

APPENDIX 13

BRIEF DESCRIPTION OF HERBICIDES CONSIDERED FOR USE ON JACKSON DEMONSTRATION STATE FOREST

Background

At this time CDF anticipates the possible use of the following herbicides for invasive weed control and reforestation purposes: Clopyralid, Glyphosate, Imazapyr, Sulfometuron methyl, and Triclopyr. New products, formulations and application techniques may provide better control and improved environmental toxicology profiles. The listed products may prove to be ineffective on a specific species. For these reasons, in the future, there may be additions or deletions to the list of herbicides considered for use on JDSF.

Information on herbicide use and cautions are available on the herbicides specific label and Material Safety Data Sheet. The California Environmental Protection Agency, Department of Pesticide Regulation, maintains a web site with information (www.cdpr.ca.gov/docs/label/m4.htm) as does the National Pesticide Information Center (<http://npic.orst.edu/>) and the Extension Toxicology Network (<http://extoxnet.orst.edu/>). The UDSA Forest Service has compiled information on herbicides used in wildlands (<http://infoventures.com/e-hlth/pesticide/pest-fac.html>) as well as technical risk assessments at <http://www.fs.fed.us/foresthealth/pesticide/risk.shtml>.

These herbicide summaries are not intended to be exhaustive reviews of the herbicides that may be used on JDSF. They will provide an introduction to the respective products and a summary of some attributes.

Assessments of herbicides hazards to humans and other species utilize research on dose and effect. These results are standardized then compiled into descriptive ratings. These specific descriptive terms will be used in herbicide descriptions that follow. CDF does not anticipate any aerial applications. Where the product descriptions below include the fact the product is labeled for aerial application, this fact is provided for information only.

Compounds

Clopyralid is commonly used as Transline®, primarily for control of star thistle in wildland settings in California. Application is typically by hand, but it is registered for aerial application as well. It is licensed in California for control of thistles on forest sites and for selective control of weeds and woody plants on rangeland, non-cropland areas,

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rights-of-way, and other sites. Clopyralid is absorbed by the leaves and indirectly via the roots of the weed and moves rapidly through the plant. It affects plant cell respiration and growth. It has little effect on grasses, members of the mustard family (*Brassicaceae*), and several other groups of broad-leaved plants. Clopyralid controls many annual and perennial broadleaf weeds, particularly of the *Asteraceae*, *Fabaceae*, *Solanaceae*, *Polygonaceae*, and *Violaceae*. Because Clopyralid is highly soluble in water, there is a potential for surface waters to be contaminated if Clopyralid is applied directly to bodies of water or wetlands. The potential for leaching or runoff is functionally reduced by the relatively rapid degradation of Clopyralid in soil. Clopyralid does not bind tightly to soil particles. Soil microorganisms break down Clopyralid. The half-life in soil can range from 15 to 287 days (SERA. 1999a). In 2002, registration for specialty lawn products containing Clopyralid were canceled in California due to concerns that its presence in compost could damage non-target plants (Brank, 2003).

Clopyralid is practically nontoxic to fish and aquatic invertebrate animals. It has a low potential to build up (bioaccumulate) in fish tissues. Clopyralid is slightly toxic to birds and practically nontoxic to mammals. Clopyralid is not toxic to bees. The risk assessment prepared by SERA (1999) states that "The potential for substantial effects on non-target species appears to be remote" and noted "...consistent with this assessment of toxicity to non-target species, one long-term (8-year) field study has been conducted that indicates no substantial or significant effects on species diversity (Rice et al. 1997)."

Clopyralid caused eye irritation, placing it in Toxicity Category II, (Table 1, Eye Irritation). Clopyralid produced slight skin irritation in Toxicity Category IV, (Table 1, Skin Irritation). Four hour inhalation tests placed the compound in Toxicity Category III, (Table 1, Inhalation). Acute oral dose test results placed Clopyralid in Category IV, (Table 1, Oral). Based on the results of animal studies, clopyralid is not classified as a carcinogen, teratogen, mutagen, or reproductive inhibitor. Birth defects were observed at doses that were severely toxic to the mother.

The EPA approved label for Transline®, the Clopyralid product carries the signal word CAUTION and the precautionary statements include: "Hazard to Humans and Domestic Animals. Causes Eye Injury. Harmful if Inhaled or Absorbed Through Skin."

Glyphosate is widely used as the proprietary product Roundup®. There are now other glyphosate formulations registered for use in California including labels for aquatic use and formulations with different adjutants. Glyphosate is used to control grasses, herbaceous plants including deep-rooted perennial weeds, brush, and some broadleaf trees and shrubs. Timing of application is critical for effectiveness on some broadleaf woody plants and conifers. It is applied to foliage and rapidly moves through the plant. It acts by preventing the plant from producing an essential amino acid. It also may be used as a cut stump, injection, or frill application directed to the cambium. The potential for leaching into groundwater is low as it is strongly adsorbed by soil particles. The half-life in water is 7 days. The half-life of glyphosate in soil can range from 2 to 174 days.

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The surfactant in Roundup® has a soil half-life of less than one week. It does not evaporate easily. Roundup® has no known effect on soil microorganisms (SERA. 2003a).

Table 1. Categories of Herbicide Toxicity.

Categories of Toxicity: Human Hazards						
		Route of Administration			Hazard	
Category	Signal Word	Oral (mg/kg)	Dermal (mg/kg)	Inhalation (mg/L)	Eye Irritation	Skin Irritation
I	DANGER Poison	0-50	0-200	0-0.2	corrosive: corneal opacity not reversible within 7 days	corrosive
II	WARNING	>50-500	>200-2000	>0.2-20	corneal opacity reversible within 7 days; irritation persisting for 7 days	severe irritation at 72 hours
III	CAUTION	>500-5000	>2000-20,000	>2.0-20	no corneal opacity; irritation reversible within 7 days	moderate irritation at 72 hours
IV	none	>5000	>20,000	>20	no irritation	mild or slight irritation at 72 hours
Categories of Toxicity: Ecotoxicological Categories						
Toxicity Category	Mammalian (Acute Oral)*mg/kg		Avian (Acute Oral)*mg/kg	Avian (Dietary) ppm	Aquatic Organisms‡ ppm	
very highly toxic	<10		<10	<50	<0.1	
highly toxic	10-50		10-50	50-500	0.1-1	
moderately toxic	51-500		51-500	501-1000	>1-10	
slightly toxic	501-2000		501-2000	1000-5000	>10-100	
practically non-toxic	>2000		>2000	>5000	>100	
* Reflects dose given to test animals and is based on body weight of the test animal.[40 CFR 162.10 (h) (1), July 3, 1975] - Concentration in the diet. Unrelated to body weight of the test animal. Measure of environmental exposure. ‡Concentration in water. Unrelated to body weight of test animal. Measure of environmental exposure.						

Glyphosate's aquatic toxicity varies with the formulation. Accord® and Rodeo® are rated respectively as slightly toxic to practically nontoxic for aquatic organisms (Table 1, Ecotoxicological Categories). Roundup® Pro is slightly toxic to aquatic invertebrates and moderately toxic to fish. Neither formulation bioaccumulates in fish. SERA (2003) summarized studies that showed with regard to pH, the toxicity of glyphosate decreases and the toxicity of the surfactant increases with increasing pH. It also noted two studies indicate that POEA (a component of surfactant additive of Roundup) is substantially more toxic than glyphosate and that POEA surfactant is the primary toxic agent of concern for fish (SERA. 1997). The aquatic Rodeo® formulation does not contain surfactant. Glyphosate is practically non-toxic to birds, mammals and bees.

Glyphosate was a slight eye irritant in Category III (Table 1 Eye Irritation). Glyphosate dermal rating is essentially non-irritating, Category IV (Table 1). Inhalation test results placed it in practically non-toxic, Category IV. For acute oral ingestion the results were practically non-toxic, Category IV. The EPA has concluded that glyphosate should be classified as a compound with evidence of non-carcinogenicity for humans. Based on

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the results of animal studies, glyphosate does not cause genetic damage or birth defects, and has little or no effect on fertility, reproduction, or development of offspring.

Glyphosate's widespread use worldwide has resulted in more data available on deliberate or accidental human exposures than the other compounds discussed here. Most short-term incidents in humans have involved skin or eye irritation or nausea and dizziness in workers after exposure during mixing, loading, or application. Swallowing the Roundup® formulation caused mouth and throat irritation, stomach pain, vomiting, low blood pressure and in some cases, death. These effects have occurred when the concentrate was accidentally or intentionally swallowed in amounts averaging about half a cup and not as a result of the proper use of Roundup® (SERA, 2003a). The EPA approved labels for Roundup® Pro, Accord® and Rodeo® all carry the signal word CAUTION. The precautionary statements vary slightly by product. They include: "Hazard to Humans and Domestic Animals. Causes Eye Irritation. Harmful if Inhaled".

Imazapyr is sold under the trade names of Chopper or Arsenal in California. This product can be applied by air, but primarily is applied by low-volume hand-held spray equipment as a foliar, basal stem treatment, cut stump treatment, tree injection, or frill. It controls plant growth by preventing the synthesis of amino acids. Action is slower than some other herbicides and can take several months or longer. Imazapyr can remain active in the soil for 6 months to 2 years. It is strongly adsorbed in soil and usually found only in the top few inches. Imazapyr is degraded in soils primarily by microbial action. It is soluble in water. It has a low potential for leaching into ground water. Like other herbicides the potential for movement into streams via stormflow can be reduced by utilizing a no-application streamside management zone. The half-life of imazapyr in water is about 4 days (SERA, 1999b).

Imazapyr is practically nontoxic to fish and invertebrates (Table 1, Ecotoxicological Categories). EPA has approved an aquatic label in some states. Imazapyr is not expected to accumulate or build up in aquatic animals (I.V. 1995). Imazapyr is considered practically non-toxic to mammals and birds (Category IV, Table 1). Its toxicity to bees is believed to be similar to mammals. Risk to non-target plants may be slightly higher than other herbicides because of its soil activity.

Imazapyr has been tested to be not irritating to eyes (Category IV, Table 1). Skin tests showed that it was moderately irritating, Category III. Acute oral ingestion test results placed it in Category IV. Lab studies with Imazapyr in rats indicated no evidence of teratology and tests were negative for mutagenicity.

The EPA approved labels for Chopper® or Arsenal® both carry the signal word CAUTION. The precautionary statements vary slightly by product. Chopper's label includes the most precautions including: "Hazard to Humans and Domestic Animals. Harmful if inhaled or absorbed through skin. Avoid breathing spray mist. Avoid contact with skin, eyes or clothing. Prolonged or frequent repeated skin contact may cause allergic reactions in some individuals".

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Sulfometuron Methyl is the active ingredient in Oust® SP, a broad-spectrum sulfonylurea herbicide. In contrast to the other herbicides proposed for use it is effective as a preemergent and postemergent herbicide. It controls annual, biennial, and perennial grasses and broad-leaf weeds. The herbicide is used for general weed control on industrial non-crop sites and for selective weed control in forest site preparation and in the release. Preemergence treatments control or suppress weeds through root uptake, and post-emergence treatments control via root and foliar uptake. Sulfometuron methyl acts to suppress amino acid synthesis in plants by inhibiting the plant enzyme acetolactate synthase, particularly in growing tips, roots, and shoots. Best results are seen when applications are made prior to or during early weed development, before root systems are established. Sulfometuron methyl should be applied during seasons when rainfall occurs because moisture is needed to move the herbicide to the root system. The photolysis half-life in water at pH 7 and 25° C is 12 days (Kollman and Segawa 1995 in DPR undated) Sulfometuron methyl is practically insoluble in water. Its potential to move in the soil declines with low soil pH and in soils with a high organic content. Sulfometuron methyl has a half-life of approximately one month in soil. Soil microorganisms and chemical hydrolysis break it down (SERA,1998).

Sulfometuron methyl is slightly toxic to fish and is practically nontoxic to aquatic invertebrates (Table 1, Ecotoxicological Categories). The potential for it to build up in fish tissues (bioaccumulate) is low. The acute oral toxicity tests for birds resulted in a rating of practically nontoxic (Table 1). Oust® was a moderate eye irritant (Toxicity Category III, Table 1, Eye Irritation). Acute dermal toxicity is moderate (Toxicity Category III, Table 1, but not described as a skin irritant). For inhalation the compound tested as slightly toxic, a Toxicity Category III (Table 1, Inhalation). For Acute oral toxicity Sulfometuron methyl fell into Toxicity Category IV, (Table 1, Oral). Sulfometuron methyl is not classified as a carcinogen, mutagen or teratogen. Reproductive effects have been observed in rats but only at maternally toxic dose levels.

The EPA approved label for Oust XP carries the signal word CAUTION. The precautionary statements include: "Hazards to Humans and Domestic Animals. Causes (moderate) eye injury (irritation). Avoid contact with eyes or clothing."

Triclopyr is known commercially in forestry applications primarily in two forms; the triethylamine salt (Garlon® 3A) and the butoxyethyl ester (Garlon® 4). There are almost 40 other triclopyr-containing products that are labeled for use in California, many of which are marketed for turf, but some also list forestry uses as well. It is used to control woody plants and broadleaf weeds on rights-of-way, non-crop areas, forests, wildlife openings, and other areas. Triclopyr is applied by ground or aerial foliage spray, basal bark and stem treatment, cut surface treatment, and tree injection. Triclopyr acts by disturbing plant growth. Triclopyr's solubility in water is moderate to low. Sunlight rapidly breaks down triclopyr in water. The half-life in water is less than 24 hours. The potential for leaching depends on the soil type, acidity and rainfall conditions. Triclopyr should not be a leaching problem under normal conditions since it binds to clay and organic matter in soil. The ester formulation has lower water solubility and higher affinity for soils.

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Microorganisms degrade triclopyr rapidly; the average half-life in soil is 46 days. Triclopyr is slightly toxic to practically non-toxic to soil microorganisms.

Triclopyr varies in toxicity depending on the formulation. The ester form of triclopyr, found in Garlon® 4, is considerably more toxic to salmonids than Garlon® 3A. For Garlon® 4 the test results rate it highly toxic for aquatic organisms (Table 1, Ecotoxicological Categories). Under normal conditions in water, Garlon® 4 rapidly breaks down to a less toxic form. Garlon® 3A is slightly toxic to aquatic invertebrates and practically non-toxic to fish (Table 1). Triclopyr does not accumulate in fish. Garlon 3A and Garlon 4 have been specifically tested for malformations in the frog embryo teratogenesis assay and no statistically significant effects were noted. Amphibian toxicity appears to be similar to that of fish (Berrell et al. 1994). Triclopyr is slightly toxic to birds (Table 1). Triclopyr is moderately to slightly toxic to mammals. In mammals, most triclopyr is excreted, unchanged, in the urine. Triclopyr is nontoxic to bees (SERA, 2003b.)

The toxicology also varies by formulation for eye and skin tests. Garlon® 4 tests resulted in a rating as a slight eye irritant, Toxicity Category III, (Table 1, Eye irritation) and the dermal results were Toxicity Category III, (Table 1, Dermal). Garlon® 3A is classified as a severe eye irritant (Category I) and a skin irritant (Category IV). California Department of Pesticide Regulation notes it may cause a skin sensitization reaction. For both formulations one-hour inhalation the laboratory test resulted in a rating of Toxicity Category III, (Table 1, Inhalation). For both formulations the acute oral rating was Toxicity Category III, (Table 1, Oral). Based on the results of animal studies, triclopyr does not cause birth defects and has little or no effect on fertility, or reproduction. Triclopyr is mildly fetotoxic. The majority of the studies of carcinogenicity and mutagenicity were negative. However two studies provide conflicting information about tumors. The EPA has classified Triclopyr as a Group D chemical, not classifiable as to human carcinogenicity. The label notes that "If the material is handled in accordance with proper industrial handling, exposures should not pose a carcinogenic risk to man."

The EPA approved labels for the two Triclopyr products differ. Garlon® 4 carries the signal word CAUTION. The precautionary statements for this ester formulation include: "Hazards to Humans and Domestic Animals. Harmful if Swallowed, Inhaled or Absorbed Through Skin. Avoid Contact With Eyes, Skin, or Clothing. Avoid Breathing Spray Mists or Vapors. Avoid Contaminating Food." Garlon® 3A carries a higher level of concern signal word, WARNING. Its precautionary statements include: "Hazards to Humans and Domestic Animals. Corrosive. Causes Irreversible Eye Damage. Harmful if Swallowed or Absorbed Through Skin. Prolonged or Frequently Repeated Skin Contact May Cause Allergic Reaction in Some Individuals."

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