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# Glyphosate

## HERBICIDE INFORMATION PROFILE

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This information profile is produced by the USDA Forest Service, Pacific Northwest Region, for employees, forest workers, and for the public. It provides information on forest and land management uses, environmental and human health effects, and safety precautions for the herbicide glyphosate and its formulations. A list of definitions is included in Section VIII of the information profile. For general information on herbicide use by the Forest Service, refer to the PNW Region Treatment Methods Profile for Herbicides.

The principal sources of information and findings in this profile are the PNW Region FEIS (Final Environmental Impact Statement) for Managing Competing and Unwanted Vegetation; Forest Service "Herbicide Background Statement: Glyphosate;" and herbicide and surfactant product labels and Material Safety Data Sheets. Information from other sources is specifically referenced.

The PNW Region periodically publishes a bibliography of recent anecdotal and scientific accounts, and analyzes reported worker health effects. This herbicide information profile has been updated to reflect new information from a review of new literature through 1995.

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### I. BASIC INFORMATION

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COMMON NAME: Glyphosate

CHEMICAL NAME: N-(phosphonomethyl) glycine

COMMON PRODUCT NAMES: Accord<sup>®</sup>, Rodeo<sup>®</sup>, Roundup<sup>®</sup>, Roundup Pro<sup>®</sup>

PESTICIDE CLASSIFICATION: Herbicide

REGISTERED USE STATUS: "General Use"

FORMULATIONS: Commercial glyphosate products generally contain one or more inert ingredients. An inert ingredient is anything added to the product other than the active plant-killing ingredient. The names of inert ingredients are not usually listed on the label. The contents of three glyphosate formulations are listed below:

**Accord<sup>®</sup>**

glyphosate (41.5%) and water (58.5%)

**Rodeo<sup>®</sup>**

glyphosate (53.5%) and water (46.5%)

**Roundup<sup>®</sup>**

glyphosate (41.0%); related organic acids of glyphosate (1.5%); isopropylamine (0.5%); polyethoxylated tallow amine surfactant (15.4%) and water (41.6%) (Monsanto, a. undated.)

## Roundup Pro®

glyphosate (41%); phosphate ester neutralized ethoxylated tallow amine surfactant (14.5%) and water (44.5%)

Rodeo® and Accord® labels require that other chemicals, called surfactants, be added to the herbicide for certain kinds of spray applications. A herbicide + surfactant mixture may be equivalent to a formulation of the herbicide. Surfactants, when sold separately, are not tested as extensively as the herbicide itself. The PNW Region has reviewed available information on six surfactants recommended by Monsanto for use with Accord® or Rodeo®. This profile reviews publicly available information on potential effects on the human environment from using these surfactants in Forest Service applications. The surfactants and their manufacturers are:

Accord® herbicide + Entry II®                      Monsanto

Entry II surfactant consists of the same compounds, other than glyphosate, that are found in Roundup®. Roundup® formulation information in this profile characterizes potential effects from Accord® plus Entry II used in Forest Service applications.

Rodeo® herbicide + R-11®                      Wilbur-Ellis  
LI-700®                      Loveland Industries  
Agri-Dex®                      Helena Chemical  
Latron AG-98®-AG                      Rohm and Haas  
Latron AG-98®-N                      Rohm and Haas

Many surfactants could be used with Rodeo® to comply with label directions. These surfactants are recommended by Monsanto for use with Rodeo® in the Pacific Northwest (Yoder 1996). The chemical constituents of these surfactants, and data and evaluations of their effects are presented in this profile where information is available.

RESIDUE ASSAY METHODS: Gas/liquid chromatography and high performance liquid chromatography methods are available for residue assay. In

laboratory tests, an average of 82 percent of known glyphosate concentrations was recovered. New detection methods report 1.0 ppb detection limit, using simpler and shorter processes. (Oppenhuizen and Cowell, 1991).

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## II. HERBICIDE USES

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**REGISTERED FORESTRY, RANGELAND, RIGHT-OF-WAY USES:** Planting site preparation, conifer release, forest nurseries, rights-of-way and facilities maintenance, and noxious weed control. Rodeo® is labeled for control of plants growing in or immediately adjacent to water.

### OPERATIONAL DETAILS:

**TARGET PLANTS:** Glyphosate is used to control grasses, herbaceous plants, including deep rooted perennial weeds, brush, some broadleaf trees and shrubs, and some conifers. Glyphosate does not control all broadleaf woody plants. Timing is critical for effectiveness on some broadleaf woody plants and conifers.

**MODE OF ACTION:** Glyphosate is applied to foliage. It is absorbed by leaves and rapidly moves through the plant. Glyphosate prevents the plant from producing amino acids that are the building blocks of plant proteins. The plant, unable to make proteins, stops growing and dies. Glyphosate is metabolized or broken down by some plants, while other plants do not break it down. AMPA (aminomethylphosphonic acid) is the main break-down product of glyphosate in plants.

**METHOD OF APPLICATION:** Aerial spraying, spraying from a truck, backpack or hand-held sprayer; wiper application; frill treatment; cut stump treatment, and by cartridge injecting lance (E-Z-Ject®).

**USE RATES:** 0.3 to 4.0 pounds of active ingredient per acre.

### **SPECIAL PRECAUTIONS:**

Always read all of the information on the product label before using any pesticide. Read the label for application restrictions.

**TIMING OF APPLICATION:** Apply after leaves expand fully but before fall color change.

**DRIFT CONTROL:** Do not allow careless application or spray drift. Do not permit spray or spray drift to contact desirable plants.

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### **III. ENVIRONMENTAL EFFECTS/FATE**

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#### **SOIL:**

**RESIDUAL SOIL ACTIVITY:** Glyphosate does not have herbicidal properties once it contacts soil. It is not absorbed from the soil by plant roots.

A related chemical, called N-nitroso-glyphosate or NNG, has been detected in test soils after applying glyphosate at five times the normal use rate. No studies have found conclusive evidence of NNG production using normal application rates (Khan and Young 1977; Newton et al., 1984).

**ADSORPTION:** Glyphosate and the surfactant used in Roundup® are both strongly adsorbed by the soil.

**PERSISTENCE AND AGENTS OF DEGRADATION:** Glyphosate remains unchanged in the soil for varying lengths of time, depending on soil texture and organic matter content. The half-life of glyphosate in soil can range from 3 to 249 days. Soil microorganisms break down glyphosate. The surfactant in Roundup® has a soil half-life of less than 1 week. Soil microorganisms break down the surfactant.

**METABOLITES/DEGRADATION PRODUCTS AND POTENTIAL ENVIRONMENTAL EFFECTS:** The main break-down product of glyphosate in soil is AMPA (aminomethylphosphonic acid), which is broken down further by soil microorganisms. The main break-down

product of the surfactant used in Roundup® is carbon dioxide.

#### **WATER:**

**SOLUBILITY:** Glyphosate dissolves easily in water.

**POTENTIAL FOR LEACHING INTO GROUND-WATER:** The potential for leaching is low. Glyphosate and the surfactant in Roundup® are strongly adsorbed to soil particles and are not easily released back into water moving through soil. Monitoring found neither glyphosate nor AMPA were susceptible to leaching after a forest application in British Columbia (Feng and Thompson 1989).

**SURFACE WATERS:** Test shows that the half-life for glyphosate in water ranges from 35 to 63 days. The surfactant half-life ranges from 3 to 4 weeks. Studies examined glyphosate and AMPA residues in surface water after forest application in British Columbia with and without no-spray streamside zones. With a no-spray streamside zone, very low concentrations were sometimes found in water and sediment after the first heavy rain. Where glyphosate was sprayed over the stream, higher peak concentrations in water always occurred following heavy rain, up to 3 weeks after application. Glyphosate and AMPA residues peaked later in stream sediments, where they persisted for over 1 year. These residues were not easily released back into the water (Wan 1986).

#### **AIR:**

**VOLATILIZATION:** Glyphosate does not evaporate easily.

**POTENTIAL FOR BY-PRODUCTS FROM BURNING OF TREATED VEGETATION:** Major products from burning treated vegetation include phosphorus pentoxide, acetonitrile, carbon dioxide and water. Phosphorous pentoxide forms phosphoric acid in the presence of water. None of these compounds is known to be a

health hazard at the levels which would be found in a vegetation fire.

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#### IV. ECOLOGICAL EFFECTS

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##### SOIL MICROORGANISMS:

Most studies have shown no adverse effects on soil microorganisms, including soil nitrogen cycling processes (USDA-FS 1984). One study found a significant reduction in nitrogen fixation by bacteria associated with clover that was planted in a sandy soil 120 days after glyphosate was applied. The authors could not conclude whether the reduction was due to direct glyphosate effects on the bacteria, or on plant processes that support nitrogen fixation (Eberbach and Young 1983). Monitoring of Roundup® application to British Columbia forest soils found no long-term effects to any soil animals or microorganism populations over six months. Some populations were reduced after spraying but recovered within thirty days (Preston and Trofymow 1989). Monitoring of pine seedlings and associated mycorrhizal fungi found no effect on seedling growth or ectomycorrhizal development following field applications of glyphosate in Ontario, Canada (Chakravarty, P. and Chartapaul, L. 1990).

##### PLANTS:

Contact with non-target plants may injure or kill plants. Roundup® was not toxic to algae species in British Columbia forest streams at post-spray levels, and appears to act as a source of phosphorus for algal growth where the nutrient is in short supply. (Austin et al., 1991).

##### AQUATIC ANIMALS:

Glyphosate is no more than slightly toxic to fish, and practically non-toxic to amphibians (McComb 1990) and aquatic invertebrate animals. Glyphosate is more toxic in alkaline water than in acidic water. Glyphosate and its formulations have not been tested for long-term effects in aquatic animals.

The Roundup® formulation is moderately toxic to freshwater fish and slightly toxic to aquatic invertebrate animals. No synergistic effects between glyphosate and the surfactant POEA have been measured (SERA, Inc. 1997a). In contrast to glyphosate, POEA is less toxic in alkaline water than in acidic water. Acute toxic levels for Roundup® are:

<u>species</u>	<u>LC50</u>
frog	7.7 to 39.7 ppm
fish	5 to 26 ppm
invertebrates	4 to 37 ppm

Although the surfactant in Roundup Pro® is chemically similar to POEA in Roundup®, no data are available to assess its actual toxicity to aquatic organisms.

The Accord® and Rodeo® formulations are practically non-toxic to freshwater fish and aquatic invertebrate animals.

<u>Rodeo® and Accord® species</u>	<u>LC50</u>
fish	>1,000 ppm
invertebrates	930 ppm

Monsanto conducted aquatic toxicity studies on three surfactants recommended for use with Rodeo® (McLaren/Hart 1995). Studies for R-11® and LI-700 were reviewed and accepted by California EPA (Lapurga 1996). R-11® would be classified as Moderately Toxic to fish and Slightly Toxic to invertebrates; LI-700® and Agri-Dex® would be classified as Practically Non-toxic to both fish and invertebrates.

<u>species</u>	<u>surfactant</u>	<u>LC50</u>
fish	R-11®	3.8 mg/l
	LI700®	130.0 mg/l
	Agri-Dex®	> 1000.0 mg/l
invertebrates	R-11®	19.0 mg/l
	LI700®	190.0 mg/l
	Agri-Dex®	> 1000.0 mg/l

These data do not allow any conclusions of absolute toxicity of formulations, or of relative toxicity among Rodeo® + surfactant formulations. The combined toxicity of Accord® + Entry II® (tested as Roundup®) is lower than would be predicted based on acute toxicity of the two components (SERA, Inc. 1997b).

Glyphosate does not build up (bioaccumulate) in fish. A misprinted concentration in fish fillets in one published study has caused confusion (Folmar 1984).

**TERRESTRIAL ANIMALS:**

Glyphosate has been tested on a variety of wildlife birds and mammals in both laboratory and wildland environments. Data for a single toxic dose (LD50) classify glyphosate as Practically Non-toxic to tested insects and birds. Data for multiple dietary doses classify glyphosate as no more than Slightly Toxic to birds (US EPA 1993a.).

**GLYPHOSATE**

<u>species</u>	<u>LD50</u>	<u>LC50</u>
bobwhite quail	>1000 mg/kg	>4640 mg/kg
mallard duck		>4640 mg/kg
bee	>100 micrograms/bee = ~1075 mg/kg (SERA 1996d)	

Data for laboratory mice adequately characterized acute toxicity of glyphosate to seven of nine tested wildlife mammal and amphibian species; adequacy could not be predicted for two other amphibian species (McComb 1990).

No significant effects on survival and reproduction of deer mice and Oregon voles were observed over five years following Roundup® release treatment of Douglas-fir plantations in British Columbia. Roundup® had little or no direct effect on development of young mice or vole populations; however possible health effects on individual animals were not directly studied (Sullivan 1990). Non-lethal or behavioral effects

on rough-skinned newts and Townsend’s chipmunks could not be detected following glyphosate application in PNW forests (McComb 1990). Field studies indicate that application rates of glyphosate greater than the rates used in Forest Service applications, toxic effects on terrestrial mammals will be secondary to habitat changes resulting from vegetation treatment (SERA, Inc. 1996e.)

In mammals, most glyphosate is excreted, unchanged, in urine and feces. Glyphosate was not broken down in rats given oral doses, and it did not bioaccumulate (Brewster et al. 1991).

Glyphosate and its formulations have not been tested for chronic toxicity on wildlife species. Testing on laboratory mammals of glyphosate and its formulations are reported in Section V.

**THREATENED AND ENDANGERED SPECIES:**

Glyphosate may be a hazard to endangered plants if it is applied to areas where they live. EPA identified 76 species that may be endangered by glyphosate use, including 74 plant, one toad and one beetle species.

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**V. HEALTH EFFECTS TESTING**

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These data are results of laboratory animal studies. These data have been evaluated by the Forest Service and are used to make inferences relative to potential human health effects.

For glyphosate and its formulations, findings are from studies conducted by the manufacturer. These studies have been presented to EPA to support product registration, but may not be available to the public.

For glyphosate, the Environmental Protection Agency has evaluated these studies during the registration process. For Roundup® formulations, data are from studies supported by the manufacturer that are cited in the Material Safety Data Sheet. The Rodeo® and Accord® formulations, which consist of glyphosate and water

only, are not cited because they are not expected to cause any greater health effects than concentrated glyphosate.

For LI-700® surfactant, data are from studies reviewed by California Department of Pesticide Regulation (Lapurga 1996). Product manufacturers reported the data for the other surfactants in MSDS or technical information sheets.

**Table 2-1. Acute Toxicity**

<b>PRODUCT NAME</b>	<b>ACUTE ORAL TOXICITY</b> (tests in male & female rats)	<b>ACUTE DERMAL TOXICITY</b> (tests on rabbits)
Glyphosate	Median lethal dose: 4,320 mg/kg. Slightly toxic (Category III)	Median lethal dose (males): 5,010 mg/kg (females): 794 mg/kg Slightly toxic (Category III)
Roundup® formulation	Median lethal dose: 5,000 mg/kg. Slightly toxic (Category III)	Median lethal dose: >5,000 mg/kg Practically nontoxic (Category IV)
Roundup Pro® formulation	Median lethal dose: >5,000 mg/kg. Practically nontoxic (Category IV)	Median lethal dose: >5,000 mg/kg Practically nontoxic (Category IV)
Agri-Dex® surfactant	Median lethal dose: >5,010 mg/kg. Practically nontoxic (Category IV)	Median lethal dose: >2,020 mg/kg Slightly toxic (Category III)
Entry II® surfactant	Median lethal dose: >100 mg/kg. Moderately toxic (Category II)	Median lethal dose: >100 mg/kg Moderately toxic (Category II)
Latron AG-98®-AG & AG-98®-N	Not specified	Not specified
LI-700® surfactant	Median lethal dose: >5,000 mg/kg. Practically nontoxic (Category IV)	Median lethal dose: >5,000 mg/kg Practically nontoxic (Category IV)
R-11® surfactant	Not specified	Not specified
<b>PRODUCT NAME</b>	<b>PRIMARY SKIN IRRITATION</b> (tests on rabbits)	<b>PRIMARY EYE IRRITATION</b> (tests on rabbits)
Glyphosate	Not an irritant. (Category IV)	Mild eye irritant. (Category III)
Roundup® formulation	Slightly irritating (Category III)	Moderately irritating (Category II)
Roundup Pro® formulation	Essentially non-irritating	Slightly irritating (Category III)
Agri-Dex® surfactant	Moderately irritating (Category II)	Slightly irritating (Category III)
Entry II® surfactant	Irritating, may cause allergic reaction	Severely irritating to corrosive (Category I)
Latron AG-98®-AG surfactant	Severely irritating (Category I)	Moderately irritating (Category II)
Latron AG-98®-N surfactant	Moderately irritating (Category II)	Severely irritating to corrosive (Category I)
LI-700® surfactant	Severely irritating (Category I)	Severely irritating (Category I)
R-11® surfactant	Moderately irritating (Category II)	Moderately irritating (Category II)
<b>PRODUCT NAME</b>	<b>ACUTE INHALATION</b> (this requirement was waived by the EPA for glyphosate)	
Roundup® formulation	Median lethal concentration: 3.18 mg/l (Rat) Slightly toxic (Category III)	
Roundup Pro® formulation	Median lethal concentration: 4.2 mg/l Practically nontoxic (Category IV)	

## **CHRONIC TOXICITY:**

These data are also based on tests in laboratory animals. EPA requires chronic toxicity tests only for the active ingredient glyphosate. Please refer to Section X for an explanation of how NOEL (No Observable Effects Level) is calculated.

The Pacific Northwest Region FEIS risk assessment evaluated the quality of the testing that had been done for glyphosate up to 1988. Quality consideration for individual studies included: ranges of doses and species that were tested; length of test; identification of the most sensitive effect. Additionally, the degree of quantitative agreement among all tests for an effect was considered. Please refer to Section X for an explanation of qualitative ratings in this section.

## **SYSTEMIC TOXICITY:**

NOEL for glyphosate: 31 mg/kg/day (rat); 20 mg/kg/day (dog)

The PNW Region FEIS rated the quality of testing as Marginally Adequate; the dose at which effects are seen in animal studies varies widely.

After repeated skin exposure for three weeks to Roundup® formulation at five times recommended use concentration, severe skin irritation and systemic toxic effects were observed in rabbits. Slight to moderate skin irritation was the only effect in rabbits treated with three times recommended use strength.

## **CARCINOGENICITY:**

The PNW Region FEIS rated the quality of testing as Marginally Adequate, and assumed that glyphosate could cause cancer. Since the 1988 rating, EPA has concluded that glyphosate should be classified as having evidence of non-carcinogenicity for humans. There was no convincing evidence of carcinogenicity in new studies in two animal species (Dykstra and Ghali 1991).

Glyphosate was negative in tests for mutagenic-

ity (the ability to cause genetic damage).

## **REPRODUCTION/DEVELOPMENTAL:**

The EPA and the PNW Region FEIS used a NOEL of 10mg/kg/day, based on observed kidney effects in rat pups.

The PNW Region FEIS evaluated the testing as Marginally Adequate for these effects.

## **IMMUNE SYSTEM EFFECTS**

The PNW Region FEIS evaluated the testing as Inadequate for these effects.

## **NERVOUS SYSTEM EFFECTS**

The PNW Region FEIS evaluated the testing as Inadequate for nervous system effects.

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## **VI. HUMAN HEALTH EFFECTS**

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### **FOREST SERVICE EVALUATION OF HUMAN HEALTH RISKS:**

The Pacific Northwest Region evaluated a range of glyphosate health effects data, including some laboratory studies cited in Section V. Both quantitative (numerical) estimates of toxicity, and the quality of data used to make numerical estimates were evaluated. The new information cited in Section V would improve the “quality of information” ratings in those categories. No new studies indicated a reduced margin of safety which would warrant additional restrictions on use of glyphosate beyond those specified in the FEIS.

The FEIS Quantitative Risk Assessment predicts the amount of human exposure—both to project workers and to the public—from typical forestry operations, and also from a large accidental spill. The Risk Assessment used this information to assess health risks from typical uses. These risks were compared to EPA standards of acceptable risk for human health effects. The FEIS risk assessment identified as “Moderate” or “High” any predicted risks from Forest Service operations that were greater than EPA standards.

Specific mitigation measures were designed to reduce human exposure from these operations; they are mandatory for every applicable project on National Forest lands.

The complete set of risk ratings is displayed in Sec. X.

The quality of the existing data affects the reliability of these risk ratings. The FEIS judged the overall quality of available data on glyphosate toxicity to be "Marginal." There were studies of adequate quality and results did not vary greatly, but more information would increase reliability. Although new studies may change estimates of health effects, the results are considered moderately reliable.

#### **POTENTIAL FOR HEALTH EFFECTS TO THE PUBLIC:**

Forest visitors and nearby residents could be exposed to herbicide drift, to vegetation with herbicide residues, and to accidental spraying. They also could eat food or drink water containing herbicide residues.

No studies of public exposure to forest herbicide applications were available. Public doses were estimated based on the behavior of the herbicide in the environment. "Routine Application" estimates maximum possible public exposure under normal operating conditions. The "Large Spill" situation models the highest doses that could ever be reasonably be expected to occur. Typical public exposures and risks would be much lower than either situation.

#### **MITIGATING MEASURES TO REDUCE GLYPHOSATE RISKS TO PUBLIC:**

"Low" risk of general health effects for all routine projects. "Moderate" risk of reproductive health effects for people who receive multiple exposures to glyphosate from a large (400-acre) aerial application project. "Low" risk for smaller (40-acre) aerial projects, and for all ground-based applications:

Consider potential for public exposure when

designing contact procedures, posting and signing needs in the Herbicide Application Plan.

"Moderate" risk of general health effects, and "High" risk of reproductive effects if exposed to concentrated glyphosate from a large spill:

Prevent all public contact with accidental spills (emergency spill notification system, restrict public access to spill site).

#### **PROBABILITY OF A WORKER RECEIVING A DOSE WHICH AFFECTS GENERAL HEALTH OR REPRODUCTION:**

Worker exposure and dose are estimated for typical forestry applications. Worker doses do not account for any reduction in exposure from following safety precautions or mitigating measures (such as wearing protective clothing).

Studies are available that measure actual worker doses of herbicide for some typical forestry applications. Backpack applicators of Roundup® in forest plantations have been monitored for the doses they absorbed in actual spray operations (Middendorf 1993). The measured doses for workers averaged 1/1000 the amount that was predicted in the PNW Region FEIS for Routine applications, and 1/67 the amount predicted for a Worst-case application situation. The worker risks would be much lower than the risk estimates used in the PNW Region FEIS (shown in this Profile) if these new operational doses were used.

#### **MITIGATING MEASURES TO REDUCE IDENTIFIED GLYPHOSATE RISKS TO WORKERS:**

The probability of worker exposure to a toxic concentration for general health effects was rated "Low" or "Negligible" for all application methods. The probability of worker exposure to a toxic concentration for reproductive effects was rated "Low" or "Negligible" for aerial and tank truck mixer/loaders; "Moderate" for backpack spray and hack-and-squirt applicators.

In the PNW Region FEIS, Mitigating Measure



13 requires workers applying any herbicide to wear protective clothing. Mitigating Measure 23 requires worker exposure monitoring for all herbicide application projects.

The 1992 Amendment to the ROD requires workers to review this Information Profile before agreeing to apply glyphosate herbicides. The worker may request reassignment without penalty. Additional personal protective equipment will be available at the worksite for workers who want to reduce their exposure to the herbicide.

#### **ACUTE TOXICITY (POISONING)**

**REPORTED EFFECTS:** Most incidents reported in humans have involved skin or eye irritation in workers after exposure during mixing, loading or application of glyphosate formulations. Nausea and dizziness have also been reported after exposure.

Swallowing the Roundup® formulation caused mouth and throat irritation, pain in the abdomen, vomiting, low blood pressure, reduced urine output, and in some cases, death. These effects have only occurred when the concentrate was accidentally or intentionally swallowed, not as a result of the proper use of Roundup®. The amount swallowed averaged about 100 milliliters (about half a cup).

#### **CHRONIC TOXICITY:**

**Reported Effects:** There are no reported cases of long term health effects in humans due to glyphosate or its formulations.

#### **POTENTIAL FOR ADVERSE HEALTH EFFECTS FROM INERT INGREDIENTS AND SURFACTANTS:**

The manufacturer has identified the inert ingredients in glyphosate formulations to the EPA and to the public. Inert ingredients in the Roundup® formulation include water and surfactant POEA. POEA is a skin irritant and a severe eye irritant in concentrate form (Entry II). The surfactant compounds are more dilute and less toxic in the Roundup® formulation. The only inert

ingredient in Rodeo® or Accord® is water, which is considered nontoxic.

EPA classified all inerts into one of four categories, called "Lists." List 1 contains chemicals of known toxic concern. List 2 contains chemicals of suspected toxic concern which are high priority for testing. List 4A contains chemicals of minimal concern, and List 4B contains chemicals with sufficient information to conclude that current uses will not adversely affect public health and the environment. All other chemicals were classified on List 3: Inerts of unknown toxicity. EPA did not find enough information available on the toxic properties of List 3 chemicals to classify them on Lists 1, 2, or 4.

The EPA classifications for all identified compounds in the four surfactants recommended for use with Rodeo®. Some compounds were not classified by EPA; other compounds were not identified precisely enough to be correlated with any chemical on the EPA Lists.

**Table 2-2. EPA inerts list classification for constituents of selected surfactants.<sup>a</sup>**

Surfactant Product	Chemical Constituents <sup>b</sup>	CAS No.	EPA Inerts Classification
Agri-Dex <sup>®</sup>	Polyol fatty acid esters <sup>c</sup>	NA	—
	Polyoxyethyl polyol fatty acid esters <sup>c</sup>	NA	—
	Paraffin base petroleum oil	64741-88-4	NC
		64741-89-5	NC
LI-700 <sup>®</sup>	Phosphatidylcholine	8002-43-5 <sup>d</sup>	4A
	Propionic acid	74-09-4	4B
	Alkylpolyoxyethylene ether <sup>c</sup>	NA	—
R-11 <sup>®</sup>	Octylphenoxypolyethoxyethanol	9036-19-5 <sup>e</sup>	4B
	n-Butanol	71-36-3	4B
	Compounded silicone <sup>c</sup>	NA	—
Latron AG-98 <sup>®</sup> -AG	Octylphenoxypolyethoxyethanol	9036-19-5	4B
	Isopropanol	67-63-0	4B
	Polydimethylsiloxane	63148-62-9	4B
Latron AG-98 <sup>®</sup> -N	Nonylphenoxypolyethoxyethanol	68412-54-4	3
	n-Butanol	71-63-3	4B
	Silicone antifoam compound <sup>c</sup>	NA	—

<sup>a</sup> EPA classification of Inert Ingredients in Pesticides (US EPA 1994): List 1 = Toxicological concern; List 2 = Potentially toxic with high priority for testing; List 3 = Unknown toxicity; List 4 = minimal concern (further subdivided into: List 4A = classified in US EPA 1987 as List 4; and List 4B = sufficient information to conclude that current use patterns in pesticide products will not adversely affect public health and the environment).

<sup>b</sup> Sources: Technical data sheets, material data safety sheets for surfactant products.

<sup>c</sup> Not sufficiently described to identify the specific constituent(s).

<sup>d</sup> lecithins

<sup>e</sup> polyoxyethylene (1, 1, 3, 3-tetramethylbutyl) phenyl ether

NA, not available; NC, not classified

### HEALTH EFFECTS OF EXPOSURE TO FORMULATED PRODUCTS:

Because Accord<sup>®</sup> and Rodeo<sup>®</sup> contain water as the only inert ingredient, health effects are assumed to be no greater than those for pure glyphosate. The Roundup<sup>®</sup> formulation is moderately toxic, and may cause skin irritation and eye irritation. Effects of Roundup<sup>®</sup> characterize the effects expected for a spray mix of Accord<sup>®</sup> with Entry II surfactant. Roundup Pro<sup>®</sup> appears to be similar in toxic properties to Roundup<sup>®</sup> except it may be less irritating to the skin and eyes (SERA, Inc. 1997d).

Inadequate data exists for Rodeo<sup>®</sup> + surfactant

formulations to assess their potential for toxic effects. Aquatic and mammalian toxicology data for some of the surfactants is displayed in Sections IV, V, VI, and VII of this profile. However, these data alone are insufficient for predicting either the toxicity of the formulations, or the potential for various surfactants to affect the toxicity of Rodeo<sup>®</sup> (SERA 1997e).

### HEALTH EFFECTS ASSOCIATED WITH CONTAMINANTS:

Glyphosate contains the contaminant N-nitroso glyphosate (NNG) at 0.1 ppm or less. The potential for NNG to cause cancer is unknown. The EPA has not assessed the health risks of NNG.

No carcinogenic effects were observed in tests of glyphosate; the EPA concluded these tests were evidence of noncarcinogenicity. (Dykstra and Ghali, 1991)

1,4-dioxane, a known cancer-causing agent, is a common contaminant of ethoxylated surfactants. The EPA decided that reported trace levels of 1,4-dioxane (0.030%) in the Roundup® formulation were not likely to result in unreasonable adverse health effects. More recently, Monsanto reports that 1,4-dioxane contamination has been further reduced to 23 ppm (Monsanto Corp. Undated(b)).

#### **HEALTH EFFECTS ASSOCIATED WITH OTHER FORMULATIONS:**

Some formulations contain glyphosate mixed with other herbicides such as 2,4-D or dicamba. This profile does not fully describe the potential for health or environmental effects from these formulations containing multiple herbicides. Additional information on properties and potential effects of these formulations will be prepared before they are used in the PNW Region.

#### **SOCIETAL PERCEPTIONS:**

Public opinion about herbicide use in general ranges from a perception that herbicides are completely safe, to a perception that they are very hazardous. A full range of opinion is available in the FEIS.

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## **VII. SAFETY PRECAUTIONS:**

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#### **SIGNAL WORD AND DEFINITION:**

**Roundup®:** WARNING - Causes substantial but temporary eye injury. Harmful if inhaled.

**Rodeo®:** CAUTION - May cause eye irritation. May be harmful if inhaled.

**Accord®:** CAUTION - May cause eye irritation.

**Agri-Dex®:** CAUTION - Mild skin and eye irritant.

**Entry II®:** DANGER - Causes eye burns. Causes skin irritation. Harmful if swallowed. May cause allergic skin reaction.

**Latron AG-98®-AG:** WARNING - Causes severe eye and skin irritation. Vapor harmful if inhaled. Harmful if swallowed.

**Latron AG-98®-N:** WARNING - Causes severe eye irritation and possible permanent injury. Causes skin irritation. Vapor harmful if inhaled. Harmful if swallowed.

**LI-700®:** DANGER - Liquid causes skin and eye injury.

**R-11®:** CAUTION - Causes eye irritation. May cause skin irritation. Harmful if swallowed.

#### **PROTECTIVE PRECAUTIONS FOR WORKERS:**

Avoid contact with eyes, skin or clothing. Avoid breathing vapors or spray mist. Wash thoroughly with soap and water after handling.

#### **MEDICAL TREATMENT PROCEDURES (ANTIDOTES):**

There is no specific antidote for glyphosate; treat symptoms. For exposure to the eyes, flush with plenty of water for at least 15 minutes. Get medical attention. For exposure to the skin, flush skin with plenty of water. In case of emergency, call your local poison control center for advice.

#### **HANDLING, STORAGE AND DISPOSAL:**

Glyphosate is corrosive to unlined steel and galvanized steel. Do not mix, store or apply glyphosate in galvanized steel or unlined steel containers of spray tanks. Glyphosate is stable under normal storage conditions for at least 5 years. Wastes should be disposed of in a landfill approved for pesticide disposal or according to federal, state, and local rules. Do not contaminate water, food, animal feeds or seed by storage.

## EMERGENCY (SPILL) HAZARDS AND PROCEDURES:

Spills that soak into the ground should be dug up and put in plastic-lined metal drums for disposal. Spills on floors or other hard surfaces should be contained or diked. An absorbent clay should be used to soak up the spill. The contaminated absorbent should be put in plastic-lined metal drums. Drums of contaminated soil should be disposed of in a landfill approved for pesticide disposal or according to federal, state and local rules. Do not contaminate water, food, animals feeds or seeds by disposal. In case of a large spill, call CHEMTREK at 1-800-424-9300 for advice.

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## VIII. DEFINITIONS

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**acute toxicity** - the amount of a substance, as a single dose, to cause poisoning in a test animal

**adsorption** - the process of attaching to a surface

**basal treatment** - applied to the stem of a plant just above the soil

**bioaccumulate** - the uptake of a chemical by an organism from its environment

**broadcast application** - applied over an entire area

**carcinogenicity** - ability to cause cancer

**chronic toxicity** - toxic effects produced in test animals exposed for long periods to a chemical

**dermal** - of, or related to, the skin

**EC50** - the concentration which will cause a toxic effect in 50% of the subjects

**formulation** - the form in which the pesticide is supplied by the manufacturer for use

**half-life** - the time required for a chemical to be reduced by natural processes to one half its original amount

**herbicide** - a substance used to destroy plants or to slow down their growth

**LC50** - the concentration in air or water which will kill 50% of the subjects

**LD50** - the dose which will kill 50% of the subjects

**leach** - to dissolve out by the action of water

**mg/kg** - milligrams of the substance per kilogram of body weight. Equals ppm

**mg/l** - milligrams of dissolved substance per liter of water. Equals ppm

**microorganisms** - living things too small to be seen without a microscope

**mutagenicity** - ability to cause genetic changes

**non-target** - animals or plants other than the ones which the pesticide is intended to kill

**persistence** - tendency of a pesticide to remain in the environment after it is applied

**ppb** - parts per billion parts

**ppm** - parts per million parts. Equal to mg/kg, and mg/l

**residual activity** - the remaining amount of activity as a pesticide

**sensitizer** - a delayed allergic response to a substance; symptoms usually resemble an acute toxic response

**surfactant** - a chemical added to a spray mixture to improve the ability of the pesticide to stick to and be absorbed by the plant surface

**teratogen** - a compound having the property of causing birth defects

**volatility** - the tendency to become a vapor at relatively low temperature

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## IX. INFORMATION SOURCES

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### U.S. GOVERNMENT AGENCY PUBLICATIONS

Forest Service, U.S. Department of Agriculture, 1984. *Herbicides*. Agriculture Handbook No. 633.

- Pacific Northwest Region, Forest Service, USDA, Portland, OR, 1988. *Final Environmental Impact Statement for Managing Competing and Unwanted Vegetation*.
- Chapter IV, Environmental Consequences: Human Health Effects Characterization and Management of Risk
- Appendix C: Herbicide Use and Efficacy
- Appendix D: Quantitative Risk Analysis
- Appendix J: Herbicide Review with Wildlife-oriented Effects
- U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC, 1986. *Pesticide Background Statements. Volume 1*. EPA Publication No. 540/FS-88-124
- U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances, Washington D.C. 1993a. *Reregistration Eligibility Decision: Glyphosate*. EPA Publication No. EPA 738-R-93-014.
- U.S. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances, Washington D.C. 1993b. *Pesticide Tolerances for Glyphosate (Proposed Rule)*. Federal Register, Vol. 58, No. 85, May 5, 1993, pp. 26725-26727.
- U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances, Washington, DC. 1986. *Guidance for the Reregistration of Pesticide Products Containing Glyphosate as the Active Ingredient*. EPA Publication No. 540/RS-R6-156,
- Forest Service, USDA, Atlanta, GA. 1989. *Final Environmental Impact Statement. Vegetation Management in the Coastal Plain/Piedmont*. Management Bulletin R8-MB-23.
- Forest Service, USDA, San Francisco, California, 1989. *Final Environmental Impact Statement. Vegetation Management for Reforestation*.
- MONSANTO AGRICULTURAL COMPANY PUBLICATIONS**
- Monsanto Corp. (anon.). 1992. *Roundup® Material Safety Data Sheet*.
- Monsanto Corp. (anon.). 1993a. *Accord® Material Safety Data Sheet*.
- Monsanto Corp. (anon.). 1993b. *Rodeo® Material Safety Data Sheet*.
- Monsanto Corp. (anon.). Undated(a). *Backgrounder; Roundup® Herbicide Ingredients*.
- Monsanto Corp. (anon.). Undated(b). *1,4-Dioxane Questions and Answers*.
- OTHER SOURCES**
- American Conference of Governmental Industrial Hygienists, Inc. 1991. *Documentation of the Threshold Limit Values and Biological Exposure Indices*. ACGIH, Inc. Cincinnati, OH. pp 512-515.
- Austin, A.P., Harris, G.E., and Lucey, W.P. 1991. *Impact of an Organophosphate Herbicide (Glyphosate) on Periphyton Communities Developed in Experimental Streams*. Bull. Environ. Contam. Toxicol. 47: 29-35.
- Brewster, D. W., Warren, J., and Hopkins, W.E. 1991. *Metabolism of Glyphosate in Sprague-Dawley Rat: Tissue Distribution, Identification, and Quantitation of Glyphosate-Derived Materials following a Single Oral Dose*. Fundamental and Applied Toxicology 17: 43-51.
- Chakravarty, P., and Chartapaul, L. 1990. *Non-target Effect of Herbicides: II. The Influence of Glyphosate on Ectomycorrhizal Symbiosis of Red Pine under Greenhouse and Field Conditions*. Pestic. Sci. 0031-613X.

- Dykstra, W., and Ghali, G. 1991. *Second Peer Review of Glyphosate*. U.S. Environmental Protection Agency Memo.
- Eberbach, P. L.; Douglas, L. A. 1983. *Persistence of Glyphosate in a Sandy Loam*. *Soil Biology and Biochemistry* 15 (4). 485-487.
- Feng, J.C., and Thompson, D.G. 1989. *Persistence and Dissipation of Glyphosate in Foliage and Soils of a Canadian Coastal Forest Watershed*. In: Proceedings of the Carnation Creek Herbicide Workshop. Forestry Canada, FRDA Report ISSN 0835-0752; 063.
- Folmar, Dr. Leroy C. , U.S. Department of Commerce, National Oceanic and Atmospheric Administration. 1984. *Personal Communication to Dr. Robert A. Campbell re: Error in Published Roundup® Concentration in Fish Fillets*.
- Khan, Shahamat U., and Young, J. Christopher. 1977. *N-Nitrosamine Formation in Soil from the Herbicide Glyphosate*. *Journal of Agricultural and Food Chemistry* 25; no. 6: 1430-1432.
- Middendorf, P.J. 1993. *Forest worker exposures to glyphosate during directed foliar applications of Roundup® herbicide*. Rep. Project #A-8196-000. Ga. Tech. Res. Inst., Ga. Inst. Tech., Environ. Sci. and Technol. Lab. 71 p.
- Newton, Michael, et al. 1984. *Fate of Glyphosate in an Oregon Forest Ecosystem*. *Journal of Agricultural and Food Chemistry* 32, no. 5. 1144-1151.
- Oppenhuizen, M.E.; Cowell, J.E. 1991. *Liquid Chromatographic Determination of Glyphosate and AMPA in Environmental Water: Collaborative Study*. *J. Assoc. Off. Anal. Chem.* Vol. 74, No. 2.
- Preston, C.M. and Trofymow, J.A. 1989. *Effects of Glyphosate (Roundup®) on Biological Activity of Two Forest Soils*. In: Proceedings of the Carnation Creek Herbicide Workshop. Forestry Canada, FRDA Report ISSN 0835-0752; 063.
- Sullivan, Thomas P. 1990. *Influence of Forest Herbicide on Deer Mouse and Oregon Vole Population Dynamics*. *J. Wildlife Management*, Vol 54, No. 4: 566-576.
- Wan, M.T.K. 1989. *The Persistence of Glyphosate and its Metabolite Amino-methylphosphonic Acid in Some Coastal British Columbia Streams*. *Environment*. Canada, Environmental Protection Service, Pacific and Yukon Region, Regional Program Report 85-0

*For more information on glyphosate contact your local Forest Service Office*

February 1997

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## **X. TOXICITY AND RISK CATEGORIES**

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### **ESTIMATES OF HEALTH RISKS TO THE PUBLIC AND TO WORKERS FROM FOREST SERVICE OPERATIONS**

The FEIS predicts levels of human exposure (dose) for project workers and for the public, for both a typical field project and for a large accidental spill. These dose levels are compared to the highest dose level in animal tests that showed no health effect (No Observed Effects Level). The risk is ranked from “Negligible” to “High” based on the margin between the expected human dose and the highest NOEL—”no effect” dose. A “High” risk rating means that the highest NOEL dose is not more than ten times larger than predicted human dose under the specified conditions. A “Moderate” risk rating means that the highest NOEL dose is between 10 and 100 times larger than the expected human dose.

<b>Estimated Health Risks To The Public</b>		
<b>Situation</b>	<b>General Health</b>	<b>Reproduction</b>
<b>Routine Large Aerial Application</b>	Moderate	Moderate
<b>Routine Application Other</b>	Low	Low
<b>Large Spill</b>	High	High

<b>Estimated Health Risks To Project Workers</b>		
<b>Situation</b>	<b>General Health</b>	<b>Reproduction</b>
<b>Aerial Mixer/Loader</b>	Low	Low
<b>Backpack Sprayer</b>	Moderate	Moderate
<b>Right-of-way Mixer/Loader</b>	Negligible	Negligible
<b>Hack-and-Squirt</b>	Low	Low

\* Glyphosate was presumed not to be used in hack-and-squirt operations.

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**ECOTOXOLOGICAL CATEGORIES**

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<b>Mammalian (Acute Oral):</b>	
<i>mg/kg</i>	<i>Risk Category</i>
<10	very highly toxic
10-50	highly toxic
51-500	moderately toxic
501-2000	slightly toxic
>2000	practically non toxic

<b>Avian (Acute Oral):</b>	
<i>mg/kg</i>	<i>Risk Category</i>
<10	very highly toxic
10-50	highly toxic
51-500	moderately toxic
501-2000	slightly toxic
>2000	practically non toxic

<b>Avian (Dietary):</b>	
<i>ppm</i>	<i>Risk Category</i>
<50	very highly toxic
50-500	highly toxic
501-1000	moderately toxic
1001-5000	slightly toxic
>5000	practically non toxic

<b>Aquatic Organisms:</b>	
<i>ppm</i>	<i>Risk Category</i>
<0.1	very highly toxic
0.1-1	highly toxic
>1-10	moderately toxic
>10-100	slightly toxic
>100	practically non toxic

<b>Human Hazards</b>				
		<b>Route of Administration</b>		
<b>Risk Category</b>	<b>Signal Word</b>	<b>Oral (mg/kg)</b>	<b>Dermal (mg/kg)</b>	<b>Inhalation (mg/kg)</b>
<b>I</b>	<b>DANGER--Poison</b>	0-50	0-200	0-0.2
<b>II</b>	<b>WARNING</b>	>50-500	>200-2000	>0.2-2.0
<b>III</b>	<b>CAUTION</b>	>500-5000	>2000-20,000	>2.0-20
<b>IV</b>	<b>NONE</b>	>5000	>20,000	>20

<b>Hazard</b>		
<b>Category</b>	<b>Eye Irritation</b>	<b>Skin Irritation</b>
<b>I</b>	Corrosive: corneal opacity not reversible within 7 days	corrosive
<b>II</b>	corneal opacity reversible within 7 days; irritation persisting for 7 days	severe irritation at 72 hours
<b>III</b>	no corneal opacity; irritation reversible within 7 days	moderate irritation at 72 hours
<b>IV</b>	no irritation	mild or slight irritation at 72 hours

<b>Categories of Quality of Health Effects Data</b>	
<b>Inadequate:</b>	Inadequate information available for evaluating toxicity. There were too few studies of sufficient quality to yield useful or reliable information.
<b>Marginal-Inadequate:</b>	Some useful information exists for evaluating toxicity. There were studies of marginal quality that provided useful information, but studies were inconsistent and some contained flaws. It is likely that new studies would change estimates of health effects.
<b>Marginal:</b>	Marginal but useful information available for evaluating toxicity. There were studies of adequate quality, and results did not vary greatly, but more information would increase reliability. Although new studies may change estimates of health effects, the results are considered moderately reliable.
<b>Adequate:</b>	Adequate information is available. Studies are of sufficient quality and quantity that estimates of human health are considered reliable. New studies are unlikely to change estimates of health effects.