoff would be negligible in relatively arid environments as well as sandy or loam soils.
- In clay soils, off-site loss could be substantial (up to about 55 percent of the applied amount) in regions with annual rainfall rates of 15 to 250 inches (SERA, 2003a; Herbicide Handbook, 2002).

### **Triclopyr**

Triclopyr has been identified as capable of inhibiting soil fungi and bacteria, but research suggests that it is not persistent at levels high enough following recommended application rates to negatively affect soil productivity. Relationships between observed maximal residues and threshold concentrations for toxicity to soil biota suggest that sustained deleterious effects on soil organisms or functional processes are unlikely to result from normal operational use of either triclopyr or glyphosate herbicides (Thompson, et al. 2000).

The five commercial formulations of triclopyr contain one of two forms of triclopyr, BEE (butoxyethyl ester) or TEA (triethylamine). Triclopyr BEE is much more toxic to aquatic organisms than triclopyr TEA. A breakdown product, TCP (3,5,6-trichloro-2-pyridinol), is more toxic than either form of triclopyr. Site-specific cumulative effects analysis buffer determinations need to consider the form of triclopyr used and the proximity of any aquatic triclopyr applications, as well as toxicity to aquatic organisms (SERA, 2003f).

- R6 ROD Standard #16 restricts triclopyr to selective applications, which would reduce direct effects to ectomycorrhizal fungi.
- Triclopyr has not been studied on soil invertebrates. Triclopyr does have direct toxicity to ectomycorrhizal fungi.
- Soil fungi growth was inhibited at concentrations 2 to 5 times higher than concentrations expected from USDA Forest Service application rates.
- Triclopyr has an average half-life in soil of 46 days, while TCP has an average half-life in soil of 70 days. Warmer temperatures decrease the time to degrade triclopyr.
- Soil adsorption is increased as organic material increases and decreased as pH increases. Triclopyr is weakly adsorbed to soil, though adsorption varies with organic matter and clay content. Both light and microbes degrade triclopyr (SERA, 2003f; Herbicide Handbook, 2002).

### **Glyphosate**

Glyphosate is a non-selective, non-residual, systemic, post emergence herbicide used for the control of a great variety of annual, biennial, and perennial grasses, sedges, broad-leaved weeds, and woody shrubs. It is very effective on deep-rooted perennial species.

- Glyphosate dissipates rapidly from the water column as a result of adsorption and possibly biodegradation. The half-life in water is a few days. Sediment is the primary sink for glyphosate. After spraying, glyphosate levels in sediment rise and then decline to low levels in a few months.
- Modeling results indicate glyphosate runoff is highest in loam soils with peaks after the first rainfall (SERA, 2003b; Herbicide Handbook, 2002).
- Studies suggest glyphosate does not adversely affect soil organisms.
- Glyphosate is readily metabolized by soil microorganisms and some species can use glyphosate as a sole source of carbon (SERA, 2003b).
- Numerous soil bacteria, fungi, invertebrates, and other microorganisms have been studied for effects of glyphosate application.
- It is degraded by microbial action in both soil and water.

- Sylvia and Jarstfer (1997) found that after 3 years, pine trees in plots with grassy invasive plants had 75 percent fewer mycorrhizal root tips than plots that had been treated 3 times per year with a mixture of glyphosate and metsulfuron methyl to remove invasive plants.
- Glyphosate degrades in soil, with an estimated half-life of 30 days.
- Glyphosate is highly soluble, but adsorbs rapidly and binds tightly to soil.
- Glyphosate has low leaching potential because it binds so tightly to soil.

### **Clopyralid**

Clopyralid is a selective herbicide used for the control of broadleaf weeds, especially thistles and clovers. It is the only effective herbicide for the control of creeping thistle, *Cirsium arvense*, a noxious, perennial weed. Clopyralid is in the pyridine family of herbicides, which also includes picloram, triclopyr, and several less common herbicides. It is particularly active on members of the Asteraceae and Fabaceae families but does not affect grasses.

Clopyralid is a synthetic plant growth hormone and has some structural similarities to naturally occurring hormones called auxins. Clopyralid is similar in structure and mode of action to the herbicide picloram. It disrupts plant growth by binding to molecules that are normally used as receptors for the natural growth hormones. Because clopyralid is more persistent in plant tissue than auxins, the binding causes abnormal growth leading to plant death in a few days or weeks, depending on the species.

- Studies of clopyralid effects on soil invertebrates have been conducted, including field studies on the effects to microorganisms. Clopyralid is in the same chemical family as triclopyr and is identified as having a low toxicity to soil microorganisms.
- Soil concentrations from USDA Forest Service applications are expected to be 1,000 less than concentrations that would cause toxic effects. Therefore, no effects to soil invertebrates or microorganisms are expected from use of clopyralid (SERA, 1999a).
- Clopyralid is degraded by soil microbes, with an estimated half-life of 14 to 29 days, meaning that one-half of the amount applied remains in the soils after 14 to 29 days, one-fourth of the applied amount remains after 28 to 58 days, one-eighth after 42 to 87 days, and so on.
- Increased soil moisture decreases degradation time.
- Clopyralid is weakly adsorbed and has moderate leaching potential.
- Modeling results indicate clopyralid runoff is highest in clay soils with peaks after rainfall events.
- Clopyralid percolation is highest in sandy loam soils (SERA, 1999a; Herbicide Handbook, 2002).

### **Imazapic**

Imazapic is a relatively new herbicide, and there are no studies on the effects of imazapic on either soil invertebrates or soil microorganisms. This herbicide is a member of the Imidazolinones chemical family and appears to have low toxicity to soil microbes.

- If imazapic was extremely toxic to soil microorganisms, it is reasonable to assume that secondary signs of injury to microbial populations would have been reported (SERA, 2001a).
- Imazapic degrades in soil, with a half-life of about 113 days.
- Half-life is decreased by the presence of microflora.
- Imazapic is primarily degraded by microbes and it does not degrade appreciably under anaerobic conditions.
- Imazapic is weakly adsorbed in high soil pH, but adsorption increases with lower pH (acidic soils) and increasing clay and organic matter content.
- Field studies indicate that imazapic remains in the top 12 to 18 inches of soil and do not indicate any potential for imazapic to move with surface water.

- Modeling results indicate imazapic runoff is highest in clay and loam soils with peaks after the first rainfall. Imazapic percolation is highest in sandy soils (SERA, 2001a; Herbicide Handbook, 2002).

### **Imazapyr**

Imazapyr is a non-selective herbicide used for the control of a broad range of weeds including terrestrial annual and perennial grasses and broadleaved herbs, woody species, and riparian and emergent aquatic species. It controls plant growth by preventing the synthesis of branched-chain amino acids. Because imazapyr is a weak acid herbicide, environmental pH will determine its chemical structure, which in turn determines its environmental persistence and mobility. Below pH 5 the adsorption capacity of imazapyr increases and limits its movement in soil. Above pH 5, greater concentrations of imazapyr become negatively charged, fail to bind tightly with soils, and remain available (for plant uptake and/or microbial breakdown). In soils imazapyr is degraded primarily by microbial metabolism.

There are no studies on the effects of imazapyr on soil invertebrates, and incomplete information on the effects on soil microorganisms.

- Imazapyr can persist in soil for over a year. Persistence studies suggest that imazapyr residues damage plants at concentrations that are not detectable by laboratory analysis.
- Imazapyr moves readily in soil. It has contaminated surface and ground water following aerial and ground forestry applications.
- Small amounts of imazapyr (as little as 1/50 of a typical application rate) can damage crop plants.
- Imazapyr exposure also has the potential to seriously impact rare plant species. The U.S. Fish and Wildlife Service has identified 100 counties in 24 states east of the Mississippi River where endangered species may be jeopardized by use of imazapyr.
- Over a half-dozen weedy plant species have developed resistance to imazapyr.
- This herbicide is a member of the Imidazolinones chemical family and appears to have low toxicity to soil microbes.
- One study indicates cellulose decomposition, a function of soil microorganisms, can be decreased by soil concentrations higher than concentrations expected from USDA Forest Service applications.
- There is no basis for asserting adverse effects to soil microorganisms (SERA, 1999b).
- Imazapyr degrades in soil, with a half-life of 25 to 180 days.
- Degradation rates are highly dependent on microbial action.
- Anaerobic conditions slow degradation.
- Adsorption increases with time as soil dries and is reversible.
- Field studies indicate that imazapic remains in the top 20 inches of soil and do not indicate any potential for imazapic to move with surface water.
- In forest field studies, imazapyr did not run off and there was no evidence of lateral movement.
- Modeling results indicate imazapyr runoff is highest in clay and loam soils with peaks after the first rainfall.
- Imazapyr percolation is highest in sandy soils (SERA, 1999b; Herbicide Handbook, 2002).

### **Sethoxydim**

Selective post-emergence herbicide used to control annual and perennial grass weeds among broad-leaved plants.

- Sethoxydim is a member of the cylohexanone chemical family and has been researched to be very low in toxicity to soil microbes (Roslycky, 1986).
- Sethoxydim has not been studied on soil invertebrates.

- Assays of soil microorganisms noted transient shifts in species composition at soil concentration levels far exceeding concentrations expected from USDA Forest Service application.
- No adverse effects to soil organisms are expected (SERA, 2001c).
- Sethoxydim is degraded by soil microbes, with an estimated half-life of 1 to 60 days. Adsorption of sethoxydim varies with organic material content of the soil.
- Modeling results indicate sethoxydim runoff is highest in clay and loam soils with peaks after the first rainfall (SERA, 2001c; Herbicide Handbook, 2002).