SERA TR-052-25-01a

Triclopyr

Human Health and Ecological Risk Assessment

Initial Introduction, Program Description, and Literature Search

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None in this draft

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ACGIH	American Conference of Governmental Industrial Hygienists
ADD	attention-deficit disorder
ADHD	attention-deficit hyperactivity disorder
AEL	adverse-effect level
a.e.	acid equivalent
a.i.	active ingredient
APHIS	Animal and Plant Health Inspection Service
ATSDR	Agency for Toxic Substances and Disease Registry
BCF	bioconcentration factor
BEE	butoxyethyl ester
BUN	blood urea nitrogen
bw	body weight
CBI	confidential business information
cm	centimeter
CNS	central nervous system
DAA	days after application
DAT	days after treatment
DER	data evaluation record
d.f.	degrees of freedom
EC_x	concentration causing X% inhibition of a process
EC_{25}	concentration causing 25% inhibition of a process
EC_{50}	concentration causing 50% inhibition of a process
EDTA	ethylenediaminetetra acetic acid
EFED	Environmental Fate and Effects Division (U.S. EPA/OPP)
ExToxNet	Extension Toxicology Network
F	female
FH	Forest Health
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FQPA	Food Quality Protection Act
g	gram
GLP	Good Laboratory Practices
ha	hectare
HED	Health Effects Division (U.S. EPA/OPP)
HQ	hazard quotient
IARC	International Agency for Research on Cancer
IC_{50}	concentration causing 50% inhibition
IRIS	Integrated Risk Information System
K	potassium (salt)
k_a	absorption coefficient
k_e	elimination coefficient
kg	kilogram
$K_{o/c}$	organic carbon partition coefficient
$K_{o/w}$	octanol-water partition coefficient
K_p	skin permeability coefficient
L	liter

lb	pound
LC_{50}	lethal concentration, 50% kill
LD_{50}	lethal dose, 50% kill
LOAEL	lowest-observed-adverse-effect level
LOC	level of concern
m	meter
M	male
MCS	multiple chemical sensitivity
mg	milligram
mg/kg/day	milligrams of agent per kilogram of body weight per day
mL	milliliter
mM	millimole
mPa	millipascal, (0.001 Pa)
MOS	margin of safety
MRID	Master Record Identification Number
MSDS	material safety data sheet
MSMA	monosodium methanearsonate
MW	molecular weight
NAWQA	USGS National Water Quality Assessment
NCI	National Cancer Institute
NCOD	National Drinking Water Contaminant Occurrence Database
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
NOEL	no-observed-effect level
NOS	not otherwise specified
NRC	National Research Council
NTP	National Toxicology Program
OM	organic matter
OPP	Office of Pesticide Programs
OPPTS	Office of Pesticide Planning and Toxic Substances
OSHA	Occupational Safety and Health Administration
Pa	Pascal
PBPK	physiologically-based kinetic
ppm	parts per million
PSP	phenolsulfonphthalein
RBC	red blood cells
RED	re-registration eligibility decision
RfD	reference dose
RTU	ready to use
S.A.	South American
SERA	Syracuse Environmental Research Associates
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCP	3,5,6-trichloro-2-pyridinol
TEA	triethylamine
TEP	typical end-use product
T.G.I.A.	Technical grade active ingredient
TIPA	Triisopropanolamine

TRED	Tolerance Reassessment Eligibility Decision
UF	uncertainty factor
U.S.	United States
USDA	U.S. Department of Agriculture
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WCR	water contamination rate
WHO	World Health Organization

COMMON UNIT CONVERSIONS AND ABBREVIATIONS

To convert ...	Into ...	Multiply by ...
acres	hectares (ha)	0.4047
acres	square meters (m^2)	4,047
atmospheres	millimeters of mercury	760
centigrade	Fahrenheit	1.8°C+32
centimeters	inches	0.3937
cubic meters (m^3)	liters (L)	1,000
Fahrenheit	centigrade	0.556°F-17.8
feet per second (ft/sec)	miles/hour (mi/hr)	0.6818
gallons (gal)	liters (L)	3.785
gallons per acre (gal/acre)	liters per hectare (L/ha)	9.34
grams (g)	ounces, (oz)	0.03527
grams (g)	pounds, (oz)	0.002205
hectares (ha)	acres	2.471
inches (in)	centimeters (cm)	2.540
kilograms (kg)	ounces, (oz)	35.274
kilograms (kg)	pounds, (lb)	2.2046
kilograms per hectare (hg/ha)	pounds per acre (lb/acre)	0.892
kilometers (km)	miles (mi)	0.6214
liters (L)	cubic centimeters (cm^3)	1,000
liters (L)	gallons (gal)	0.2642
liters (L)	ounces, fluid (oz)	33.814
miles (mi)	kilometers (km)	1.609
miles per hour (mi/hr)	cm/sec	44.70
milligrams (mg)	ounces (oz)	0.000035
meters (m)	feet	3.281
ounces (oz)	grams (g)	28.3495
ounces per acre (oz/acre)	grams per hectare (g/ha)	70.1
ounces per acre (oz/acre)	kilograms per hectare (kg/ha)	0.0701
ounces fluid	cubic centimeters (cm^3)	29.5735
pounds (lb)	grams (g)	453.6
pounds (lb)	kilograms (kg)	0.4536
pounds per acre (lb/acre)	kilograms per hectare (kg/ha)	1.121
pounds per acre (lb/acre)	mg/square meter (mg/m^2)	112.1
pounds per acre (lb/acre)	μg/square centimeter ($\mu g/cm^2$)	11.21
pounds per gallon (lb/gal)	grams per liter (g/L)	119.8
square centimeters (cm^2)	square inches (in^2)	0.155
square centimeters (cm^2)	square meters (m^2)	0.0001
square meters (m^2)	square centimeters (cm^2)	10,000
yards	meters	0.9144

Note: All references to pounds and ounces refer to avoirdupois weights unless otherwise specified.

CONVERSION OF SCIENTIFIC NOTATION

Scientific Notation	Decimal Equivalent	Verbal Expression
$1 \cdot 10^{-10}$	0.0000000001	One in ten billion
$1 \cdot 10^{-9}$	0.000000001	One in one billion
$1 \cdot 10^{-8}$	0.00000001	One in one hundred million
$1 \cdot 10^{-7}$	0.0000001	One in ten million
$1 \cdot 10^{-6}$	0.000001	One in one million
$1 \cdot 10^{-5}$	0.00001	One in one hundred thousand
$1 \cdot 10^{-4}$	0.0001	One in ten thousand
$1 \cdot 10^{-3}$	0.001	One in one thousand
$1 \cdot 10^{-2}$	0.01	One in one hundred
$1 \cdot 10^{-1}$	0.1	One in ten
$1 \cdot 10^{0}$	1	One
$1 \cdot 10^{1}$	10	Ten
$1 \cdot 10^{2}$	100	One hundred
$1 \cdot 10^{3}$	1,000	One thousand
$1 \cdot 10^{4}$	10,000	Ten thousand
$1 \cdot 10^{5}$	100,000	One hundred thousand
$1 \cdot 10^{6}$	1,000,000	One million
$1 \cdot 10^{7}$	10,000,000	Ten million
$1 \cdot 10^{8}$	100,000,000	One hundred million
$1 \cdot 10^{9}$	1,000,000,000	One billion
$1 \cdot 10^{10}$	10,000,000,000	Ten billion

EXECUTIVE SUMMARY – Pending

1. INTRODUCTION

1.1. Chemical Specific Information

This document provides human health and ecological risk assessments of the environmental consequences of using triclopyr in Forest Service vegetation management programs. These risk assessments update previous USDA Forest Service risk assessments on triclopyr (SERA 1996, 2003).

In the preparation of this risk assessment, an updated literature search of triclopyr was conducted using TOXLINE. In addition, a FOIA has been submitted to the U.S. EPA/OPP for a current list of all registrant submitted studies. Additional sources of information were used including the U.S. EPA Reregistration Eligibility Decision document on triclopyr and related risk assessments (U.S. EPA/OPP 1998a,b,c) as well as a more recent EPA ecological risk assessment on triclopyr (U.S. EPA/OPP 2009a). Other sources of relevant literature were identified through reviews and risk assessments in the open literature (Antunes-Kenyon and Kennedy 2004; Cal EPA 1986; Cessna et al. 2002; Cox 2000; Ganapathy 1997; Kegley et al. 2008; Neary et al. 1993; Petty et al. 2003; Sassaman et al. 1984; Smith and Oehme 1991). Generally, these reviews are used only to identify published studies to ensure adequate coverage of the literature.

In the previous Forest Service risk assessment (SERA 2003), 1117 registrant submissions on triclopyr and triclopyr formulations were identified. Of these, 142 submission—i.e., full copies of the studies submitted to the U.S. EPA—were kindly provided by the U.S. EPA Office of Pesticide Programs. These submissions included all key studies cited in the RED (U.S. EPA/OPP 1998a) as well as some additional studies submitted after the completion of the RED. The U.S. EPA/OPP no longer provides full copies of registrant studies for risk assessments conducted in support of activities outside of U.S. EPA/OPP. Consequently, summaries of the 142 submissions from SERA (2003) are included in the current Forest Service risk assessment. In the current Forest Service risk assessment, the registrant-submitted studies are cited using standard author/year designations and are identified in Section 5 (References) as MRID03. Other registrant-submitted studies taken from various U.S. EPA/OPP risk assessments are designated in the body of the current Forest Service risk assessment only by MRID number.

The U.S. EPA/OPP is in the process of reviewing the registration of many pesticides (http://www.epa.gov/oppsrrd1/registration_review). The review of triclopyr, however, is not scheduled to begin until 2014, and the U.S. EPA has not yet opened a docket for the registration review (U.S. EPA/OPP 2010, p. 14). Thus, the EPA registration review can have no impact on the current Forest Service risk assessment.

1.2. General Information

This document has four chapters, including the introduction, program description, risk assessment for human health effects, and risk assessment for ecological effects or effects on wildlife species. Each of the two risk assessment chapters has four major sections, including an identification of the hazards, an assessment of potential exposure to this compound, an assessment of the dose-response relationships, and a characterization of the risks associated with plausible levels of exposure.

This is a technical support document and it addresses some specialized technical areas. Nevertheless an effort was made to ensure that the document can be understood by individuals who do not have specialized training in the chemical and biological sciences. Certain technical concepts, methods, and terms common to all parts of the risk assessment are described in plain language in a separate document (SERA 2007a). The human health and ecological risk assessments presented in this document are not, and are not intended to be, comprehensive summaries of all of the available information. The information presented in the appendices and the discussions in chapters 2, 3, and 4 of the risk assessment are intended to be detailed enough to support a review of the risk analyses.

As discussed in Section 1.1, the current Forest Service risk assessment is an update to previous risk assessments on triclopyr (SERA 1996, 2003). At some point in the future, the Forest Service will update this risk assessment again and welcomes input from the general public and other interested parties on the selection of studies included in the risk assessment. This input is helpful, however, only if recommendations for including additional studies specify why and/or how the new or not previously included information would be likely to alter the conclusions reached in the risk assessments.

As with all Forest Service risk assessments, almost no risk estimates presented in this document are given as single numbers. Usually, risk is expressed as a central estimate and a range, which is sometimes quite large. Because of the need to encompass many different types of exposure as well as the need to express the uncertainties in the assessment, this risk assessment involves numerous calculations, most of which are relatively simple. They are included in the body of the document.

Some of the calculations, however, are cumbersome. For those calculations, EXCEL workbooks (sets of EXCEL worksheets) are included as attachments to this risk assessment. The worksheets provide the detail for the estimates cited in the body of the document. Documentation for the use of these workbooks is presented in SERA (2009a).

The EXCEL workbooks are an integral part of the risk assessment. The worksheets contained in these workbooks are designed to isolate the large number of calculations from the risk assessment narrative. In general, all calculations of exposure scenarios and quantitative risk characterizations (i.e., hazard quotients) are derived and contained in the worksheets. The rationale for the calculations as well as the interpretation of the hazard quotients are contained in this risk assessment document.

2. Program Description

2.1 Overview

Triclopyr is an herbicide which is structurally similar to 2,4,5-T, differing from 2,4,5-T only by the presence of a nitrogen (N) atom in the ring structure . Triclopyr is used in Forest Service programs primarily for conifer and/or hardwood release, noxious weed control, site preparation, and rights-of-way management. Two forms of triclopyr are used commercially as herbicides: the triethylamine salt (TEA) and the butoxyethyl ester (BEE). As listed in Table 2, the BEE formulations include ready-to-use 13.6% formulations as well as 60.5, 61.6, and 83.9% liquid formulations. The TEA formulations include several 44.4% liquid formulations and one 14% granular formulation. Several TEA formulations are labeled for aquatic applications. Although aquatic applications have limited use in Forest Service programs, they are addressed in the current Forest Service risk assessment.

The most common application method for triclopyr is backpack (selective) foliar applications. Other application methods include ground broadcast foliar application, several non-broadcast application methods (i.e., basal bark, cut stump, and streamline basal bark), and aerial application. While aerial applications are not commonly used in Forest Service programs or projects, aerial applications are encompassed in this risk assessment.

Formulations of triclopyr BEE may be applied at rates of up to 8 lb a.e./acre, and formulations of triclopyr TEA may be applied at rates of up to 9 lb a.e./acre. While the full range of labeled application rates are considered in this risk assessment, the typical application rate in Forest Service programs is 1 lb a.e./acre and rarely exceeds 6 lb a.e./acre. Some aquatic applications are based on target concentrations in water of up to 2.5 mg a.e./L.

Based on Forest Service use statistics for 2004 (the most recent year for which Forest Service pesticide use statistics are available), about 12,500 lbs of triclopyr are used annually in Forest Service programs, and most of this use occurs in the southeastern region of the United States (Forest Service Region 8). The use of triclopyr is Forest Service programs represents only about 1% of the agricultural use of triclopyr.

2.2. Chemical Description and Commercial Formulations

Triclopyr is the common name for [(3,5,6-trichloro-2-pyridinly)oxy]acetic acid. Triclopyr is the pyridine analogue of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) and differs from 2,4,5-T only by the presence of a nitrogen (N) atom in the ring structure (Figure 1). Like 2,4,5-T, triclopyr mimics auxin, a plant growth hormone, thus disrupting the normal growth and viability of plants (Section 4.1.2.5).

Two forms of triclopyr are used commercially as herbicides: the triethylamine salt (TEA) and the butoxyethyl ester (BEE). The structure of both of these forms is also illustrated in Figure 1. Some basic chemical and physical properties of triclopyr and triclopyr BEE are summarized in Table 2. At ambient temperatures, triclopyr is a fluffy solid (Budavari et al. 1989) and is readily soluble in water (Table 1). In aqueous solutions, the hydrogen atom of the carboxylic acid group (**COOH**) may be associated (e.g., **-COOH**) or dissociated (e.g., $\mathbf{-COO^-} + \mathbf{H^+}$), depending on the pH of the solution. The dissociation constant, or pK_a, for the carboxylic acid group is approximately 3. Thus, at a pH of 3, 50% of the acid is associated and 50% is disassociated. As

the acidity of the solution decreases (i.e., the pH of the solution increases), the proportion of triclopyr that is ionized or dissociated increases. The pH of most biological fluids ranges from approximately 5 to 9. Thus, within this range of pH, most of the triclopyr acid has a net negative charge (**-COO**$^-$).

As discussed in Section 2.4, application rates for triclopyr are expressed in this risk assessment in units of acid equivalents (a.e.) rather than active ingredients (a.i.). For triclopyr, the term active ingredients refers to the TEA salt or BEE ester. Many of the toxicity studies conducted on triclopyr, summarized in the appendices to this risk assessment, report exposures in units of a.i. rather than a.e. For the risk characterization, concentrations or doses in units of a.i. are converted to units of a.e. by multiplying the a.i. value by the ratio of the molecular weight of triclopyr acid (256.5 g/mole) to the molecular weight of the a.i. — i.e., 358.67 g/mole for triclopyr TEA or 356.63 g/mole for triclopyr BEE. The specific conversion factors used in this risk assessment are given in Table 1— i.e., 0.719 for triclopyr BEE and 0.715 for triclopyr TEA.

The formulations of triclopyr considered explicitly in the current Forest Service risk assessment are listed in Table 2. The number of triclopyr formulations with labeled uses relevant to Forest Service programs continues to grow. When the initial Forest Service risk assessment on triclopyr was conducted, there were only two available formulations, Garlon 3A and Garlon 4 (SERA 1996). The Forest Service risk assessment conducted in 2003, covers six formulations, Garlon 3A, Garlon 4, Forestry Garlon 4, Pathfinder II, Remedy RTU, and Renovate 3. As summarized in Table 2, 19 triclopyr formulations are covered in the current Forest Service risk assessment.

Many formulations of triclopyr are equivalent to one another in terms of the active ingredient. For example, eight formulations, including Forestry Garlon, Garlon 4, Remedy, Tahoe 4E, Triclopyr 4 Ester R&P, Triclopyr 4E, Triclopyr R&P, and Triquad, contain triclopyr BEE at a nominal concentration of 61.6%, and five formulations, including Garlon 3A, Renovate 3, Tahoe 3A, Triclopyr 3A, and Triclopyr 3SL, contain triclopyr TEA at a concentration of 44.4%. Thus, of the 19 formulations identified in Table 2, 13 or about 70% of the formulations may consist of only two distinguishable groups of formulations—i.e., 61.6% BEE and 44.4% TEA.

Formulations with the same amount of active ingredient are not necessarily identical. In some cases, the U.S. EPA registration number for the formulation may be useful in assessing the equivalence of formulations. For example, Pathfinder II and Remedy RTU have the same EPA registration number of 62719-176, as indicated in Table 2. Formulations with identical EPA registration numbers may be regarded as equivalent formulations. Similarly, the EPA registration number for Renovate 3 from SePRO is 62719-37-67690. Note that the first two elements of the registration number (i.e., 62719-37) are identical to the registration number for Garlon 3A from Dow AgroSciences. The two-component registration numbers consist of the company identification number followed by the product code. The third element in the three-part registration number for Renovate 3 is the company code for SePRO. This registration number indicates that Renovate 3 is a repackaging of Garlon 3A. In other words, the two formulations are equivalent to one another.

In considering formulations with unique registration numbers, information on the MSDS for the formulation may be useful in assessing the similarity of the formulations. Appendix 1 (Table 1) provides a summary of the mammalian toxicity information from the MSDS for the formulations included in Table 2. The basis for and significance of the toxicity values are discussed further in Section 3.1 (Hazard Identification for Human Health Effects). The current discussion is concerned only with the apparent similarities among the different formulations.

Table 1 of Appendix 1 is organized by the type of a.i. (BEE or TEA) and its concentration in the formulation. Accordingly, there are six groups of distinct formulations identified as 13.6% BEE, 60.5% BEE, 61.6% BEE, 83.9% BEE, 14% TEA (granular), and 44.4% TEA. In Appendix 1, Table1, five of the eight formulations specify identical oral LD_{50} values—i.e., 1581 mg/kg bw for male rats and 1338 mg/kg bw for female rats—and the other three formulations specify the LD_{50} as >1000 mg/kg bw. The identical LD_{50} values for five of the eight formulations do not necessarily indicate that the formulations are identical or that five separate bioassays yielded the same LD_{50} values. Instead, the identical LD_{50} values indicate that the U.S. EPA/OPP probably allowed data on one formulation to be used to support the registration of other formulations. This general approach is sometimes referred to as *bridging*. If the two formulations are identical—i.e., the same formulation is marketed under different names—data bridging is obviously sensible. If the two formulations are substantially different, however, bridging is not permitted and formulation-specific data are required. For triclopyr formulations, a specific discussion of formulation bridging is not available. While most data on the 61.6% formulations are reasonably similar, Tahoe 4E appears to be distinct in that the MSDS for this formulation indicates that Tahoe 4E is not a skin sensitizer. All other 61.6% formulations indicate that the formulations may cause skin sensitization.

Substantial differences in the toxicity of the various formulations of triclopyr are likely to be related to differences in the other ingredients, formerly called inerts, in the formulations. The known and disclosed inerts in triclopyr formulations are summarized in Table 3. Triclopyr BEE is much less soluble in water, compared with triclopyr TEA (Table 1). As summarized in Table 3, all of the 61.6% triclopyr BEE formulations contain kerosene; however, the description of the amount of kerosene in the formulations differs. Garlon 4 specifies additional ingredients including ethylene glycol and solvent naphtha. Pathfinder II and Remedy RTU are both “ready to use” formulations—i.e., require no mixing and no addition of surfactants or other adjuvants—and both contain 13.6% triclopyr-BEE and 86.4% inert ingredients. The inert ingredients in these formulations are specified only as “proprietary surfactants”. The liquid formulations of 44.4% triclopyr TEA specify other ingredients as either ethanol (Garlon 3A, Renovate 3, and Tahoe 3A) or ethylenediaminetetraacetic acid (EDTA), which is a chelating agent (Triclopyr 3A, Triclopyr 3SL). Triclopyr 3SL also contains ethylene glycol.

The single granular formulation of triclopyr, Renovate OTF, contains a different set of other ingredients characterized only as proprietary fiber, proprietary clay, proprietary salt, and titanium dioxide. One or more of these other ingredients may be toxicologically significant. As indicated in Appendix 1, Table 1, the MSDS for Renovate OTF indicates that this formulation may cause sensitization on inhalation exposure. None of the liquid formulations of triclopyr indicate a potential for causing sensitization after inhalation exposures.

The significance of the other ingredients in triclopyr formulations is discussed further in Section 3.1.14 (Inerts and Adjuvants).

2.3. Application Methods

2.3.1. Terrestrial Applications

2.3.1.1. Terrestrial Broadcast Applications

Table 4 provides an overview of the label directions for terrestrial applications of the triclopyr formulations covered in this risk assessment. Except for the ready-to-use formulations (i.e., Pathfinder II and Remedy RTU), the triclopyr formulations are labeled for ground or aerial broadcast applications.

The most commonly used application method is backpack (selective) foliar applications. In selective foliar applications, the herbicide sprayer or container is carried by backpack and the herbicide is applied to selected target vegetation. Application crews may treat up to shoulder high brush, which means that chemical contact with the arms, hands, or face is plausible. To reduce the likelihood of significant exposures, application crews are directed not to walk through treated vegetation. Usually, a worker treats approximately 0.5 acres/hour with a plausible range of 0.25-1.0 acres/hour (USDA/FS 1989 p 2-9 to 2-10).

Broadcast foliar ground applications, which may be conducted occasionally, involve the use of a two- to six-nozzle boom mounted on a tractor or other heavy duty vehicle. With this equipment, workers typically treat 11-21 acres/hour, with the low end of this range representative of a four-wheel drive vehicle in tall grass and the upper end of the range representative of a large bulldozer (USDA/FS 1989 p 2-9 to 2-10).

As noted in Table 4, several triclopyr formulations are labeled for aerial application. In Forest Service programs, aerial broadcast applications are avoided; nonetheless, aerial applications are included in the current Forest Service risk assessment in the event that aerial applications of triclopyr are considered in specific Forest Service programs or projects. Aerial applications of some triclopyr BEE formulations (i.e., Forestry Garlon, Garlon 4 Ultra, and Triclopyr 4E) are limited to helicopters, while the other triclopyr BEE formulations may be applied by helicopter or fixed wing aircraft. No information has been encountered on the rationale for limiting the aerial application of some triclopyr BEE formulations to helicopters. For triclopyr TEA formulations, the product labels generally limit aerial applications to helicopters. Triclopyr 3SL may be applied to rice using fixed wing aircraft; however, applications to rice are not relevant to Forest Service activities.

2.3.1.2. Non-Broadcast Applications

Pathfinder II and Remedy RTU are ready-to-use formulations which are not labeled for any form of broadcast application. Instead, these products are labeled for only basal bark and cut stump as well as streamline basal bark applications in the southern United States. These application methods may also be used with some other formulations of triclopyr BEE in which the mixing directions specify the addition of diesel fuel, No. 1 or No. 2 fuel oil, kerosene, or a commercially available basal oil.

Basal bark is a low volume application method in which bark at the base of the bottom of a small tree (usually less than six inches in diameter) is wetted with the triclopyr formulation using a backpack sprayer. While the bark is wetted as thoroughly as possible, runoff from the trunk to the ground surface is avoided.

Cut stump applications, as the name implies, involves cutting down the tree and then applying the triclopyr formulation to the tree stump. The stump is treated by applying the formulation to the cambium as well as to the bark on the stump. As with basal bark applications, the bark is wetted thoroughly; yet, not wetted to the point where the formulation will runoff to the surrounding soil.

In streamline applications, the herbicide is sprayed directly onto the bark of the lower 2–3 feet of the stem in a horizontal band to one side of the tree. The surfactant in the herbicide formulation allows the active ingredient to spread around the stem. This treatment method is generally used on relatively small trees (e.g., maximum diameters of approximately 4 inches). In these applications, the herbicide sprayer or container is carried by backpack. The nozzle on the wand or gun jet of the backpack sprayer should not be positioned higher than the handlers' waist, reducing the likelihood that the chemical will come into direct contact with the arms, hands, or face of the worker.

While not specifically noted on the triclopyr labels, triclopyr may be used in hack and squirt applications. Hack and squirt applications are a form of cut surface treatment in which the bark of a standing tree is cut with a hatchet and the herbicide is applied with a squirt bottle. This treatment method is used to eliminate large trees during site preparation, conifer release operations, or rights-of-way maintenance. As with selective foliar applications, a worker usually treats about 0.5 acres/hour with a plausible range of 0.25-1.0 acres/hour (USDA/FS 1989 p 2-9 to 2-10).

In non-broadcast applications, application rates in units of lb a.e./acre may not regarded as meaningful descriptors of an application in that the areas treated are noncontiguous. Nonetheless, the product labels for Pathfinder II and Remedy RTU have limitations on application rates in units of lb a.e./acre which are identical to the limitations on broadcast applications. Thus, an analysis of a noncontiguous application should be based on the total amount of triclopyr applied and the total area over which the application will be made to approximate an application rate in units of lb a.e./acre.

2.3.2. Aquatic Applications

As summarized in Table 5, several formulations of triclopyr TEA are labeled for aquatic applications. No formulations of triclopyr BEE are labeled for aquatic applications. While not explicitly noted on the product labels, all aquatic applications of triclopyr appear to be limited to the control of aquatic macrophytes rather than algae.

The specific types of target vegetation differ among the various formulations. Garlon 3A and Triclopyr 3A are labeled only for emergent vegetation along the shores of either standing or flowing bodies of water. As discussed further in Section 2.4.2, the application rates for these types of application are expressed as lbs a.e./acre, essentially identical to application rates used for ground broadcast applications. Renovate 3 and Triclopyr 3SL are labeled for the control of

either emergent or submerged aquatic vegetation. For emergent vegetation, application rates are expressed in units of lb a.e./acre and are identical to those for Garlon 3A and Triclopyr 3A. For submerged vegetation, application rates are expressed as target concentrations in units of mg a.e./L. Renovate OTF is labeled for the control of immersed, floating, or submersed vegetation, and all application rates are specified as target concentrations in units of mg a.e./L. The specific target concentrations for the different formulations of triclopyr TEA are discussed further in Section 2.4.2.

2.4. Mixing and Application Rates

2.4.1. Terrestrial Applications

Foliar applications account for most of the use of triclopyr in Forest Service programs. As discussed further in Section 2.5 (Use Statistics), the most recent use statistics available from the Forest Service are for 2004. These statistics include uses defined by Forest Service region and by management objective. The uses defined by management objective for 2004 are summarized in Table 6. As indicated in Table 6, the major uses of triclopyr in terms of the amount used in Forest Service programs involve conifer release (32%), noxious weed control (27%), site preparation (18 %), mixed hardwood and conifer release (12%), hardwood release (5.5%), and rights-of-way management (4%). All of these management objectives, which account for about 98.5% of the use of triclopyr in Forest Service programs, would primarily involve foliar applications.

Table 4 presents an overview of the application rates for triclopyr formulations. The maximum application rates vary with the type of site. For sites at which grazing may occur, the maximum application rate is 2 lb a.e./acre. For formulations of triclopyr BEE, the maximum application rate at sites where grazing will not occur is 8 lb a.e./acre. Several formulations of triclopyr BEE, however, specify a maximum application rate of 6 lb a.e./acre for forestry sites. Somewhat higher application rates of up to 9 lb a.e./acre may be used with formulations of triclopyr TEA.

As summarized in Table 6, the average application rate used in Forest Service programs is about 1 lb a.e./acre. This unit application rate is used for terrestrial applications in the EXCEL workbooks that accompany this risk assessment. For 2004, the maximum application rate used in any Forest Service program was 6.63 lb a.e./acre. This application was made in Forest 7 of Region 8 (Southern Region) for noxious weed control. The lowest application rate on record for 2004 is 0.04 lb a.e./acre. This application was made in Forest 10 of Region 6 (Pacific Northwest) and also was classified as noxious weed control. Albeit speculative, it is likely that the unusually low application rate of 0.04 lb a.e./acre involved a noncontiguous area, as discussed in Section 2.3.1.2.

Except for the ready-to-use formulations (i.e., Pathfinder II and Remedy RTU), triclopyr formulations will be diluted with a carrier prior to application. For broadcast foliar applications, triclopyr will typically be diluted with water and a surfactant. As noted in Table 4, all formulations of triclopyr recommend the use of a non-ionic surfactant. The specific surfactants that might be used in Forest Service programs have not been identified. Surfactants discussed in the literature include various organosilicone surfactants such as Silwet L-77 (Bollig et al. 1995; Buick et al. 1992; Forester 1998; Jackson et al. 1998; Pline et al. 1998), and alkylphenol ethoxylate-containing surfactants such as R-11(Xie et al. 2005). Abdelghani et al. (1997) discuss

the use of Syndets surfactant, which is an ionic surfactant; however, it is not clear that this surfactant is likely to be used in applications associated with Forest Service programs. While it is beyond the scope of the current Forest Service risk assessment on triclopyr to review the toxicity of non-ionic surfactants, the available information on the impact of surfactants on triclopyr is discussed in Section 3.1.14.

For non-broadcast applications (e.g., streamline or basal bark) of triclopyr BEE, the formulation is mixed with oils such as diesel fuel, No. 1 or No. 2 fuel oil, kerosene or a commercial basal oil.

For this risk assessment, the extent to which a triclopyr formulation is diluted prior to application primarily influences dermal and direct spray scenarios, both of which are dependent on 'field dilution' (i.e., the concentration of triclopyr in the applied spray). In all cases, the higher the concentration of triclopyr, which is equivalent to the lower dilution of the triclopyr formulation, the greater the risk.

The product labels for Remedy and Triclopyr 4 Ester specify application volumes as low as 2 gallons per acre for aerial applications. In general, application volumes of 10-400 gallons per acre are recommended on product labels. For Forest Service programs, however, the upper range on the dilution volume will typically be no more than 40 gallons per acre. A typical dilution rate is 25 gallons per acre. For the current Forest Service risk assessment, the central estimate of the application volume is taken as 25 gallons per acre with a range of 5-40 gallons per acre. Details regarding the calculation of field dilution rates are provided in worksheet A01.

The selection of application rates and dilution volumes in this risk assessment is intended simply to reflect typical central estimates as well as plausible lower and upper ranges. In the assessment of specific program activities, the Forest Service will use program specific application rates and application volumes.

2.4.2. Aquatic Applications

Aquatic weed control is a very minor use for triclopyr. In the 5-year period from 2000 to 2004, only one aquatic application of triclopyr is included in Forest Service pesticide use reports, which involved an application of 3 pounds to 1.8 acres in Region 8, Forest 7.

As summarized in Table 5, most formulations of triclopyr TEA labeled for terrestrial applications are also labeled for aquatic application; however, the target vegetation differs among the various formulations. Garlon 3A and Triclopyr 3A are labeled only for emergent aquatic macrophytes. Specific aquatic application rates are not specified on the product labels for these formulations, and the label refers to use rates for terrestrial applications. In other words, the aquatic application rates are expressed in units of lbs a.e./acre in which the acreage refers to the surface area of water to be treated.

Renovate 3 and Triclopyr 3SL are labeled for either emergent or submerged vegetation. For emergent vegetation, the application rates are expressed in units of lb a.e./acre, as is the case with Garlon 3A and Triclopyr 3A. The label instructions for emergent vegetation specify application rates of 0.5-6 lb a.e./acre, which are identical to the application rates for terrestrial applications. For submerged vegetation, application rates are expressed as target concentrations ranging from

0.75 to 2.5 mg a.e./L. The upper bound of this range is also the maximum seasonable application rate.

All of the above formulations —i.e., Garlon 3A, Triclopyr 3A, Renovate 3, and Triclopyr 3SL— recommend the use of a nonionic surfactant. As discussed in the previous subsection, nonionic surfactants are also recommended in terrestrial applications of these formulations.

Renovate OTF is labeled for emersed, floating, and submerged aquatic vegetation. This granular formulation is labeled only for aquatic application, and all application rates are expressed as target concentrations—i.e., from 1 to 2.5 mg a.e./L for floating or emersed weeds and from 0.5 to 2.5 mg a.e./L for submersed weeds. Unlike the other formulations labeled for aquatic applications, Renovate OTF appears to be a ready-to-use formulation, in that no mixing directions are included on the product label and the use of surfactants is not mentioned on the product label.

2.5. Use Statistics

Forest Service risk assessments attempt to characterize the use of an herbicide or other pesticide in Forest Service programs relative to its use in agricultural applications. Forest Service pesticide use reports up to the year 2004 are available on the Forest Service web site (http://www.fs.fed.us/ foresthealth/pesticide/reports.shtml). Information on agricultural use is compiled by the U.S. Geological Survey (http://water.usgs.gov/nawqa/pnsp/usage/maps/). In addition, detailed pesticide use statistics compiled by the state of California (http://www.calepa.ca.gov/).

The USDA Forest Service tracks and reports pesticide use by geographical areas referred to as "*Regions*". The Forest Service classification divides the United States into nine regions designated from Region 1 (Northern) to Region 10 (Alaska). [Note: There is no *Region 7* in the Forest Service system.] The use of triclopyr in Forest Service regions for the year 2004 (the most recent year for which statistics are available) is illustrated in Figure 2 and detailed further in Table 5. By far, the greatest use of triclopyr occurs in the southeast, referred to by the Forest Service as Region 8 or the Southern region. This region accounted for about 87% of triclopyr use by the Forest Service in 2004. Relatively small amounts were used in Region 4 (about 5%), Region 6 (about 4%), and Region 1 (about 3%). In other regions, the use of triclopyr by the Forest Service is insubstantial, ranging from about 1% in Region 2 to no reported use in Regions 3, 9, and 10.

Triclopyr formulations are used extensively in agriculture. The USGS provides national agricultural use statistics for 2002. As illustrated in Figure 3, about 1,000,000 lbs of triclopyr were applied to pastureland is 2002. Much less triclopyr is applied to other commodities—i.e., about 150,000 lbs to rice, 100,000 lbs to hay, 2500 lbs to sod, and 10 lbs to blueberries. As noted in Table 5, the total annual use of triclopyr by the Forest Service for 2004 was about 12,500 lbs, which is about 1% of the agricultural use [≈12,500 lbs ÷ ≈1,250,00 lbs = 0.01]. As with Forest Service use, the greatest agricultural use of triclopyr is in the southeast of the United States. Unlike the Forest Service, however, significant amounts of triclopyr are used in the northeast of the United States (Forest Service Region 9).

More recent use statistics are available for California for the year 2007 (CDPR 2008). According to CDPR (2008, pp. 407-408), the total use of triclopyr BEE was 67,007 lbs. Uses of

triclopyr BEE relevant to forest applications include 10,186 pounds applied to timberland and 21,029 lbs applied to rights-of-way. Thus, for triclopyr BEE, forestry related uses account for about 46% of the uses of triclopyr BEE [≈31,000 lbs ÷ ≈67,000 lbs]. For the TEA salt of triclopyr, the total use in California was about 64,030 lbs, similar to the total use of triclopyr BEE. Of this amount, about 8923 lbs or 14% was used in forestry related applications—i.e., 997 lbs to timberland and 7926 lbs to rights-of-way.

5. REFERENCES

NOTE: The initial entry for each reference in braces {} simply specifies how the reference is cited in the text. The final entry for each reference in brackets [] indicates the source for identifying the reference.

E-Docket	**Files from http://www.regulations.gov.**
FOIA01	**Initial FOIA to EPA. Pending**
Internet	**References obtained from various sites on the Internet.**
TriArch1	**Archived papers from previous Forest Service risk assessments.**
MRID03	**CBI studies available for and summarized in the 2003 Forest Service risk assessment on triclopyr (SERA 2003).**
MCS	**Papers on Multiple Chemical Sensitivity**
Sec	**Studies taken from secondary sources**
SET00	**Papers from preliminary scoping and other communications.**
SET01	**Initial Update: a:Toxline; b 2003 missing; c ECOTOX; d Rescreen of Toxline [N=151]**
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Table 1: Triclopyr Physical and Chemical Properties

Item	Value	Reference
	Identifiers[1]	
Common name:	Triclopry	Tomlin 2004
CAS Name	[(3,5,6-trichloro-2-pyridyl)oxy]acetic acid	Tomlin 2004
IUPAC Name	3,5,6-trichloro-2-pyridyloxyacetic acid	Tomlin 2004
CAS No.	Form (Abbrev) / CAS No. Acid: 55335-06-3 Butoxyethyl ester (BEE): 64700-56-7 Triethylamine salt (TEA): 57213-69-1	Tomlin 2004
CAS No.	Triclopyr BEE: 64470-88-8	NLM TOXLINE ChemDplus Advanced
Molecular formula	$C_7H_4Cl_3NO_3$ [Acid] $C_{13}H_{16}C_{l3}NO_4$ [BEE] $C_{13}H_{19}C_{l3}N_2O_3$ [TEA]	Tomlin 2004
	Chemical Properties(1)	
Henry's Law Constant	Form (Abbrev) / Pa m^3 mol^{-1} Acid: 9.77×10^{-5} Butoxyethyl ester (BEE): 5.2×10^{-2} Triethylamine salt (TEA): 1.16×10^{-9}	Tomlin 2004
	9.66×10^{-7} atm m^3 mol^{-1} (acid)	U.S. EPA/OPP 2009a, Table 2-1
	Form (Abbrev) / Atm m^3 mol^{-1} Butoxyethyl ester (BEE): 2.47×10^{-7} Triethylamine salt (TEA): 1.15×10^{-14}	U.S. EPA/OPP 2009b
Hydrolysis	Stable	Tomlin 2004
	Stable at pH 5,7,9 (MRID 41879601)	U.S. EPA/OPP 2009a, Table 2-1
	TEA: N.A. BEE Sterile Buffered Solutions: pH 5 = 84 days pH 7 = 8.7 days pH 9 = 0.3 days Natural Water: pH 6.7 = 0.5 days	U.S. EPA/OPP 2009b, MRID 134174
Kow	2.63 [Log Kow = 0.42] (pH 5) 0.35 [Low Kow = -0.45] (pH 7) 0.11 [Low Kow = -0.96] (pH 9)	Tomlin 2004
Molecular weight (g/mole)	Form (Abbrev) / MW (g/mole) Acid: 256.5 Butoxyethyl ester (BEE): 356.63 Triethylamine salt (TEA): 358.67	Tomlin 2004 (Acid) U.S. EPA/OPP 2009b (TEA and BEE)
a.i. to a.e. conversion	Form (Abbrev) / Factor Butoxyethyl ester (BEE): 0.719 Triethylamine salt (TEA): 0.715 a.i. to a.e. calculated as MW of acid ÷ MW of BEE or TEA.	

Table 1: Triclopyr Physical and Chemical Properties

Item	Value	Reference
Melting point	150.5 °C	Tomlin 2004
	148 -150 °C	USDA/ARS 1995
pKa	3.97	Tomlin 2004
	2.7	McCall and Gavit 1986
	2.93	Woodburn et al. 1993a; USDA/ARS 1995
	2.68	Weber 1994
Photolysis (aqueous)	Acid: 8-9 hours (natural light), degrades to 5-Chloro-3,6-dihydroxy-2-pyridinyloxyacetic acid and oxamic acid (combined = 48%) MRIDs 41732201 and 42411804	U.S. EPA/OPP 2009a, Table 2-1
Photolysis (aqueous)	Acid: 1.7 days (In river water), Oxamic acid (16%), MRID 41732201 and 42411804	U.S. EPA/OPP 2009a, Table 2-1
	BEE: 6.6 days in Sterile pH 5 aqueous buffer solution	U.S. EPA/OPP 2009b MRIDs 41732201 and 42411804
Photolysis (aqueous)	TEE: Sterile solution: 0.6 days in natural light, pH7 0.36 days in artificial light, pH7	U.S. EPA/OPP 2009b MRIDs 41732201 and 42411804
Photolysis (aqueous)	TEE: River water 1.7 days in natural light 0.7 days in artificial light	U.S. EPA/OPP 2009b MRIDs 41732201 and 42411804
	0.71-1.86 days (photodegradation in natural river water)	Woodburn et al. 1993a
Specific gravity	1.85 (21 °C)	Tomlin 2004
Thermal decomposition	°C	Tomlin 2004
Vapor pressure	0.2 mPa (25 °C)	Tomlin 2004
	1.26×10^{-6} torr	U.S. EPA/OPP 2009a, Table 2-1
	Form / VP (torr) / MRID BEE / 3.6×10^{-6} / 40557003; 42443402 TEA / $<1 \times 10^{-8}$ / 41219104	U.S. EPA/OPP 2009b
Water solubility	7,690 mg/L (pH 5, 20 °C) 8,100 mg/L (pH 7, 20 °C) 8,220 mg/L (pH 9, 20 °C)	Tomlin 2004
	440 mg/L (acid)	U.S. EPA/OPP 2009a, Table 2-1
	BEE: 7.4 mg/L at 25 °C	U.S. EPA/OPP 2009b
	BEE: 6.8 mg/L	U.S. EPA/OPP 1998a
	TEA 12,000 mg/L (pH 5, 25 °C) 412,000 mg/L (pH 7, 25 °C) 1.278,000 mg/L (pH 9, 25 °C)	U.S. EPA/OPP 2009b
	TEA: 2,100,000 mg/L BEE: 23 mg/L	Knissel and Davis 2000
	Environmental Fate Properties	
Foliar washoff fraction	TEA: 0.95 BEE: 0.70	Knissel and Davis 2000
Foliar half-life	TEA: 15 days BEE: 15 days	Knissel and Davis 2000

Table 1: Triclopyr Physical and Chemical Properties

Item	Value	Reference
Foliar half-life	Average 42% decline over 6 days of triclopyr applied to various forest vegetation in northern Idaho	Whisenant and McArthur 1989
Kd/Koc	Soil (%OC) / Kd / Koc Sand (0.73%) / 0.975 / 134 Sandy loam (2.25%) / 0.571 / 25 Silty loam (0.67%) / 0.165 / 25 Clay loam (1.38%) / 0.733 / 53	U.S. EPA/OPP 2009a, Table 2-1 MRID 40749801
Koc	TEA: 20 BEE: 780	Knissel and Davis 2000
	27	McCall and Gavit 1986; Kenaga 1980
	20	Diaz-Diaz and Loague 2001
Soil half-life (NOS)	TEA: 46 days BEE: 46 days	Knissel and Davis 2000
	40 days	McCall and Gavit 1986
	46 days (average)	Weber 1994
	45 days (average)	Neary et al. 1993
	14 days (average in Canadian forest soils)	Stephenson et al. 1990
Soil half-life, aerobic	BEE: MRID 43799101 0.9 hours Hanford Sandy Loam Soil at 25° C 1.4 hours Commerce Silt Loam Soil at 25° C TEA: MRID 43837501 5.6 days Sandy Loam Soil at 25° C 13.7 days Silt Loam Soil at 25° C	U.S. EPA/OPP 2009b
	Acid: 8 days in silty clay loam soil at 25 °C TCP (26.4%) Acid: 18 days in silt loam soil at 25 °C	U.S. EPA/OPP 2009a, Table 2-1
Field dissipation half-life, terrestrial	BEE: MRID 43837503 1.1 days (degraded to triclopyr acid; depth 0 to 7.5 cm) 10.6 days (dissipation of BEE and triclopyr acid; depth 0- 7.5 cm) MRID 42730601 ~2 weeks (dissipation of BEE and triclopyr acid; depth 0 to 6 inches)	U.S. EPA/OPP 2009b
	TEA: MRID 43837503 1.1 days (BEE degraded to triclopyr acid; depth 0 to 7.5 cm) 10.6 days (dissipation of BEE and triclopyr acid; depth 0- 7.5 cm)	U.S. EPA/OPP 2009b
	Acid: MRID 43955901and 43033401 7.6 to 10.6 days) days	U.S. EPA/OPP 2009a, Table 2-1
Water half-times (NOS)	2.8-14.1 hours (photodegradation in sunlit water; 0-1 m deep)	McCall and Gavit 1986
Water, aerobic metabolic half-times	BEE: 0.6-3.4 days at 25 °C, MRID 43799106 TEA: 14-18 days, MRID 43837503	U.S. EPA/OPP 2009b
	Acid: 142 days in silty clay soil at 24-26° C, TCP (< 5%) MRID 40479101	U.S. EPA/OPP 2009a, Table 2-1

Table 1: Triclopyr Physical and Chemical Properties		
Item	**Value**	**Reference**
Water, anaerobic metabolic half-times	BEE: 1.4 days, MRID 43799103 TEA: 2 years, MRID 43837502	U.S. EPA/OPP 2009b
	Acid: Stable (1300 days), TCP (26%), MRID 151967	U.S. EPA/OPP 2009a, Table 2-1
Water, field dissipation half-time	TEA: 0.5 to 3.5 days, MRID 41714304 and 42821301	U.S. EPA/OPP 2009b
	Acid at 30 °C Lake, 3.6 days Aquatic Plants: 3.4 days Crayfish: 11.5 days Clam Tissue: 1.5 days	U.S. EPA/OPP 2009a, Table 2-1, MRID 41714304
	0.5-3.6 days (field study in Lake Seminole, GA under midsummer conditions)	Woodburn et al. 1993b
	3.8-4.3 days (field study in northern Ontario)	Solomon et al. 1988

[1] All values apply to triclopyr acid unless otherwise specified.

Working Note: Recheck all shaded values in above table. Clarify the form and/or formulation to which the values apply.

Table 2: Triclopyr Formulations Explicitly Considered in Risk Assessment

Formulation Name [a]	Supplier	EPA Reg. No.	lb a.e./gal	a.i.	% a.i.	% a.e.	Other
Forestry Garlon	Dow AgroSciences	62719-40	4	BEE	61.6%	44.3%	
Forestry Garlon XRT	Dow AgroSciences	62719-553	6.3	BEE	83.9%	60.3%	
Garlon 3A	Dow AgroSciences	62719-37	3	TEA	44.4%	31.8%	Aquatic
Garlon 4	Dow AgroSciences	62719-40	4	BEE	61.6%	44.3%	
Garlon 4 Ultra	Dow AgroSciences	62719-527	4	BEE	60.45%	43.46%	
Pathfinder II	Dow AgroSciences	62719-176	0.75	BEE	13.6%	9.81%	
Remedy	Dow AgroSciences	62719-70	4	BEE	61.6%	44.3%	
Remedy RTU	Dow AgroSciences	62719-176	0.75	BEE	13.6%	9.81%	
Remedy Ultra	Dow AgroSciences	62719-552	4	BEE	60.45%	43.46%	
Renovate 3	SePRO	62719-37-67690	3	TEA	44.4%	31.8%	Aquatic
Renovate OTF granular	SePRO	67690-42	N/A	TEA	14%	10%	Aquatic
Tahoe 3A	Riverdale	228-384	3	TEA	44.4%	31.8%	
Tahoe 4E	Riverdale	228-385	4	BEE	61.6%	44.3%	
Triclopyr 3A	Albaugh	42750-127	3	TEA	44.4%	31.8%	Aquatic
Triclopyr 3SL	Makhteshim Agan	66222-152	3	TEA	44.4%	31.8%	Aquatic
Triclopyr 4 Ester R&P	Micro Flo	51036-377	4	BEE	61.6%	44.3%	
Triclopyr 4E	Albaugh	42750-126	4	BEE	61.6%	44.3%	
Triclopyr R&P	Albaugh	42750-129	4	BEE	61.6%	44.3%	
Triquad	Makhteshim Agan	66222-153	4	BEE	61.6%	44.3%	

[a] Sources: Specimen labels from www.Greenbook.net and www.CDMS.net.

[b] Formulations that do not appear to have forestry or related uses (e.g., Grandstand R, Triclopyr Rice, Truflon Ester, and Truflon Ester Ultra) are not included in the above table.

Table 3: Disclosed Inerts in Triclopyr Formulations

Formulation Name [1]	% a.i.	Inert (CAS No. if specified)	Amount
BEE Ester			
Forestry Garlon	61.6%	Kerosene (8008-20-6) NOS	31.0% 7.4%
Forestry Garlon XRT	83.8%	NOS	16.1%
Garlon 4	61.6%	Kerosene (8008-20-6) Ethylene glycol monobutyl ether (111-76-2) Solvent naphtha (petroleum), light aromatic NOS	≥18.6% to ≤ 31% 0.5% 0.2% ≥6.7% to ≤ 19.1%
Garlon 4 Ultra	60.5%	Ethylene glycol monobutyl ether (111-76-2) NOS	0.5% 39.0%
Pathfinder II	13.8%	NOS	86.2%
Remedy	61.6%	Kerosene (8008-20-6) NOS	31% 7%
Remedy RTU	13.6%	Other (including proprietary solvent)	86.4%
Remedy Ultra	60.5%	NOS	39.5%
Tahoe 4E	61.6%	Other (including kerosene and proprietary surfactant)	38.4%
Triclopyr 4 Ester R&P	61.6%	Kerosene (8008-20-6)	>25%
Triclopyr 4E	61.6%	Kerosene (8008-20-6)	>25%
Triclopyr R&P	61.6%	Kerosene (8008-20-6)	>25%
Triquad	61.6%	Kerosene (8008-20-6)	<27.14%
TEA Salt			
Garlon 3A	44.4%	Ethanol (64-17-5) NOS	2.1% 50.5%
Renovate 3	44.4%	Ethanol (64-17-5) NOS	2.1% 50.5%
Renovate OTF (granular)	10 to 30%	Proprietary Fiber Proprietary Clay Proprietary Salt Titanium dioxide (13463-67-7)	30 to 60% 5 to10% 5 to10% 0.1 to 1%
Tahoe 3A	44.4%	Other (including ethanol)	55.6%
Triclopyr 3A	44.4%	Ethylenediaminetetraacetic acid [EDTA] (64-02-8)[2]	<5.0%
Triclopyr 3SL	44.4%	Ethylenediaminetetraacetic acid [EDTA] (60-00-4) [2] Ethylene glycol (107-21-1)	2.5% 1.0%

[1] Sources: MSDSs from www.Greenbook.net and other sites.

[2] The CAS No. for EDTA is 60-00-4 (anion). CAS No. 64-02-8 designates the tetrasodium salt of EDTA.

Table 4: Overview of Label Directions for Terrestrial Applications

Formulation(s)	Application Rates and Volumes	Adjuvants
Note: This table presents a cursory overview of label directions. In any specific application, consult and follow the product label for the formulation that is being used.		
BEE		
4 lb a.e./gallon: Forestry Garlon, Garlon 4 Ultra, Triclopyr 4E	1 to 8 lb a.e./acre Max Rate (forestry sites): 6 lb a.e./ac per season. Max Rate (non-grazing): 8 lb a.e./acre. Max Rate (grazing sites): 2 lb a.e./acre Spray Vol.: 10 to 400 gallons/acre	If agricultural surfactant is used, apply the surfactant at rates of 1 to 2 lb/acre. **(Verify)** For basal bark applications, mix with diesel fuel, No. 1 or No. 2 fuel oil, kerosene or a commercially available basal oil. Aerial applications: Helicopter only.
4 lb a.e./gallon: Garlon 4, Remedy Ultra, Tahoe 4E, Triclopyr R&P, Triquad	Same as above	As above with the exceptions noted below. Aerial applications: Fixed wing aircraft or helicopter.
4 lb a.e./gallon: Remedy, Triclopyr 4 Ester	Max Rate (grazing): Remedy: 2 lb a.e./acre Triclopyr 4: 1 lb a.e./acre Max Rate: 8 lb a.e./acre (non-grazing) Ground: 10 to 40 gal/acre [Triclopyr 4 Ester recommends 15 t0 25 gal/acre] Aerial: >2 gal/acre	Mix with basal oil, diesel fuel, fuel oil, or kerosene plus an emulsifier such as Sponto 712 or Triton X-100. Ground: Use 5-10% oil mix. Aerial: Fixed wing aircraft or helicopter. Use 20% oil/80% water.
6.3 lb a.e./gallon: Forestry Garlon XRT	1 to 8 lb a.e./acre Max Rate (forestry sites): 6 lb a.e./ac per season. Max Rate (ROW): 8 lb a.e./acre. Max Rate (grazing sites): 2 lb a.e./acre Spray Vol.: 10 to 400 gallons/acre	If agricultural surfactant is used, apply the surfactant at rates of 1 to 2 lb/acre. **(Verify)** Aerial applications: Helicopter only.
0.75 lb a.e./gallon: Pathfinder II, Remedy RTU	Same as above.	Application methods: Basal bark, cut stump, streamline basal bark (Southern U.S.). Not intended for broadcast applications.
TEA Salt, Terrestrial		
3 lb a.e./gallon: Garlon 3A, Renovate 3, Tahoe 3A, Triclopyr 3A, Triclopyr 3SL	1 to 8 lb a.e./acre Max Rate (forestry sites): 6 lb a.e./ac per season. Max Rate (grazing sites): 2 lb a.e./acre per season Max Rate (other): 9 lb a.e./acre per season 10 to 400 gallons/acre	The use of non-ionic surfactants is recommended for most applications. Aerial applications: Helicopter only (for forestry applications). Fixed wing aircraft may be used on rice.

Table 5: Overview of Label Directions for Aquatic Applications

Formulation(s)	**Application Rates and Volumes**	**Adjuvants**
Note: This table presents a cursory overview of label directions. In any specific application, consult and follow the product label for the formulation that is being used.		
3 lb a.e./gallon: Garlon 3A, Triclopyr 3A	Follow directions for forestry and non-cropland sites. Emergent weeds only.	The use of nonionic surfactants is recommended for most applications. Appears to be labeled only for emergent weeds.
3 lb a.e./gallon: Renovate 3, Triclopyr 3SL	**Emergent weeds**: 0.5 to 6 lb a.e./acre Max Rate: 6 lb a.e./acre per season. Ground: 20 to 200 gallons/acre Aerial: ≥ 10 gal/acre **Submerged weeds**: 0.75 to 2.5 mg a.e./L Max Rate: 2.5 mg a.e./L per season	Nonionic surfactant recommended for most applications.
Granular, 10% a.e. Renovate OTF	1 to 2.5 mg a.e./L (floating and emersed) 0.5 to 2.5 mg a.e./L (submersed)	Not labeled for terrestrial applications. The use of surfactants is not included in the label directions.

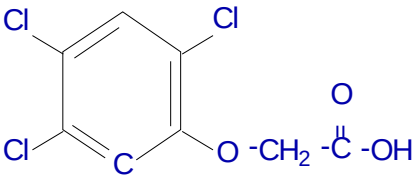
Table 6: Forest Service Use by Region for 2004

Region	Acres	Pounds	Average lbs/acre	Proportion of Total Acres	Proportion of Total Pounds
R1 (Northern)	363	424	0.86	0.034	0.030
R2 (Rocky Mountain)	128	155	0.83	0.012	0.011
R3 (Southwestern)	0	0	N/A	0	0
R4 (Intermountain)	637	546	1.17	0.044	0.053
R5 (Pacific Southwest)	45.3	74.6	0.61	0.006	0.004
R6 (Pacific Northwest)	442	1015	0.44	0.081	0.037
R8 (Southern)	10,410	10,302	1.01	0.823	0.866
R9 (Eastern)	0	0	N/A	0	0
R10 (Alaska)	0	0	N/A	0	0
Total	12,027	12,516	0.96		

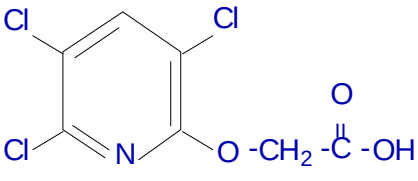
Table 7: Forest Service Use by Management Objective for 2004

Objective	Acres	Pounds	Average lbs/acre	Acres, Proportion of Total[1]	Pounds, Proportion of Total[1]
Release: Conifer	3869.3	4447.0	0.87	0.36	0.32
Noxious weeds	3275.5	3327.8	0.98	0.27	0.27
Site preparation	2196.8	2017.0	1.09	0.16	0.18
Release: Hardwood & Conifer	1432.6	1403.0	1.02	0.11	0.12
Release: Hardwood	661.6	962.0	0.69	0.077	0.055
Rights-of-way	483.0	251.0	1.92	0.020	0.04
Recreation Improvement	64.0	89.8	0.71	0.0072	0.0053
Wildlife Habitat Improvement	32.0	8.0	4.00	0.0006	0.0027
Facilities maintenance	5.8	4.6	1.27	0.0004	0.0005
Nursery weeds	3.4	4.7	0.72	0.0004	0.0003
Aquatic weeds	3.0	1.7	1.76	0.0001	0.0002
Total:	12,027.0	12,516.5	0.96		

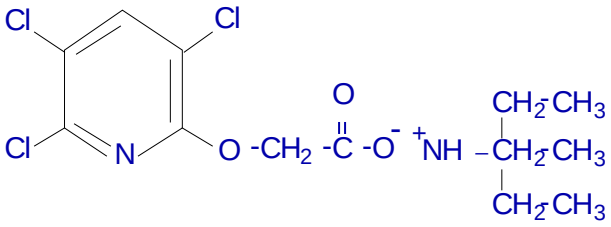
[1]Note: Due to rounding, the proportion of total acres sum to 1.0057 and the proportion of total pounds sums to 0.994.



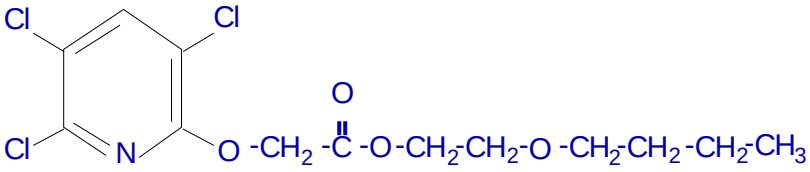
2,4,5-T



Triclopyr acid



Triclopyr, triethylamine salt



Triclopyr, Butoxyethyl ester (TBEE)

Figure 1: Structure of Triclopyr and Related Compounds

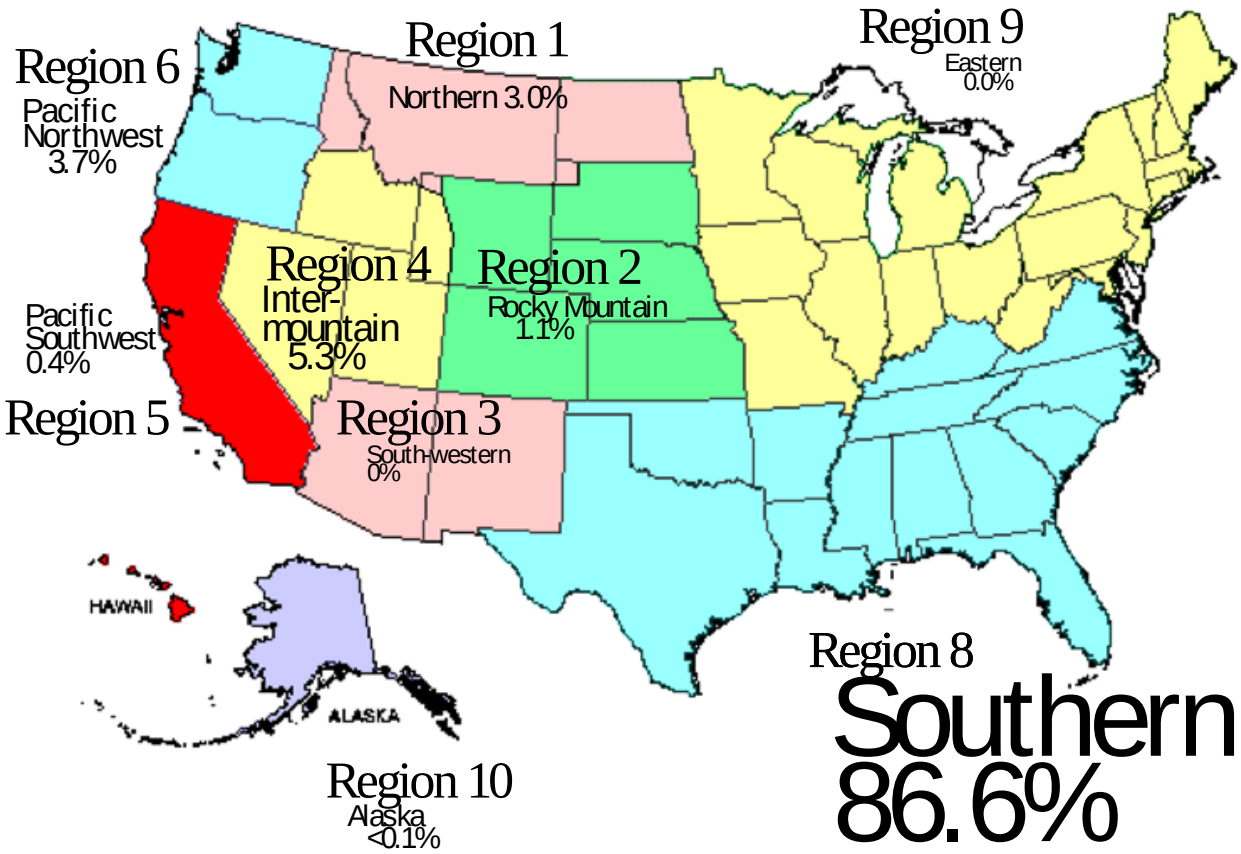
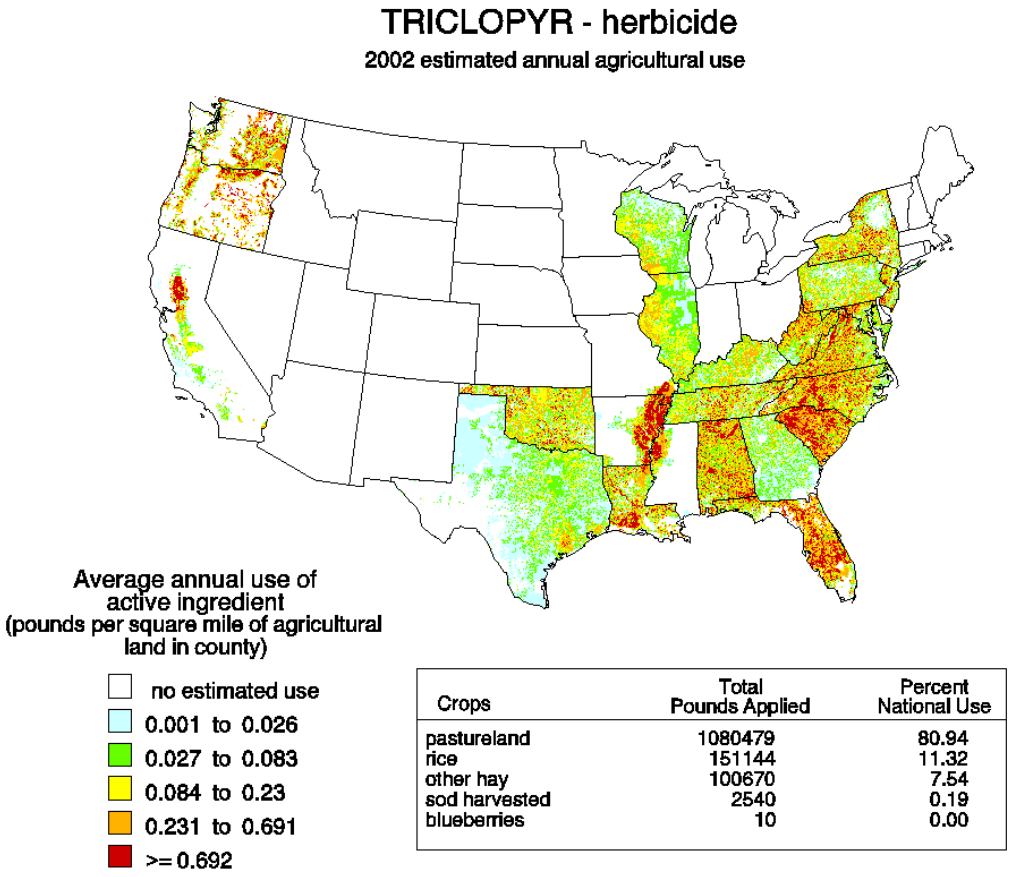


Figure 2: Triclopyr Use by Forest Service Region for 2004



Crops	Total Pounds Applied	Percent National Use
pastureland	1080479	80.94
rice	151144	11.32
other hay	100670	7.54
sod harvested	2540	0.19
blueberries	10	0.00

Figure 3: Agricultural Use of Triclopyr in 2002

Source: USGS 2003a

Appendix 1: Information from MSDSs for Triclopyr Formulations

A1 Table 1: Mammalian Toxicity Data from MSDSs

Formulation Name [a]	Oral LD_{50} (mg/kg bw)	Dermal LD_{50} (mg/kg bw)[d]	Inhalation LC_{50} (mg/L)	Eye Irritation [c]	Skin Irritation	Dermal Sensitization
BEE 13.6%						
Pathfinder II	1000 (F)	>2000	>5.0	Slight	Moderate	No (guinea pigs)
Remedy RTU	2389 (M) 1000 (F)	>2000	>5.0	Slight	May cause	No (guinea pigs)
BEE 60.5%						
Garlon 4 Ultra	3200	>5000	>5.05	Slight	Yes	Yes (mice)
Remedy Ultra	N/A	N/A		May cause	May cause	
BEE 61.6%						
Forestry Garlon	1581 (M) 1338 (F)	>2000 >5000 (rat)		Slight	May cause	May cause
Garlon 4	1581 (M) 1338 (F)	>2000	>5.2	Yes [1]		Yes (guinea pigs)
Remedy	1581 (M) 1338 (F)	>2000		Slight	Yes	May cause
Tahoe 4E	1581 (M) 1338 (F)	>2000	N/A	N/A	N/A	No
Triclopyr 4 Ester R&P	>1000	>2000	N/A	Minimal	Moderate	May cause
Triclopyr 4E	>1000	>2000	N/A	Minimal	Moderate	May cause
Triclopyr R&P	>1000	>2000	N/A	Minimal	Moderate	May cause
Triquad	1581 (M) 1338 (F)	>5000 (rat)	N/A	Moderate	N/A	Yes (guinea pig
BEE 83.9%						
Forestry Garlon XRT	2,966	>5000	>5.90	Moderate/C	Slight	Yes (mice)
TEA 14% Granular						
Renovate OTF[3]	5000[2]	5000[2]		Moderate	May cause	**Inhalation**[3]
TEA 44.4%						
Garlon 3A	2574 (M) 1847 (F)	>5000		Irreversible/C	May cause	May cause
Renovate 3	2,574 (M) 1847 (F)	>5000		Irreversible/C	May cause	May Cause
Tahoe 3A	2574 (M) 1847 (F)	>5000	N/A	Corrosive Irreversible	N/A	May cause
Triclopyr 3A	>1500	>2000	>2.5	Corrosive	Slight	May cause
Triclopyr 3SL	>1500	>2000	>2.5	Corrosive	Slight	May cause

[a] Sources: Specimen labels from www.Greenbook.net and www.CDMS.net.

[b] "N/A" designates that the MSDS explicitly states that no data are available. A blank indicates that no statements are made in the MSDS. **[During initial review of the program description, recheck the above table to make certain that this distinction is maintained.]**

[c] A "/C" indicates the possibility of corneal damage.

[d] Rabbit unless otherwise specified.

[1] *May cause pain disproportionate to the level of irritation to eye tissues.*

[2] These appear to be the results of limit tests and should probably be reported as > values.

[3] May cause sensitization by inhalation. This effect is not noted in any MSDSs for other formulations.