

# WATER QUALITY AND PESTICIDES



## GLYPHOSATE

California State Water Resources Control Board



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GLYPHOSATE  
USE IN FORESTRY (ROUNDUP) AND  
AQUATIC WEED CONTROL (RODEO):  
A WATER QUALITY ASSESSMENT

Dennis P. Corcoran, M.Sc.

David B. Cohen, Ph.D.

Gerald W. Bowes, Ph.D.

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## PREFACE

This is one of a ten volume series of reports issued by the State Water Resources Control Board (SWRCB) on agricultural chemicals. Titles of volumes in this series: (1) Water Quality and Pesticides: A California Risk Assessment Program; (2) Toxaphene; (3) 1,2-Dichloropropane/1,3-Dichloropropene; (4) Rice Herbicides: Molinate and Thiobencarb; (5) Endosulfan; (6) Ethylene Dibromide; (7) Groundwater Contamination by Pesticides: A California Assessment; (8) Malathion; (9) 2,4-D; and (10) Glyphosate.

This is an interim status report, rather than a more complete risk assessment due to the following constraints:

1. Classification of health effects and environmental fate data as trade secret information;
2. Lack of toxicity information on non-herbicidal components (e.g., inert ingredients) of the spray solutions which are applied to forests and waterways; and
3. Lack of sufficient monitoring data to assess movement and degradation in California's environment following application to forests and waterways.

Since trade secret classification of these data had imposed restrictions on this report's contents, a preliminary draft had discussed this issue in great detail. In the opinion of SWRCB legal staff, however, the June 26, 1984 decision of the U.S. Supreme Court (Ruckelshaus vs. Monsanto Co.) upholds the authority of the Environmental Protection Agency (EPA) to publicly release the human health effects and environmental fate data submitted by the registrant. The 8-0 decision made detailed discussion of public release of data concerning pesticide registration moot. It now appears that the toxicological and environmental fate data will become public information.

Due to time constraints, it was decided to issue this interim report with minimal revision of the May 1984 draft report, to reference within the text the U.S. Supreme Court decision, and to incorporate comments of peer reviewers where appropriate. A subsequent report will review additional toxicological and environmental fate data when they become available along with any newly developed data on surfactant toxicity and California monitoring data.

The use of herbicides in forest watersheds or direct application to waterways has resulted in expressions of concern by downstream water users. This report considers the potential water quality impacts of glyphosate resulting from forest and aquatic weed control programs. Water quality guidelines for drinking water supplies and aquatic habitat are suggested. Recommended management practices are described which can minimize adverse environmental effects from the use of glyphosate.

Where water quality problems have been identified, the State Board will recommend appropriate measures to correct or prevent adverse impacts on beneficial uses. The mention of any product name in this report should not be construed as a product endorsement by SWRCB. "RODEO" and "ROUNDUP" are trademarks of Monsanto Co. ORTHOX-7 is a trademark of Chevron Chemical Company.

## ACKNOWLEDGEMENTS

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## LIST OF ABBREVIATIONS

AMPA	Aminomethyl Phosphonic Acid
ADI	Acceptable Daily Intake
C	Degree Celsius
DFA	Department of Food and Agriculture
EPA	Environmental Protection Agency
g	Gram
g/ha	Gram per hectare
g/kg	Gram per kilogram
g/cc	Gram per cubic centimeter
g/kg-bw	Gram per kilogram of body weight
ha	Hectare
hr	Hour
HPLC	High Pressure Liquid Chromatography
IBT	Industrial Biotest Laboratories
Kg	Kilogram
Kg/ha	Kilogram per hectare
LAS	Linear alkyl sulfonate
LC50	Concentration lethal to 50% of test population
LD50	Dose lethal to 50% of test population
ug/l	Microgram per liter; part per billion
mg/l	Milligram per liter; part per million
MON 0818	Monsanto code for surfactant in ROUNDUP
NNG	N-nitrosoglyphosate
NOEL	No observed effect level
ppb	Part per billion; microgram/liter
ppm	Part per million; milligram/liter
SWRCB	State Water Resources Control Board
TLC	Thin layer chromatography



## SUMMARY

### Background

This report was undertaken in response to concerns regarding the registration in California of herbicides containing glyphosate for the following three uses: "ROUNDUP" for aerial application to forest land for conifer release and site preparation, and "RODEO" for aquatic weed control. These concerns were expressed by domestic water supply purveyors, environmental groups, and Regional Board staff. The purpose of this evaluation was to (1) determine potential adverse impacts of ROUNDUP and RODEO on water quality and (2) recommend protective guidelines for aquatic life and human health in consultation with other appropriate state regulatory agencies.

The classification of toxicological and environmental fate data as trade secret information hindered the public discussion of the water quality impacts of RODEO and ROUNDUP use. The U.S. Supreme Court decision of June 26, 1984 concerning public disclosure of toxicological and environmental fate data for pesticides (active ingredients) will remove the existing restrictions on public disclosure.

The lack of sufficient data on toxicity and fate of "inert ingredients", restrictions on public release of these data, and insufficient monitoring due to difficult and expensive analytical methods, all are still issues that remain unresolved. Although further review by State Board staff and public peer review of all toxicological and monitoring studies would be desirable, it appears at this time, on the basis of the information reviewed, that glyphosate and its formulated products do not pose a serious threat to beneficial uses of water in California.

### Use

Glyphosate was first used in California in 1974, and, since then, its reported use has increased over ten-fold from 20,000 pounds to 228,000 pounds in 1982. Glyphosate is an unrestricted pesticide whose use is not required to be reported to the California Department of Food and Agriculture (DFA), except for applications by licensed pesticide applicators. Approximately one-third of each year's total annual pesticide use is actually reported. If this same proportion were applied to glyphosate, the actual use would be 300 percent of the values listed in Figure 1.1. Sales data on glyphosate are considered trade secret and were, therefore, not available for citation in this report; the extent of under-reporting could not be estimated.

## Monitoring

Few monitoring data of glyphosate aquatic or silvicultural applications in California were available for inclusion in this report because of the lack of a rapid and straightforward chemical analysis for glyphosate. DFA requires that each registered pesticide have an analytical method for crop residues that can be completed in less than 24 hours. Crop residue methods are not always applicable to water, sediment, and biota residues. While the DFA lab can process a few samples at the request of State and Regional Board staff, the lab is not set up to process the large number of samples needed for water quality or environmental fate studies.

One California commercial lab, North Coast Laboratories in Arcata, has developed the capability to process glyphosate samples. Before the State and Regional Boards can rely on this lab for processing water quality monitoring samples, the accuracy and precision of their determinations need verification. North Coast Laboratories has requested the assistance of the State Board staff to organize an independent inter-lab comparison study. State Board staff will invite DFA, Monsanto, and the University of California to participate in such a study.

Studies of ROUNDUP indicated that 41 percent of the glyphosate applied to dry drainage canals was present in soil samples 172 days following treatment. In another study conducted in Ohio, ROUNDUP was applied at 8 pounds glyphosate per acre (twice the recommended maximum forestry use rate); the maximum glyphosate concentration (5200 ppb) was found in runoff from a storm one day after treatment. At a 3-pound per acre application rate, the maximum glyphosate residue in runoff ten days after application was less than 100 ppb. The potential for off-site movement depends upon the amount applied as well as the frequency and intensity of storm events.

In an aerial application study conducted by Oregon State University researchers, ROUNDUP was intentionally applied to a slow-moving stream in a forest watershed. The maximum glyphosate residues detected (230 ppb) occurred one day after application. Fourteen (14) days after application, the maximum concentration found in a composite stream bottom sediment sample was 450 ppb, decreasing to 90 ppb by the 55th day. Accumulation of pesticide residues in benthic sediment is a violation of existing regional board Basin Plan water quality objectives. Additional California monitoring is needed to verify whether or not accumulation of glyphosate is occurring as a result of the use of RODEO and ROUNDUP.

On July 2, 1984, Monsanto released for State Board staff, public review, and publication, water quality monitoring data from a June 30, 1983 application of RODEO applied to control water hyacinth in one-acre test plots near Disappointment Slough (Stockton, California). In this test, RODEO was applied at 6



pounds glyphosate per acre to an open water site subject to tidal flow. This application resulted in a maximum detected concentration of 40 parts per billion at a sampling location 20 feet downstream of the treatment, one-half hour after application. Application to a back-water site not subject to tidal flow resulted in a maximum detected concentration of 60 parts per billion, 20 feet away from the site, four hours after application.

The active ingredient (glyphosate) in both ROUNDUP and RODEO could be expected to behave similarly in the environment. Although most of the environmental fate data on pesticides are usually developed on the active ingredient rather than the formulated product, information demonstrating aquatic toxicity of the surfactant MON 0818 in the ROUNDUP formulation indicates the need for additional information on the environmental fate and toxicity of RODEO spray solution.

### Risk Assessment

Based on animal studies, the risk of acute fatal poisoning of glyphosate to mammals is slight to moderate depending upon the test and species tested. Of the 20 toxicity tests for glyphosate performed by the registrant and cited by EPA in the Federal Register, 6 were negative, 9 had a "no observed effect level" (NOEL) established, 3 developed LD50 information, and 2 tests reported some eye and skin irritation. Discussions of each of these 20 tests, as well as over 30 others not cited in the Federal Register, will now be possible due to the U. S. Supreme Court decision. This report will be updated after review of all the pertinent studies.

EPA has established a human acceptable daily intake (ADI) for glyphosate of 0.10 milligrams per kilogram body weight per day. DHS is currently reviewing the toxicological data on which EPA based the ADI determination.

The importance of testing the formulated product as well as the active ingredient is exemplified by the results of skin and eye tests using rabbits. When glyphosate alone was tested, it was classified as slightly irritating. When similar tests were conducted using the ROUNDUP formulation, this product was found to be a more serious irritant. A 1980 EPA worker illness investigation identified 109 cases of skin or eye irritation attributed to worker exposure to the ROUNDUP spray solution.

One concern raised by public interest groups was the validity of studies performed by Industrial Biotest Laboratories, Inc. (I.B.T.). EPA found some tests to be invalid. All of the repeat tests for glyphosate required of the registrant by EPA have been completed and accepted with two exceptions. A chronic mouse carcinogenicity study has been completed and is undergoing EPA review. A subchronic dog study was recently declared invalid by EPA; a replacement study is now underway.

A 21-day rabbit dermal exposure study with glyphosate showed certain testicular effects (i.e., mild degeneration of seminiferous tubules) in both control and test groups. No firm conclusions could be drawn since the effects are not necessarily due to chemical exposure. DHS is conducting a review of the glyphosate toxicological data including the rabbit tests. After this review is complete, a decision will be made on the necessity of further testing.

In a study on the effects of ROUNDUP to aquatic species, the most significant finding was the greater toxicity of the "inert" surfactant (MON 0818) compared to glyphosate, which has a relatively low toxicity to aquatic organisms. The acute toxicity of the surfactant to fish was 7 to 97 times greater than glyphosate depending on the particular species of fish exposed and the duration of the exposure. A comparison of 96-hour LC50 concentrations affecting adult and immature fish species indicates that rainbow trout fingerlings are 6.4 times more sensitive to ROUNDUP than adults.

#### Water Quality Criteria and Guidelines

Water quality limits, together with field monitoring data, can be used to evaluate the efficiency of management practices in preventing off-site movement of pesticides. Existing glyphosate information does not indicate a high potential for chronic human health effects. Consequently, the EPA proposed potable water limit of 500 ppb (ug/l) glyphosate acid appears adequate to protect human health. This limit may need to be reevaluated by EPA and DHS scientists after the review of the mouse carcinogenicity and subchronic dog feeding studies are completed.

The RODEO formulation, unlike ROUNDUP, does not contain a surfactant. The user is required, however, to add a nonionic surfactant (Ortho X-77) to the spray solution prior to application. Ideally, a comprehensive assessment of water quality impacts would involve aquatic toxicity bioassays and environmental fate studies of: (1) the actual spray solution; (2) each active ingredient; and (3) each surfactant or inert ingredient in order to determine the total impact of treatment and the relative contribution of each constituent in the herbicide solution actually applied.

Monsanto has noted that all aquatic toxicity tests required by the Office of Pesticide Programs, EPA, have been conducted. Staff has reviewed the published data for the ROUNDUP spray solution and unpublished data developed by Monsanto for the RODEO spray solution (including Ortho X-77). Although the RODEO data has not been peer reviewed, it appears that ROUNDUP is more toxic to aquatic life than the RODEO spray solution.

On the basis of limited data available, the interim recommended water quality guideline to protect aquatic life from the ROUNDUP formulation is 130 ppb (ug/l) expressed as glyphosate acid. The interim guideline is based upon the application of a 10-fold safety factor to the lowest 96-hour LC50 value. This value is 1.3 mg/l for immature rainbow trout (the most sensitive life stage of the most sensitive species tested). For the RODEO formulation, used with Ortho X-77, a guideline should be established when data on the aquatic toxicity of Ortho X-77 surfactant to early life stages of aquatic organisms become available.

#### Potential Mitigation Measures and Recommended Management Practices

The registrant has recommended a number of use practices which, if followed, should avoid exceeding presently recommended glyphosate water quality guidelines for protection of human health and aquatic life. The effectiveness of these mitigation measures under California application conditions needs field verification. The proposed mitigation measures and recommended management practices include the following:

ROUNDUP (for conifer release or site preparation): Application is not recommended (1) when wind speeds exceed 5 miles per hour (to prevent drift of spray solution); (2) when rain is expected within 6 hours (to prevent washing the herbicide from the foliage); and (3) land should not be tilled prior to or immediately after application since three to six days must be allowed for the complete translocation of glyphosate. ROUNDUP should not be directly applied to any body of water.

RODEO is applied directly to water for aquatic weed control. It should not be applied (1) within 0.5 miles upstream of potable water intakes; or (2) if heavy rainfall or irrigation is likely to occur within 2 hours after application.

Herbicide users should pay special attention to the quality of the water used to prepare the spray solution. High concentrations of sediment or dissolved inorganic chemicals in make-up water can reduce efficacy. This, in turn, could result in the need for repeated applications of the herbicide with increased potential for environmental contamination.

Users of ROUNDUP and RODEO should consult with county agricultural commissioners, regional water quality control boards, and the Department of Fish and Game for site-specific guidance and interpretation of label requirements prior to application to avoid adverse effects on water quality.

## RECOMMENDATIONS

This is an interim report. It is based upon staff investigations conducted prior to the U. S. Supreme Court decision of June 26, 1984 which clarified the ability of State Board staff to review and disclose toxicological and environmental fate data.

The following recommendations may be revised after additional monitoring information becomes available and after more extensive scientific peer review of the toxicological and environmental fate data.

The following actions are recommended:

1. The EPA drinking water guideline of 500 ppb (ug/l) glyphosate acid should be adopted by DHS as an interim action level to protect public health. This limit should be reevaluated after EPA and DHS complete their review of the chronic mouse carcinogenicity study.
2. An interim water quality guideline of 130 ppb (ug/l) glyphosate acid for forestry uses of ROUNDUP is recommended to the regional boards in order to protect aquatic life.
3. Additional aquatic toxicology data are needed for RODEO and its required surfactant (Ortho X-77). Information for both adults and early life stages, particularly the extent of structural damage to gills and other barrier membranes, is needed to derive water quality guidelines for this herbicide when used in aquatic weed control. The formulated product, including the recommended surfactant, should be used in chronic toxicity tests by the registrant to assess more completely the effect on aquatic organisms.
4. EPA registration data requirements for "inert" ingredients (e.g., MON 0818 and Ortho X-77) should be strengthened to require testing of these ingredients where they could impair beneficial uses of water.
5. An improved analytical method should be developed by the registrant for detection of glyphosate residues in water, sediment, and biota. Although the registrant's current methods of glyphosate analysis are valid and development of a simpler, less expensive method is difficult, environmental monitoring is needed to verify the effectiveness of the label use restrictions in preventing or mitigating adverse impacts on water quality.
6. EPA registration requirements for analytical methods should specify that a proposed method is reasonable for environmental monitoring, i.e., does not require excessive time and cost.

7. Monitoring studies of glyphosate for aquatic and silvicultural weed control should be conducted under California use conditions by the registrant in cooperation with the appropriate state agencies. The objectives of this monitoring should be to: (1) determine the environmental fate; (2) verify the effectiveness of recommended management practices under routine use; and (3) verify compliance with Basin Plan provisions prohibiting accumulation of pesticides in benthic sediment.
8. DHS should review Monsanto rabbit test data and evaluate the toxicological significance of these studies, if any, in a public report.
9. Although ROUNDUP and RODEO are not restricted pesticides requiring a use permit, users should consult with the appropriate county agricultural commissioner(s), regional water quality control board, and the Department of Fish and Game for site-specific guidance and interpretation of label requirements prior to application to forests or waterways.
10. EPA should accelerate issuance of an assessment concerning the toxicological acceptability of grouping data on benign and malignant tumors in laboratory animals dosed with glyphosate.
11. Existing toxicological and environmental fate data for glyphosate and its formulated products should be submitted by the registrant to peer-reviewed scientific journals.



## CHAPTER 1. INTRODUCTION

Glyphosate (Table A-3.2) was selected by State Board staff for a detailed review due to:

1. the potential for increased uses;
2. the potential impact on aquatic life and domestic water supplies; and
3. expressions of public concern (Appendix 1).

The number of available, active herbicide ingredients has increased from 15 in 1950 to 180 (over 6,000 formulations) in 1974 (Sill, 1982). Weed competition for water, nutrients, and sunlight triggered the search for weed control chemicals which are effective, yet relatively nontoxic to specified crops and other organisms.

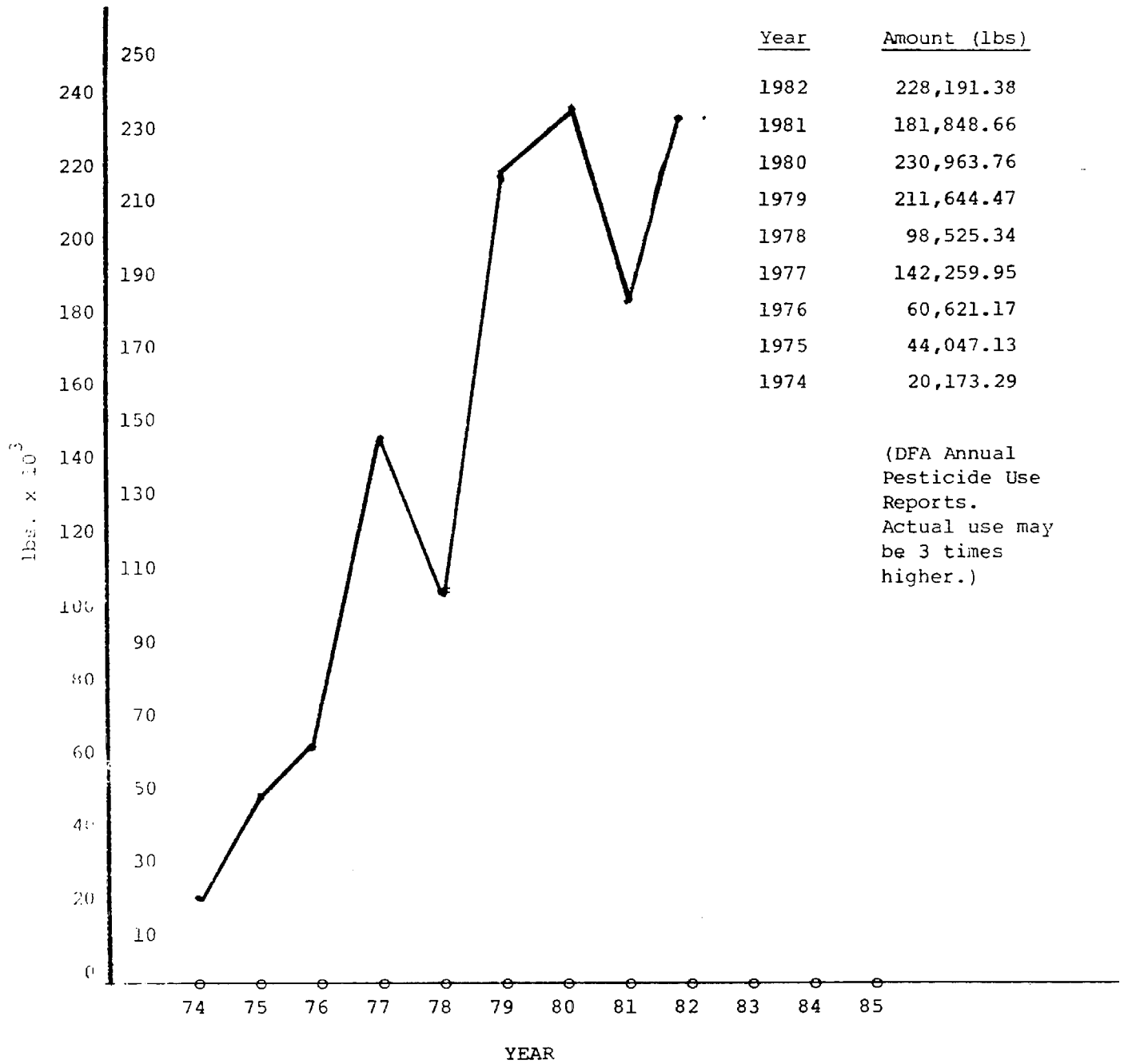
According to Monsanto, glyphosate is less persistent and more effective than many older herbicides (Serdy, 1984). Because of these advantages, as well as an apparent low toxicity, the use of glyphosate in California has increased since its introduction in 1974. Figure 1.1 shows the amount of glyphosate use reported to DFA from 1974 through 1982. The data are probably underestimated because glyphosate is not a restricted pesticide and users are not required to report applications to DFA. Approximately one-third of the total annual pesticide use is actually reported (DFA, 1978). If this same proportion were applied to glyphosate, the actual use would be 300 percent of the values listed in Figure 1.1. Sales data on glyphosate are considered trade secret and were, therefore, not available for citation in this report; the actual extent of under-reporting could not be estimated.

The forestry uses of ROUNDUP (site preparation and conifer release) were registered by EPA on May 15, 1980, and by the State of California on January 25, 1982 (all labels discussed here are reproduced in Appendix 5). EPA registered RODEO for aquatic weed use on January 20, 1983; California on March 28, 1983. Most public discussion has dealt with forestry uses.

A staff review of the published and unpublished studies of aquatic toxicity indicates that the existing data were not adequate to derive water quality criteria. In order to fill the data gaps, State Board staff has requested the registrants to perform several additional aquatic toxicity tests to assess the potential for toxic impacts on the State's fisheries. The results of these tests are discussed in Chapter 3.

Treatment for conifer release can be made in either the fall after formation of final conifer resting buds or in the spring prior to initial conifer bud swelling. In California, use for conifer release is usually made in fall (August - October) or spring (April - May). Treatment for site preparation is normally

Figure 1.1  
 POUNDS PER YEAR OF GLYPHOSATE HERBICIDE PRODUCTS  
 REPORTED TO CALIFORNIA DFA  
 (1974-1982)





carried out from midsummer to early fall, before frost, or whenever undesirable vegetation is at the proper state of growth. The maximum application rate of ROUNDUP for forestry use is five quarts per acre (3.75 pounds glyphosate acid/acre).

The maximum application rate of RODEO for aquatic weed control is 7.5 pints per acre (3.75 pounds of glyphosate acid/acre). Staff calculated the maximum water concentrations to range from 1.38 ppm at a depth of one foot to 0.138 ppm at a ten-foot depth (an acre-foot of water is approximately equivalent to 2,720,000 pounds). The subject of water quality limits is discussed in Chapter 4.

The existing methods for glyphosate analysis in water, soil, and biota are complex, time-consuming, and expensive. Consequently, routine environmental monitoring of spray operations is not practical and environmental fate data in California are very limited. A discussion of current analytical methods is contained in Appendix 2.

The U. S. Supreme Court decision (52 U.S.L.W. 4886) has made clear that the existing toxicological and environmental fate data are subject to disclosure. When available, all relevant information will be reviewed by State Board staff and peer review scientists. This interim report will then be revised as necessary.

The discussion of potential water quality impacts of glyphosate and its formulated products in this interim report is therefore based upon:

- o The limited data published in the scientific literature;
- o Data summaries and results released by Monsanto;
- o Data summaries and results from Monsanto studies which were released by EPA; and
- o Commentary by other scientists who have reviewed the Monsanto studies.

## CHAPTER 2. MONITORING

### California Monitoring Data

Few monitoring data of glyphosate applications in California were available for inclusion in this report because of the problem discussed in Chapter 1. Yates et al. (1978) studied drift of glyphosate applied to a flat dry field with short dry grass located near Davis, California. Drift was studied after application by ground, fixed-wing aircraft, and helicopter using a variety of spray nozzles. Use of a thickening agent (Nalcotrol II) in the spray solution was also investigated. The drift loss from a helicopter application averaged between 0.03 g/ha to 5 g/ha on a fallout sheet at 100 m. Differences in fallout were attributed to application equipment; use of a polymer thickening agent was only slightly responsible for the drift reduction. This study describes drift patterns produced by ROUNDUP applications to flat agricultural land and documents the variation caused by different application methods. Yates et al. note that the study was designed to collect reliable average data with a minimum number of samples (e.g., without replicate sampling) due to the expensive analytical procedures for glyphosate. (The difficulty of analytical detection is discussed in Appendix 2.)

Yates et al. did not monitor glyphosate residues in runoff. The results of this study cannot be used to estimate drift from silvicultural applications due to significant differences in topography, plant canopy, and drainage characteristics.

On July 2, 1984 Monsanto provided State Board staff with residue information from a June 30, 1983 application of RODEO. Researchers from the U. S. Department of Agriculture, in cooperation with Monsanto, monitored the levels of glyphosate in water after application of the RODEO spray solution to two separate test plots in Disappointment Slough near Stockton, California. At each one-acre test plot, 100 gallons of spray solution containing 1.5 percent RODEO concentrate and 0.5 percent Ortho X-77 surfactant were applied via handgun. This application rate is equal to 6 pounds/acre of glyphosate acid. At 0.5 hr., 2 hr., and 4 hr., four 1 liter subsamples were taken and composited in a one-gallon container. From this one-gallon container, 3 one-liter samples were taken and shipped to Monsanto for analysis. The highest concentration detected was 60 parts per billion in a sample taken four hours after application 20 feet from a site not subject to obvious tidal flow. At an open water site subject to tidal flow, the highest level detected was 40 parts per billion, 0.5 hour after application, 20 feet from the site.

Since the conifer release field data in support of ROUNDUP registration were obtained in Oregon and since the final report had not yet been prepared, the North Coast Regional Board staff recommended in May 1981 that additional field monitoring studies be conducted under environmental conditions in California.

#### Monitoring Data from Other States

Field studies of glyphosate applied in the fall to drained agricultural canals show virtually no detectable herbicide residues of glyphosate or aminoethylphosphonic acid (AMPA), the principal breakdown product, in water flowing through these canals in the following spring (Comes et al., 1976). In this study, the glyphosate detection limit was 2.5 ppb. Forty-one (41) percent of the glyphosate applied (5.6 kg/ha) was present in soil samples (0 to 10 cm) 172 days following application. The relatively long persistence noted in this study could be attributed to reduced microbial degradation during cold winter temperatures.

The maximum reported surface runoff of applied glyphosate occurred at the North Appalachian Experimental Watershed near Coshocton, Ohio, where ROUNDUP was used in no-tillage farming. Soils in this region are derived from sandstone and shale under hardwood vegetation; the slope here averaged 15 percent (range 6 to 15.8 percent). The major loss occurred from a single storm event one day after treatment. The glyphosate application rate of 8.96 kg/ha (8.0 lbs/acre) was twice the recommended maximum forestry use rate. The maximum glyphosate concentration found was 5.2 ppm in storm runoff. At lower application rates up to 3.36 kg/ha (3.0 lbs/acre), the maximum herbicide residue in runoff was less than 0.1 ppm ten days after application. Herbicide transport in the first runoff event following treatment accounted for 99 percent of the total runoff from one watershed for three consecutive years. Glyphosate residues were detected in the upper 2.5 cm of treated soil several weeks after residues in water runoff were not detectable; the limit of detection was 2 ppb in soil and water (Edwards et al., 1980). The potential for off-site movement depends upon amount applied, as well as the frequency and intensity of storm events.

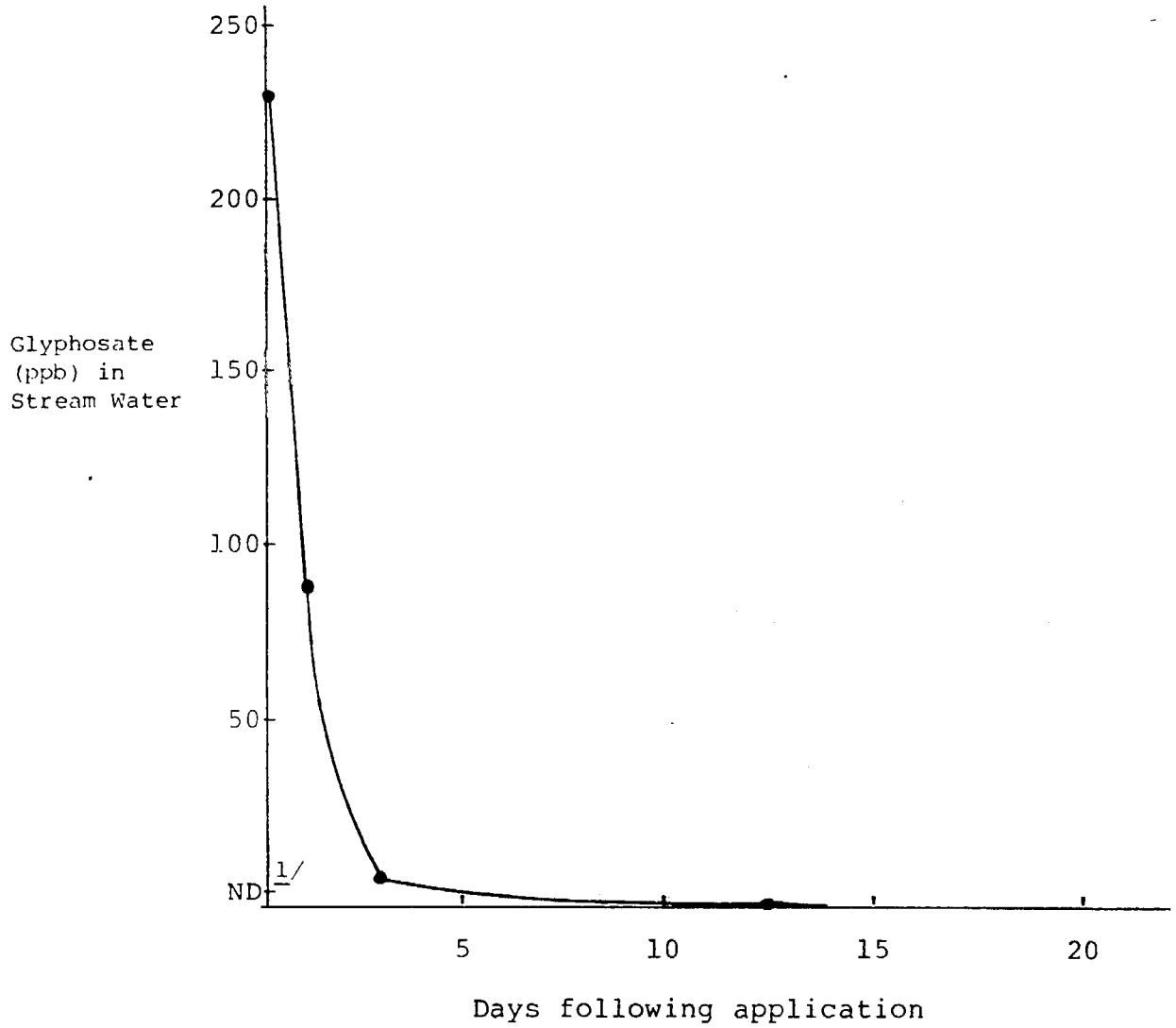
Glyphosate strongly adsorbs to soil and sediment. Microbial degradation appears to be the major route of breakdown. The average half-life in soil is about two months (Ghassemi et al., 1981; Hance, 1976). Little information is available concerning the half-life in surface waters. It is, however, expected to be less in water than in soils due to the removal of water-borne residues by adsorption to suspended substances and sediments and their subsequent benthic deposition (Ghassemi et al., 1981; Comes et al., 1976). The formation of N-nitrosoglyphosate does not appear to be probable during normal application practices.

A two-year study was conducted at Oregon State University in cooperation with Monsanto to monitor the environmental fate of glyphosate aerially applied to forest watersheds for conifer release. The final report has not yet been published. A two-page interim report (Newton, 1980) found that the half-life of glyphosate ranged from 14 to 28 days in soil, leaf litter, and litter-covered soil. The maximum residue found was 17 ppm in leaf litter following an application twice the normal rate. Glyphosate residues in water did not exceed 230 ppb despite direct application to a slow-moving stream. Subsequently, glyphosate dissipated rapidly to below 2 ppb (the limit of detection) on the 14th day after application (Figure 2.1). Stream bottom sediments adsorbed glyphosate. The maximum concentration found (450 ppb on the 14th day) decreased to 90 ppb by the 55th day. These sediment values are based on analysis of composite samples, some of which therefore could have glyphosate concentrations higher than 450 ppb.

Accumulation of pesticide residues in benthic sediment is a violation of existing regional board Basin Plan water quality objectives. Additional California monitoring is needed to verify whether or not accumulation of glyphosate is occurring as a result of the use of RODEO and ROUNDUP.

Figure 2.1

GLYPHOSATE DISSIPATION AFTER DIRECT  
APPLICATION TO A STREAM  
(DATA FROM NEWTON, 1980)



<sup>1/</sup> Not Detected (ND) at fourteen days.

## CHAPTER 3. RISK ASSESSMENT

"All substances are poisons....  
The right dose differentiates a poison and a remedy."

Paracelsus  
(1493-1541)

### Mammalian and Human Health Effects

ROUNDUP, RODEO, and their constituents, like all chemicals, can produce toxic effects when biota are exposed to sufficient quantities. The key to assessing human health and environmental impacts is careful evaluation of the amount and exposure period required to produce adverse effects.

The results of experiments where chemicals are administered to groups of test animals are extrapolated to predict the hazard of acute or chronic human exposure. In those few instances where human exposure data provide additional insights, assessments based upon animal test data may be modified. Due to the limited amount of data from human exposure, animal study data provide the basis for most toxicological risk assessments of pesticides, including glyphosate and its formulated products.

This assessment is based upon the few independent studies found in the scientific literature and the published summaries of Monsanto data, including toxicological assessments by Drs. Peter Kurtz (DFA) and Frank Dost (Oregon State University) (Kurtz, 1983; Dost, 1983).

### Acute Toxicity

The hazard of short-term poisoning is determined by calculating the LD50, the dose needed to kill 50 percent of the test animals. An oral LD50 study using rats produced a value of 3.8 grams of glyphosate per kilogram of animal body weight (Federal Register, 1981). Another oral LD50 (rat) test reported by the registrant indicated the acute lethal dose of glyphosate, RODEO and ROUNDUP, to be greater than 5.0 g/kg (Monsanto, 1982a, b; 1983). The risk of acute lethality from glyphosate is therefore relatively low, based on a common method of comparing relative toxicities:

CLASSIFICATION OF TOXICANTS INTO  
CATEGORIES RELATED TO THEIR RELATIVE LETHALITY  
(Adapted from Casarett and Doull, 1975)

<u>Rating</u>	Common Term	Probable Human Lethal Dose 70-kg (150-lb) Person	
		<u>(Lethal Dose)</u>	<u>(Common Measure)</u>
6	Supertoxic	<5 mg/kg	A taste, 7 drops
5	Extremely toxic	5-50 mg/kg	7 drops to 1 teaspoonful
4	Very toxic	50-500 mg/kg	1 tsp to 1 ounce
3	Moderately toxic	0.5-5 g/kg	1 oz to 1 pint or lb.
2	Slightly	5-15 g/kg	1 pint to 1 quart
1	Practically nontoxic	>15 g/kg	1 quart

According to this system, glyphosate would be rated slightly to moderately toxic depending upon the test. A comparison of glyphosate acute toxicity with a few other commonly used chemicals is instructive: aspirin (oral LD50 value of 1.75 g/kg to rats) would be classified as moderately toxic (Merck Index, 1976); while parathion, a commonly used agricultural pesticide (oral LD50 value of 13 mg/kg to male rats) (Farm Chemicals Handbook, 1982), is classified as extremely toxic. Animal tests indicate that the risk to human health of fatal poisoning with the active ingredient glyphosate is slight or moderate, depending upon the test and the species tested. Few data are available to compare the relative risks of the active ingredient against various formulated products containing glyphosate, since these data are not presently required by EPA as a condition of registration.

#### Chronic Toxicity

Long-term exposure to a chemical may cause either death, nonlethal adverse effects, or no discernable effect. In order to assess these possibilities, animal tests have been developed to study the possible production of birth defects, fetal death, sterility, nervous system damage, or cancer. Of the 20 tests reported by EPA for glyphosate, six were negative, nine had a "no observed effect level" (NOEL) established, three developed LD50 information, and two tests reported some eye and skin irritation (Table 3.1). Full descriptions and discussions of each of these

20 tests as well as over 30 other tests not cited in the Federal Register (Serdy, 1984) were not possible because of restrictions on data claimed to be trade secret. This report will be updated after pertinent information is obtained and has been submitted for more extensive peer review.

The EPA registration data requirements for pesticides are listed in the Code of Federal Regulations (40 CFR PART 158). A limited general description of the Monsanto toxicology data is available from two other sources, Herbicide Handbook, 1979, and a U. S. Forest Services report, 1981.

The Herbicide Handbook provides a two-paragraph summary of several chronic tests which are listed in Table 3.1. The original studies are not presently public information. In one study, technical grade glyphosate was fed to rats and dogs at dietary levels of 200, 600, and 2,000 parts per million (ppm) for 90 days. No significant differences from control animals were observed in mean body weight, food consumption, behavioral reaction, mortality, hematology, blood chemistry, or urinalysis. No relevant gross or histopathologic changes were observed. Similarly, no significant adverse effects were reported in:

- o a two-year feeding study with rats;
- o a two-year feeding study with dogs; or
- o a reproductive study with rats at dietary levels of 30, 100, and 300 ppm.

Various other tests have been conducted. Bacterial tests which can detect mutagenic potential were submitted to EPA by Monsanto. According to EPA, these tests were negative (Federal Register, 1981b). Skin tests using rabbits resulted in glyphosate being classified as slightly irritating. Tests conducted on the ROUNDUP formulation indicated this product to be an irritant. An EPA worker-illness investigation identified 109 cases of skin or eye irritation attributed to worker exposure to the ROUNDUP spray solution (EPA, 1980). EPA has established an Acceptable Daily Intake (ADI) for glyphosate of 0.10 milligrams per kilogram body weight per day (Federal Register, 1982b).

The above-cited data indicate that glyphosate poses a low toxicity hazard to human health. Skin and eye irritation were the only observed effects produced at low dosages. Despite the apparent low risk, however, concerns have been raised regarding glyphosate safety. These are discussed further in this chapter.



Table 3.1

## TOXICITY DATA FOR GLYPHOSATE ACID

<u>Species</u>	<u>Type of Test</u>	<u>Exposure Level*</u>	<u>Response</u>
Rabbit	Acute oral	3.8 g/kg-bw	LD50**
Rabbit	Teratology	30 mg/kg-bw	Negative***
Rabbit	Teratology	350 mg/kg-bw	Negative
Rabbit	Fetotoxicity	175 mg/kg-bw	NOEL****
Rabbit	Acute dermal	>5 g/kg-bw	LD50
Rabbit	Eye irritation	Not available	Slight irritation
Rabbit	Dermal irritation	Not available	Slight irritation
Rat	Acute oral	>5 g/kg-bw	LD50
Rat	90-day feeding	2000 ppm	NOEL
Rat	3 generation	100 ppm	NOEL
Rat	2-year feeding	31 mg/kg-bw	NOEL
Rat	Teratology	3.5 g/kg-bw	NOEL
Rat	Fetotoxicity	1 g/kg-bw	NOEL
Dog	90-day feeding	2000 ppm	NOEL
Dog	2-year feeding	300 ppm	NOEL
Mouse	18-month feeding (carcinogenicity)	300 ppm	Negative
Mouse	Dominant lethal	2000 mg/kg-bw	Negative
Hen	Neurotoxicity	7.5 mg/kg	Negative
<u>Bacillus subtilis</u>	Rec-assay (mutagenicity)	2,000 ug/test disk	No mutagenic response
Salmonella	Mutagenicity	Not stated	Negative
References:	Federal Register; Vol. 46, No. 175. September 10, 1981, pp. 45162-45163; Vol. 47, No. 208. October 27, 1982, pp. 47549-47550; Vol. 47, No. 241. December 15, 1982, pp. 56136-7; Vol. 48, No. 247. December 22, 1983 p. 56581 (Serdy, 1983).		

\* Exposure levels to test species are reported as either grams (g) or milligrams (mg) of toxicant per kilogram (kg) of animal body weight (bw) (g/kg-bw), or as dose in feed (parts per million of toxicant, ppm), or as micrograms (ug) of toxicant per test disk (ug/test disk). (Walters, 1984)

\*\* LD50 is defined as the amount of toxicant calculated to be a lethal dose for 50 percent of the test population.

\*\*\* Negative response means that the specified toxic effect (birth defects, fetal toxicity, reproductive anomaly) were not observed at the listed dose of toxicant.

\*\*\*\* NOEL is defined as the dose at which no effect was observed.

### I.B.T. Laboratories Data

Many of the studies performed by Industrial Biotest Laboratories, Inc. (IBT), on contract to pesticide producers, were found to be invalid (DFA, 1984). Consequently, data from these tests could be subject to challenge.

In 1977, when the first concerns were expressed about IBT, Monsanto contracted with other laboratories to repeat the major toxicology studies, i.e., chronic rat, chronic mouse, rat reproduction, and teratology studies required by EPA. Most of these studies were started in 1978; to date, all but the mouse carcinogenicity study have been completed and accepted by EPA. This mouse study was submitted to EPA in August 1983 but has not yet been accepted (Walters, 1984). According to Pesticide & Toxic Chemical News, June 15, 1983, acceptance of the mouse chronic feeding studies for glyphosate awaits resolution of the issue concerning the significance of statistically grouping benign and malignant tumors to determine the carcinogenic potential. A subchronic dog study was recently declared invalid by EPA; a replacement study is now underway with a scheduled completion date of October 1985 (Serdy, 1984).

### N-nitrosoglyphosate (NNG)

Many N-nitrosamines are considered to be carcinogenic (Rose, 1982). Glyphosate can, under certain conditions, react with nitrate to form N-nitrosoglyphosate (Appendix 4). Concern has been expressed regarding the possibility of this chemical being formed in significant concentrations (Merrel, 1980). Monsanto discovered and subsequently reported to EPA that the ROUNDUP formulation contained the impurity N-nitrosoglyphosate at levels ranging from 0.2 to 0.4 ppm. This was reported in the December 5, 1978 Federal Register. Monsanto now reports that the level has been reduced to as low as 0.075 ppm (Serdy, 1983).

No evidence exists that N-nitrosoglyphosate is carcinogenic. The normal use conditions do not favor its formation or persistence (Appendix 4). A DFA toxicologist concluded: "Another submitted report concerns the very detailed toxicity testing and residue analysis on N-nitrosoglyphosate (NNG), a manufacturing impurity in the glyphosate formulation which occurs at less than the 0.4 ppm level. An extensive testing program consisted of the studies on NNG in crop residues and plant metabolism, worker exposure, and a wide variety of toxicology studies ranging from acute to chronic/oncogenicity studies. The results of these studies indicated that (1) in 12 plant metabolism studies on 22 different crops, no measurable amount of NNG was found; (2) analysis of inhalation and dermal exposure to workers in a typical field working situation did not give rise to detectable levels of NNG; and (3) NNG has a low order of acute toxicity, it is not mutagenic, teratogenic, or carcinogenic in the rat (a two-year mouse study has just been completed). NNG does not cause any adverse reproductive effects, and is readily excreted by the rat" (Wang, 1983).

Based upon the negative results in toxicological tests, the reportedly low concentrations in the formulated products, and the unlikelihood of formation in the environment after use, NNG does not appear to be a water quality problem.

#### Rabbit Dermal Study

The dermal and testicular effects produced by the 21-day exposure to the formulated product were summarized by Sandquist (1979) in the USFS summary of Monsanto test data. A DFA toxicologist has reviewed the Monsanto test data at the request of SWRCB staff and provided the following evaluation: "I reviewed the data but could not locate any 21-day subacute dermal study with the formulated (emphasis added) product. However, data was submitted on a 21-day dermal toxicity study in rabbits treated with glyphosate (technical), in which certain "testicular effects" were observed. In the study, testes of rabbits in both the control and test groups showed trace to mild degeneration of seminiferous tubules. This effect could well be attributable to nonspecific stress caused by treatment procedures (e.g., body constraint, hair shaving, skin abrasion, etc.) rather than from any specific effect of the treatment compound. There have been reports of testicular damage in rabbits resulting from simple chemical cutaneous irritation or physical stress" (Liao, 1982). Monsanto indicates that 21-day subacute studies have been performed with the formulated product. At the time this report was written, State Board staff had not received this information. Because mild testicular effects were observed in both control and test group animals, no firm conclusions can be drawn. In order to allay concerns regarding the data in these tests, the Department of Health Services should review the Monsanto studies of both formulated and technical glyphosate with rabbits and issue a statement on the public health significance of the results, particularly the desirability of repeating the tests with another species or with greater attention to treatment procedures to minimize degenerative effects in the control group.

#### Nigerian Studies

Studies performed by a group of researchers at the University of Ibadan, Nigeria, indicated that when glyphosate was injected intraperitoneally, the acute LC50 to rats was 235 mg/kg. These results are consistent with many toxicological studies which find that the route of administration influences the toxicity. Direct injection into the body cavity is usually more toxic than oral administration for a variety of materials. The acute oral LD50 to rats was an order of magnitude higher (4,704 mg/kg). Tissue studies by the Nigerian researchers (Olorunsogo et al., 1978) led them to conclude that "uncoupling of mitochondrial oxidative phosphorylation may be a major lesion in glyphosate intoxication." This statement has been subject to various interpretations. In the context of the Nigerian study, the term "lesion" does not mean tumor. A more appropriate word would be

"effect". While the study identifies a biochemical response of poisoning and the dose required to produce injury, it does not provide any evidence of carcinogenicity.

Monsanto notes that the toxicological data in support of glyphosate registration have been reviewed by toxicologists with DFA, EPA, Health Protection Branch Canada, and other countries around the world. Subsequent to dissemination of the May 1984 draft of this report for scientific peer review, Monsanto provided to State Board staff statements by Drs. Peter Kurtz (DFA) and Frank Dost (Oregon State University) for inclusion in the report (Serdy, 1984).

In a four-page affidavit, Dr. Kurtz summarized his conclusions on glyphosate and ROUNDUP based upon his review of the registration data on file at DFA. Dr. Kurtz (1983) concludes that with regard to human health effects:

1. "The toxic hazards associated with glyphosate are limited....
2. "Short-term (acute) contact with glyphosate on the skin or in the eyes can result in significant irritation....
3. "Glyphosate fed to animals in relatively large doses has a very low potency compared with other chemicals used in Pest Management....
4. "Glyphosate is not associated with long-term irreversible health effects such as cancer, birth defects, or cell mutations.
5. While in-depth review of all I.B.T. replacement studies has not been completed, preliminary evaluation indicates no new findings relative to toxicity. Previous impressions regarding cancer, birth defects, and cell mutations for glyphosate have been verified.

In a nine-page affidavit, Dr. Dost (1983) summarized his conclusions regarding the human health effect of glyphosate as follows:

1. (With regard to tests for genetic mutation) "while glyphosate has not been subjected to every one of the great variety of such tests, it has been examined in several, with negative results, except for a study reporting increased sister chromatid exchanges. This latter work is of questionable utility.
2. "Glyphosate shows none of the biochemical characteristics ... suggesting or accompanying the kinds of interaction that lead to carcinogens.

3. "Allegations have been made that dermal treatment of rabbits with ROUNDUP formulation result in testicular atrophy. The high mortality and high incidence of testicular pathology in both treated and untreated groups indicates strongly that factors other than the herbicide formulation were responsible for the effect." The Nigerian research (Olorunsogo, 1978) does not imply any unusual toxic properties in intact animals. The formation of N-nitrosoglyphosate (NNG) in any general agricultural or forestry context is not significant.

### Aquatic Toxicology

#### Acute Toxicity

Glyphosate, the active ingredient of ROUNDUP, has a low toxicity to aquatic organisms according to Monsanto research data (Table 3.2). In other tests, acute toxicities were reported by Folmar et al. (1979) to range from 55 ppm for midge larvae (48-hr EC50) to as high as 140 ppm for rainbow trout and bluegill (96-hr EC50). The toxicity of the formulated product (ROUNDUP) is considerably higher because it contains the surfactants (MON 0818) among the "inert" ingredients.

Table 3.2

RESULTS OF ACUTE (48-hr and 96-hr LC50)  
AQUATIC TOXICITY TEST CONDUCTED BY MONSANTO

(Serdy, 1983)<sup>1/</sup>

<u>CHEMICAL</u>	<u>TIME PERIOD (hr)</u>	<u>ORGANISM COMMON NAME</u>	<u>LC50 VALUES (mg/l)</u>
ISOPROPYLAMINE SALT OF GLYPHOSATE	96	Bluegill sunfish	>1000
	96	Trout	>1000
	96	Carp	>10,000
GLYPHOSATE ACID	96	Bluegill sunfish	120
	96	Trout	86
	96	Carp	115
	96	Daphnia	780
	48	Atlantic oyster	> 10
	96	Shrimp	281
	96	Fiddler crab	934
	96	Harlequin fish	168

<sup>1/</sup> Additional information on species identification, life history stages of organisms, test conditions, and confidence limits of LC50 values will be in a subsequent report after release by registrant.

The surfactant MON 0818 is a cationic polyethoxylated tallow amine (Sprankle et al., 1978). The acute toxicity of the surfactant is 7 to 97 times higher than technical grade glyphosate, depending on the particular species of fish exposed and the duration of the exposure (Folmar et al., 1979).

Surfactants (surface active agents) are added to pesticide formulations in order to increase solubility and penetration of the spray solution into the target organism. These chemicals are classified as nonionic, anionic, or cationic. MON 0818 is cationic; Ortho X-77 is nonionic. Little information is available concerning the toxicity of surfactants to aquatic organisms. Maki (1979) found that longer chain surfactants were more acutely toxic to Daphnia and the fathead minnow than shorter chain surfactants (Tables 3.3 and 3.4). Nonionic surfactants were more toxic than anionic in tests with Daphnia exposed to both nonionic and anionic compounds; fathead minnow (Pimephales promelas) reproduction was not impaired.

Since information concerning the identity, the chain length, and the physical/chemical characteristics of Ortho X-77 and MON 0818 was not available to State Board staff, the specific responses of these surfactants compared to the values cited in Tables 3.3 and 3.4 are not known.

Florence and Gillian (1975) discuss the pharmacological properties of nonionic surfactants that are responsible for producing high aquatic toxicity. Surface-active reagents increase the rate of adsorption across gill membranes. Goldfish (Carassius auratus) exposed to certain nonionic surfactants absorb drugs more rapidly leading to a greater intoxicification. Increased absorption is promoted because the surfactant penetrates and increases the permeability of epithelial membranes. Another toxic effect of surfactants is structural damage to skin and gill tissues. Membrane alterations disturb both the osmotic and ionic balance of cell systems, leading to osmoregulatory and metabolic disorders. In tests by Folmar et al., the toxicity of the surfactant alone (without glyphosate) is nearly equivalent to that of the formulated product ROUNDUP. This suggests that the surfactant is the primary toxic agent. The acute aquatic toxic effect of either ROUNDUP, glyphosate, or the surfactant is relatively rapid. Exposure beyond 24 hours (up to 96 hours) did not significantly increase mortality (Table 3.5). Folmar's studies further showed that (1) water temperature influenced the toxicity of ROUNDUP to both the bluegill and the rainbow trout, and (2) maximum acute toxicity of ROUNDUP to rainbow trout and bluegills occurred at pH 7.5 and above.

Table 3.3

COMPARISON OF CHRONIC TOXICITY VALUES (NOEL) FOR DAPHNIA MAGNA  
AND FATHEAD MINNOWS FOR ANIONIC AND NONIONIC SURFACTANTS  
(Adapted from Maki, 1979)

TEST MATERIAL <sup>1/</sup>	NOEL VALUES (ug/l) <sup>2/</sup>	
	Daphnia	Fathead Minnows
Anionic Surfactants		
C <sub>11.8</sub> LAS*	1,180	900
C <sub>13</sub> LAS**	570	150
Alkyl ethoxylate sulfate	270	100
Nonionic Surfactants		
C <sub>12</sub> -C <sub>13</sub> alkyl ethoxylate*	240	320
C <sub>14</sub> -C <sub>15</sub> alkyl ethoxylate**	240	180
Amine Oxide	700	500

<sup>1/</sup> \* Shorter chain; \*\* Longer chain

<sup>2/</sup> NOEL = No observed effect level, based on 21-day chronic toxicity tests.

Table 3.4  
 CONCENTRATIONS (mg/l) OF FOUR SURFACTANTS THAT AFFECT THE  
 SURVIVAL, GROWTH, AND REPRODUCTION OF DAPHNIA MAGNA  
 UNDER CONTINUOUS-FLOW TESTING CONDITIONS  
 (Adapted from Maki, 1979)

Surfactant <sup>1/</sup>	Reproductive inhibition EC50 (mg/l)				
	96-h LC50	21-d LC50	Total young production	Average brood size	Percentage of days reproduction occurred
<u>Anionic</u>					
C <sub>11.8</sub> LAS*	3.94	1.67	1.50	2.30	2.31
C <sub>13</sub> LAS **	2.19	1.17	1.11	1.41	1.29
<u>Nonionic</u>					
C <sub>12</sub> -C <sub>13</sub> alkyl ethoxylate*	1.14	0.93	0.46	0.47	0.70
C <sub>14</sub> -C <sub>15</sub> alkyl ethoxylate**	0.43	0.37	0.28	0.29	0.33

<sup>1/</sup> \*= Shorter chain; \*\*= Longer chain.



Table 3.5

ACUTE TOXICITY OF ROUNDUP AND ITS COMPONENTS TO FISH.  
(Folmar et al., 1979)

Organism	T°C	24-Hour LC50 (mg/l)			96-Hour LC50 (mg/l)			Ratio (G:S)
		Roundup	Glyphosate (G)	Surfactant (S)	Roundup	Glyphosate (G)	Surfactant (S)	
Rainbow trout ( <u>Salmo gairdneri</u> )	12	8.3	140	2.1	8.3	140	2.0	70
Channel catfish ( <u>Ictalurus punctatus</u> )	22	13	130	18	13	130	13	10
Bluegills ( <u>Lepomis macrochirus</u> )	22	6.4	150	3	5.0	140	3	47
Fathead minnow ( <u>Pimephales promelas</u> )	22	2.4	97	1.4	2.3	97	1.0	97

## Fish Embryo and Larval Effects

Species-specific information concerning the developmental biology of aquatic biota should be used to determine appropriate testing with toxic chemicals in order to protect the most vulnerable life stages. The LC50 of ROUNDUP to early life stages of rainbow trout ranges from 1.3 mg/l to 46 mg/l (Table 3.6). The egg stages (embryonic period) are most tolerant, while the stages following hatching and first feeding are most sensitive (Folmar et al., 1979). During the embryonic phase of development, embryos are surrounded by a hardened protective coating, the chorion, which acts as a partial barrier against the movement of compounds into the egg. Trout and catfish embryos hatch out of the chorion, with a large abdominal yolk sac completely enmeshed by an extensive network of blood vessels, the perivitelline blood supply. This abdominal surface can easily absorb pollutants. It is during this period of development that several organ systems develop, including the liver (O'Connell, 1981), which is the major organ for detoxification of teleostian fish and is usually not functional until the initiation of feeding. The later stage alevins (fry) have lost the yolk sac, possess a fully functional liver, and, at different life stages, are protected by scales and multi-layered skin.

A comparison of 96-hour LC50 ROUNDUP concentrations affecting adult and immature fish species indicate that rainbow trout fingerlings are 6.4 times more sensitive; channel catfish fry are approximately 4 times more sensitive than the adults. Analogous data with RODEO spray solution (including ORTHO X-77) are needed to determine which aquatic species and life stages are most sensitive to this formation.

Assessment of potential toxicity to aquatic life must consider the response of immature life stages and not only the data derived from tests with less sensitive adults, since the success of the population will be limited by the success of the early life history stages. Assessment of aquatic toxicity must also consider the length and frequency of exposure (continuous or intermittent). In order to complete such an assessment, California monitoring data during routine applications of both ROUNDUP and RODEO spray solutions are needed.

Table 3.6  
 EMBRYO-LARVAL TOXICITY OF ROUNDUP TO  
 RAINBOW TROUT AND CHANNEL CATFISH  
 (Folmar et al., 1979)

<u>ORGANISMS</u>	<u>STAGE</u> <sup>1/</sup>	<u>LC50 (mg/l)</u>	
		<u>24-hour</u>	<u>96-hour</u>
Rainbow trout ( <u>Salmo gairdneri</u> )	Eyed egg (embryo)	46	16
	Yolk sac fry (eleuthryoembryo)	11	3.4
	Swim-up fry (first-feeding eleuthryoembryo)	2.4	2.4
	Fingerling (1.0 g) (early alevin/juvenile)	2.2	1.3
	Fingerling (2.0 g) (alevin/juvenile)	8.3	8.3
Channel catfish ( <u>Ictalurus punctatus</u> )	Eyed egg (embryo)	43	-
	Yolk sac fry (eleuthryoembryo)	4.3	4.3
	Swim-up fry (first-feeding eleuthryoembryo)	3.7	3.3
	Fingerling (2.2 g) (juvenile)	13	13

<sup>1/</sup> Terminology in parentheses is according to Balon (1975).

## CHAPTER 4. WATER QUALITY CRITERIA AND GUIDELINES

Application of herbicides in or near water courses may result in their residues being discharged into the water. These residues should be kept to the lowest practical limits to assure the public that the beneficial uses of water are protected. Numerical limits for domestic water supply and aquatic habitat are desirable to protect water quality and to interpret the biological significance of detected residues.

The SWRCB Pesticide Guidance Document (SWRCB, 1982) indicates that, in collaboration with the regional boards, water quality limits will be set for pesticides of statewide significance. Specific regional water quality limits may be developed if local conditions warrant. Water quality limits, coupled with good monitoring data, can be used by agencies to determine the health of an aquatic habitat and the need for regulatory measures. They can also be of value in determining the effectiveness of existing management practices and mitigation measures.

### Domestic Water Supply Guideline

EPA's recommended limit for glyphosate in drinking water (500 ppb) is included in the total acceptable daily intake (ADI) for this herbicide of 0.10 milligrams/kilogram/day. The ADI is based upon the most recent three-generation reproduction study (NOEL=10 mg/kg/day) and includes a 100-fold safety factor (Federal Register, 1982b). For a 60 kg person drinking two liters of water a day, the ADI would be reached with a concentration of 3.0 mg/l. Total daily intake includes food-borne residues as well as drinking water. EPA proposed a potable water limit of 0.5 ppm (mg/l). In the absence of information indicating a high potential for chronic human health effects from this chemical, the 100-fold safety factor appears appropriately protective. Staff, therefore, supports adopting the EPA recommended limit (0.5 ppm glyphosate) by the California Department of Health Services.

### Aquatic Habitat Guideline

As indicated in previous chapters, the toxic effects of the surfactants should not be ignored. The ROUNDUP formulation contains a surfactant (MON 0818); the exact amount is considered a trade secret. The RODEO formulation does not initially contain a surfactant. The registrant recommends that the user add a surfactant (e.g., Ortho X-77) prior to application. A comprehensive assessment of water quality impacts would require comparisons of the two formulations as a final spray solution, as well as a test-by-test comparison of the two surfactants. Neither published nor unpublished data in DFA files are sufficient to make this rigorous comparison. Ghassemi et al. (1982) also recommended this type of comparison be performed by independent researchers to allow better assessment of environmental effects.

Gaps in the existing data base for various forms of aquatic life do not allow use of EPA's comprehensive methodology (Federal Register, 1980) to calculate water quality criteria for glyphosate. A valid comparison of surfactant (MON 0818 and ORTHO X-77) toxicities is difficult since the limited tests with each surfactant were run under different test conditions. Recommended water quality guidelines to protect aquatic life, therefore, must be derived from the limited data available. An aquatic guideline of 0.130 ppm (mg/l) glyphosate acid is recommended for water-borne residues of ROUNDUP due to the increased toxic effect of the surfactant in the ROUNDUP formulation. This value is based upon the application of a 10-fold safety factor to the 96-hour LC50 value of 1.3 mg/l ROUNDUP analyzed as glyphosate acid. This result was obtained using immature rainbow trout, the most sensitive life stage of the most sensitive species (Folmar et al., 1979; Finlayson, 1983). An aquatic toxicity interim guideline for the RODEO formulation should be derived when data on toxicity of the recommended surfactant (Ortho X-77) to early life stages of aquatic organisms become available.

In 1981, State Board staff reviewed the available aquatic toxicity data and found that information was not sufficient to calculate water quality criteria to protect aquatic life using the November 1980 EPA methodology. This method requires continuous-flow acute and chronic tests for various species and trophic levels (Federal Register, 1980). In order to derive water quality criteria using the EPA method, staff requested Monsanto to perform the following studies:

1. Acute (96-hour) continuous-flow toxicity tests using the ROUNDUP formulation with rainbow trout, bluegill, and scud; and
2. Chronic toxicity tests of three aquatic species using the ROUNDUP formulation.

Monsanto agreed to perform (1) the 96-hour continuous-flow tests requested, and (2) a chronic toxicity test of one species, but used the glyphosate acid rather than the formulated product, ROUNDUP.

The Department of Fish and Game (DFG) staff has recommended that some chronic toxicity studies on aquatic organisms, i.e., a salmonid, a non-salmonid fish, and an invertebrate, be performed on RODEO and its surfactants. State Board staff concurs with this recommendation. Additional toxicity tests for the more toxic ROUNDUP formulation are also recommended. Ideally, a comprehensive assessment of water quality impacts would involve aquatic toxicity bioassays and environmental fate studies of:

1. the actual spray solution
2. each active ingredient
3. each surfactant or other inert ingredient

In this way, the total impact of treatment and the relative contribution of each constituent in the herbicide solution actually applied could be determined.

Since all the chronic tests needed to meet the protocol of the EPA methodology are not available, State Board staff concluded that a water quality guideline could only be estimated. Complete descriptions of Monsanto's aquatic toxicity tests are not yet public information and, therefore, cannot be presented in this report. Additional chronic tests on formulated material would allow application of EPA's comprehensive methodology to derive appropriately protective water quality criteria.

When additives (e.g., MON 0818) are the major concern, DFA (Kurtz, 1984) has suggested establishing maximum allowable concentrations which take into account synergistic effects of the additive and active ingredients. State Board staff agree with this suggestion. Implementation will require the registrant to provide chemical identity of these substances as well as practical analytical methods for determining concentrations in water and sediment.

CHAPTER 5. POTENTIAL MITIGATION MEASURES  
AND RECOMMENDED MANAGEMENT PRACTICES

The specific time, place, and manner of a chemical's application can reduce or eliminate its residues in water. The water quality guidelines for human health and aquatic life protection that are recommended in this report should not be exceeded if the registrant's use practices are followed (See Appendix 5). These mitigation measures should be verified under California application conditions.

Label restrictions for ROUNDUP (conifer release) include:

Do not apply:

1. When rain is likely (within six hours of application).
2. Under wind or other conditions (>5 mph) which allow drift to occur.
3. By air:
  - (a) To right-of-way sites;
  - (b) Within 200 feet of any agricultural, horticultural, park, golf course, homestead, or any populated areas;
  - (c) Within 125 feet of lakes, ponds, and streams used for significant domestic purposes or angling (when using more than two quarts per acre); or within 75 feet of lakes, ponds, and streams used for significant domestic purposes or angling (when using two quarts or less per acre).
4. Directly to any body of water.
5. To weed foliage to the point of runoff.
6. In areas where an adverse impact on federally designated endangered/threatened plant or aquatic species is likely.
7. With improperly maintained and calibrated equipment.
8. Additionally: The user should not dispose of wastes or clean equipment in a manner which may contaminate water.

Although ROUNDUP is not presently a restricted pesticide requiring a use permit, it is further recommended that users consult with county agricultural commissioners, the regional water quality control boards, and the Department of Fish and Game for site-specific guidance and interpretation of label requirements prior to application for silvicultural uses. For example, a greater than 50 percent chance of rain could be used to determine whether or not aerial application should occur.

RODEO (Aquatic Weed Control):

Because RODEO is applied directly to water, different use restrictions are recommended and include:

Do not apply:

1. Within 0.5 mile upstream of potable water intakes.
2. On rice levees when floodwater is present.
3. In seawater areas.
4. If heavy rainfall or irrigation is likely to occur within 2 hours after application.

Additionally:

5. Avoid wash-off of sprayed foliage by boat backwash. Do not repeat within 24 hours following the initial treatment.
6. Make applications to moving bodies of water while traveling upstream to prevent concentration of the product in water. When making any bankside applications, do not overlap more than one foot into open water. The maximum rate (7.5 pints per acre) must not be exceeded in any single application. Do not spray across open, moving bodies of water.
7. Allow seven or more days after drawdown or in dry ditches before reintroduction of water. Apply the product within one day after drawdown to ensure application to actively growing weeds.
8. Dispose of pesticide spray mixture or rinse water that cannot be used according to label instructions and applicable federal, state, or local procedures. Triple rinse containers.
9. In case of spill or leak, soak up and remove to any approved landfill.



10. Herbicide users should pay special attention to the quality of the water used to prepare the spray solution. This can greatly affect the efficacy of the herbicide. For example, high concentrations of sediment and dissolved inorganic chemicals in makeup water can reduce herbicide efficacy. This, in turn, could result in the need for repeated applications of the herbicide with increased potential for environmental contamination (Buhler and Burnside, 1983).

As with the recommendations for silvicultural uses of ROUNDUP, users applying RODEO to public waters should consult with the appropriate county agricultural commissioner, regional water quality control board, and the Department of Fish and Game for site-specific guidance and interpretation of label requirements prior to application of RODEO for aquatic weed control.



APPENDICES





CONTRA COSTA WATER DISTRICT  
1331 CONCORD AVENUE  
POST OFFICE BOX H20, CONCORD, CA 94524  
TELEPHONES 682-5950 OR 439-9169

Appendix 1

DIRECTORS

CRAIG Z RANDALL, PRES.  
BETTE BOATMUN, V.P.  
DONALD P. FREITAS, TREAS.  
RONALD E. BUTLER  
DANIEL L. PELLEGRINI

JOHN E. DEVITO, GEN. MGR.  
JOHN S. GREGG, MGR. OF OPER.

July 22, 1983

Dennis Corcoran  
Toxic Substance Control Program  
State Water Resources Control Board  
P.O. Box 100  
Sacramento, CA 95801

Dear Mr. Corcoran

As discussed during our telephone conversation yesterday, the Water District requests your assistance in assessing the potential for any public health effects associated with the use of Rodeo, a herbicide, for control of water hyacinth in waters near the intake to the Contra Costa Canal.

The Water District diverts water from Rock Slough into the Contra Costa Canal for delivery to municipal treatment plants throughout eastern and central Contra Costa County. The Canal's intake structure is located at the western end of Rock Slough, about 3-1/2 miles west of Old River. Between Old River and the Canal intake, Rock Slough is essentially a closed channel with no tributary inflow. Municipal water treatment plants divert water from the Canal at points ranging from five to 50 miles westerly of the intake. The residential population dependent on this source of drinking water exceeds 300,000 persons.

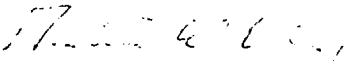
We have learned that Rodeo, whose active ingredient is glyphosate, is being used at a marina on Old River at the entrance to Rock Slough. The marina operator states that he is currently applying the material within the marina at the rate of a few ounces per day. However, he states that he will use the material at locations outside his marina, including the waters of Rock Slough, if he determines that such action is necessary.

We would appreciate your opinion on the question of whether the use of Rodeo within Rock Slough or near its entrance poses a public health risk to our municipal water users. Information on the degree to which Rodeo may be removed from source water during conventional sedimentation and filtration would be useful. Finally, please give us your

Dennis Corcoran  
July 22, 1983  
Page 2

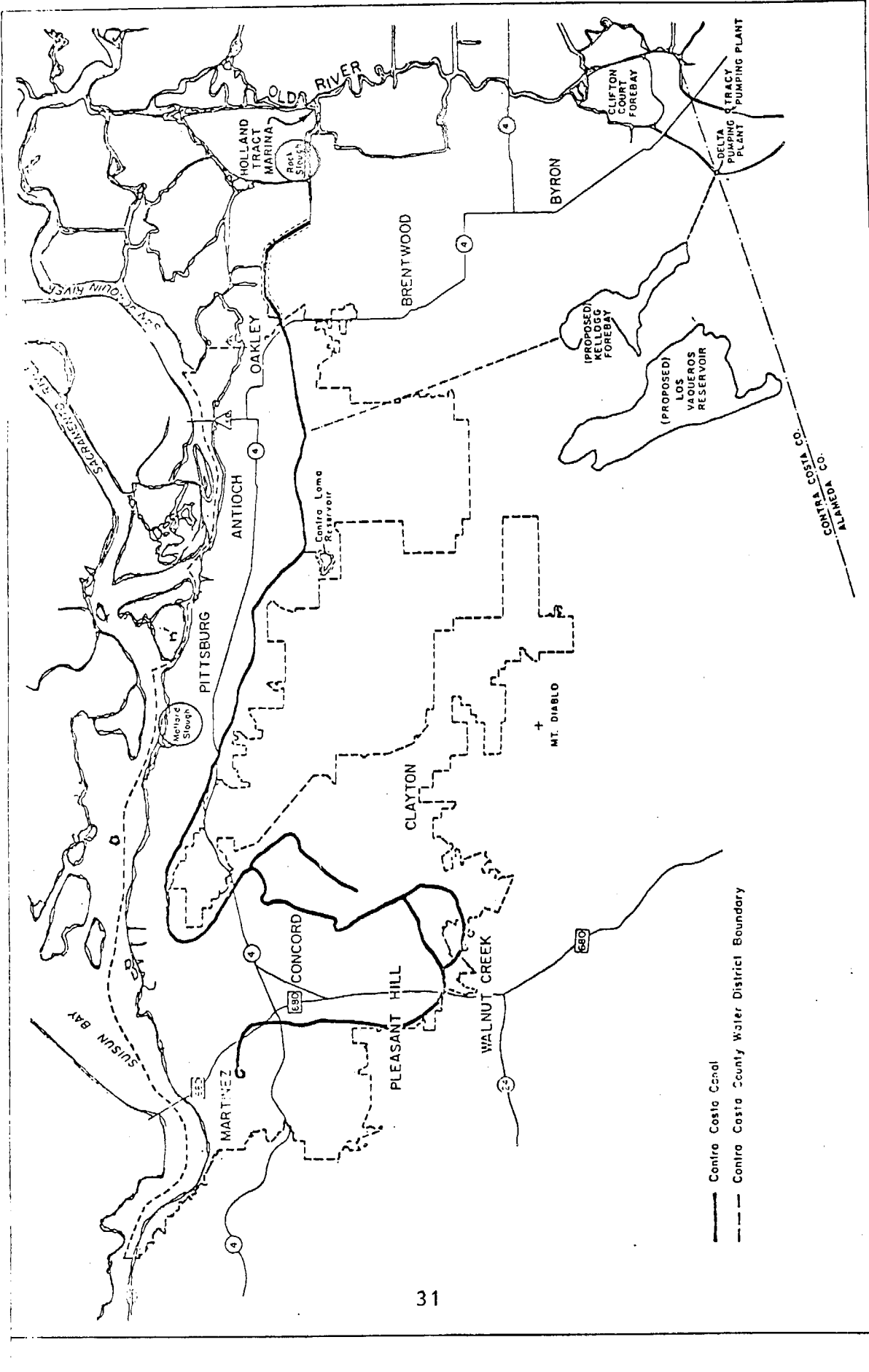
advice as to any appropriate response to this situation,  
including any precautionary measures you think necessary.

Sincerely



Austin W. Nelson  
Chief, Water Supply Division

AWN:da



——— Contra Costa Canal  
 - - - Contra Costa County Water District Boundary

## APPENDIX 2

### GLYPHOSATE ANALYTICAL METHODOLOGY

#### PROBLEMS

Although several methods have been proposed for the analysis of glyphosate and its major metabolite, aminomethyl phosphonic acid (AMPA), none is totally adequate. Table A-2.1 summarizes some of the methods cited in the literature. In general, glyphosate analysis is tedious, requiring much cleanup and derivatization (particularly for biological samples). For these reasons, quantitative reproducible recoveries are difficult to obtain and therefore commercial laboratories generally do not analyze for glyphosate. In the few glyphosate environmental fate studies reported in the literature, analyses of the pesticide were done by Monsanto.

According to Bronstad and Friestad (1976), the original method from the manufacturer (Monsanto, 1974) is extremely tedious and requires a four-step cleanup and two-step derivatization reaction before gas-liquid chromatography. Elaborate cleanup is required to remove salts and water completely before forming a volatile derivative according to the method recommended by EPA (Food and Drug Administration, 1977).

The only commercial laboratory in the U. S. which has routinely analyzed for glyphosate is Analytical Biochem Laboratory, Columbia, Missouri. The time required to analyze a set of ten samples was two weeks. The analytical method used is that proposed by Monsanto with a detection limit of 5 ppb for either glyphosate or its major metabolite AMPA (Schofield, 1982). A second commercial laboratory, Analytical development Corporation (ADC) of Monument, Colorado, had analyzed for glyphosate in the past. Because of the complexity of the Monsanto procedure and the uncertainty of the results, ADC gave up the analysis several years ago (Breault, 1982). A commercial laboratory in California (North Coast Labs, Arcata) has recently indicated that it may be able to analyze for glyphosate (Chaney, 1984). However, an interlaboratory calibration study involving Monsanto would be required to verify the precision and accuracy of any commercial laboratory's analytical methodology.

#### Gas-liquid chromatography (GLC)

Since glyphosate is not a volatile chemical, GLC analysis requires derivatization. Guinivan et al. (1982) formed 2-chloroethyl N-heptafluorobutyryl derivatives of glyphosate and AMPA for GLC analysis of the pesticide residues in blueberry samples. However, McChesney (1984) was not successful in adopting this procedure for kiwi fruit analysis. Moye and Deyrup (1984) developed a single-step derivatization method for the GLC



Table A-2.1

## SELECTED ANALYTICAL METHODS FOR GLYPHOSATE

<u>METHOD</u>	<u>MATRIX</u>	<u>DETECTION LIMIT</u>	<u>REMARKS</u>	<u>REFERENCE</u>
1. Gas-liquid chromatography (G.L.C.) (flame photometric detector)	Soil & water	2.5 ug/l	1. Requires extensive cleanup and derivatization. 2. Aminomethylphosphonic acid (AMPA) can be analyzed.	Edwards et al., 1980; FDA, 1977
2. G.L.C. (electron capture detector)	Plant	25 pg (Glyphosate) 75 pg (AMPA)	1. Requires cleanup and derivatization. 2. AMPA can be analyzed.	Guinivan et al., 1982
3. G.L.C. (flame ionization detector)	Soil & water	ug amt.	1. Requires cleanup and derivatization. 2. AMPA can be analyzed.	Rueppel et al., 1976
4. High pressure liquid chromatography (HPLC) (colorimetric detector)	Water	2.5 (ppm)	1. For formulation and technical samples only. Not for residue analysis. 2. Surfactant can be analyzed.	Burns and Tomkins, 1979
5. Polarography	Water	35 ppb	1. Requires derivatization. 2. AMPA cannot be analyzed.	Bronstad and Friestad, 1976
6. Colorimetric (phosphomolybdate heteropoly blue complex measured at 830 nm)	Water	1 ppm	1. Requires hydrogen peroxide pretreatment (to oxidize organic phosphate to orthophosphate). 2. Interferences; non-specific.	Glass, 1981
7. Amino acid analysis	Water	3.4 ug	1. Cysteic acid interference. 2. AMPA can be analyzed.	Ekstrom and Johansson, 1975
8. Thin-layer chromatography (TLC)/ninhydrin (microcrystalline cellulose)	Water	0.1 ug 0.0g ug (AMPA)	AMPA can be analyzed.	Ragab, 1978
9. TLC/fluorescence	Plant	10 ng (std.)	1. Derivatization on TLC plate. 2. Interferences from amines.	Young et al., 1977
10. TLC/auto-radiography	Plant	N.A.	Separation and identification of metabolites.	Sprankle et al., 1978
11. Liquid scintillation counting	Water, soil & plant	N.A.	Not applicable to field situation.	Hance, 1976; Sprankle et al., 1975a,b
12. Bioassay	Soil	40 ppm	A 40 ppm solution caused 50% root growth inhibition of a test plant (grain sorghum).	Hensley et al., 1978

analysis of glyphosate and AMPA. Residues could only be quantified at the ug/ml solvent level using analytical "standard". It has not been used for environmental samples (e.g., water, soil, and biota).

#### High-performance liquid chromatography (HPLC)

HPLC analysis of glyphosate also requires extensive cleanup and derivatization. The methods reported in the literature differ in the use of the derivatization agents and cleanup steps. The procedure of Seiber et al. (1984) for HPLC analysis of glyphosate residues in kiwi fruit and asparagus involves cleanup of the water extract by anion-exchange and gel permeation chromatography prior to derivatization with trifluoroacetic anhydride followed by diazomethane. Further cleanup of derivatized glyphosate was achieved with silica gel HPLC.

It took 18 months to develop this method and one month to run 35 samples (McChesney, 1984). Other researchers (Class, 1983; Moye et al., 1983) claim that their procedures are simpler, faster, and more specific for HPLC analysis of glyphosate residues. Monsanto has also developed a new HPLC method which is considered confidential (Sieckert, 1984). The only direct HPLC analysis of glyphosate (without derivatization) has been reported for formulations and technical samples (Burns and Tompkins, 1979).

#### Miscellaneous

The polarographic method of analysis also involves a derivatization step (nitrosation of glyphosate to form N-nitrosoglyphosate) because glyphosate itself is not polarographically active (Bronstad and Friestad, 1976). Even the simplest colorimetric method of detection involves a pretreatment step to oxidize glyphosate to orthophosphate (Glass, 1981). Methods involving thin-layer chromatography (TLC) are good for separation but not sensitive for quantification. Use of radioactive labeled glyphosate and its subsequent analysis by liquid scintillation counting is applicable only under laboratory or greenhouse experimental conditions for plant and animal metabolism studies as well as soil and water degradation studies. Bioassay is a time-consuming nonchemical method of analysis which is neither sensitive nor specific.

## APPENDIX 3

### PHYSICAL AND CHEMICAL PROPERTIES

ROUNDUP is Monsanto's brand name for an herbicide product (MON 2319) which contains 41 percent of the isopropylamine salt of glyphosate (MON 0139) (Table A-3.1). In addition to the active ingredient, various "inert ingredients" including a surfactant (MON 0818), make up the other 59 percent of the product. The Environmental Protection Agency and the Department of Food and Agriculture have also registered another Monsanto product called RODEO. This formulation contains 53.5 percent of the isopropylamine salt of glyphosate (MON 0139) and 46.5 percent inert ingredients. The surfactant in the ROUNDUP formulation (MON 0818) is different from the one added to the RODEO formulation prior to application. Several "home garden" products containing less than 2 percent of isopropylamine salt of glyphosate are registered by the Ortho Chemical Division of Chevron.

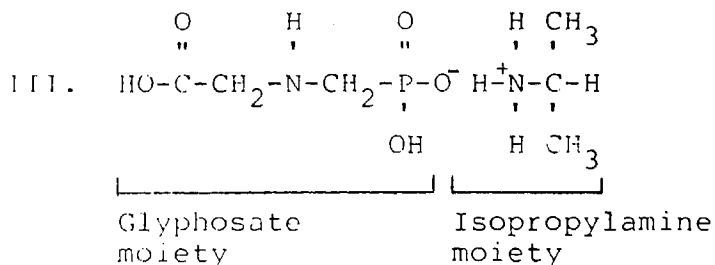
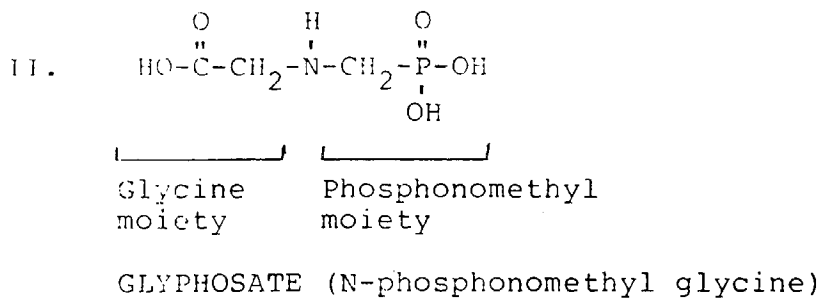
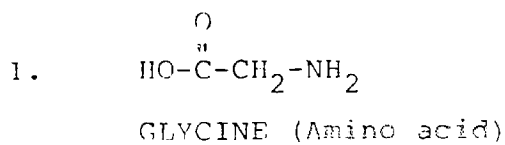
The chemical structures of glyphosate and related compounds are described in Table A-3.2; physical and chemical properties are listed in Table A-3.3. Monsanto, the primary manufacturer of glyphosate, and Chevron, a formulator, consider public disclosure of inert ingredients to be a violation of trade secret rights since Section 10, FIFRA does not require disclosure of this information.

Table A-3.1  
 COMPARISON OF ROUNDUP AND RODEO  
 FORMULATION OF GLYPHOSATE  
 (FROM PRODUCT LABELS)

	<u>ROUNDUP</u>	<u>RODEO</u>
Active Ingredient: isopropylamine salt of glyphosate	41.0%	53.5%
"Inert" ingredients*	59.0%	46.5%
Pounds of glyphosate acid per gallon	3.0	4.0
Pounds of isopropylamine salt of glyphosate per gallon	4.0	5.4

\*ROUNDUP contains the surfactant MON0818. RODEO does not contain the surfactant MON0818, but the user is required to add the surfactant Ortho X-77 prior to application.

Table A-3.2  
 CHEMICAL STRUCTURES OF GLYCINE, GLYPHOSATE,  
 AND ISOPROPYLAMINE (IPA) SALT OF GLYPHOSATE



IPA SALT OF GLYPHOSATE (Active ingredient of formulated product, ROUNDUP)\*

- IV. ROUNDUP contains (III) + Surfactant (MON0818) + Inert ingredients\*\*  
 RODEO contains (III) + inert ingredients\*\*\*

This structure is believed to be correct based on pka values of OH groups.

\*\* ROUNDUP contains 4 pounds/gallon of the isopropylamine salt of glyphosate.

\*\*\* RODEO contains 5.4 pounds/gallon of the isopropylamine salt of glyphosate.

Table A-3.3

PHYSICAL AND CHEMICAL PROPERTIES OF GLYPHOSATE<sup>1/</sup>


---

1. Physical state, color, and odor	Solid, white, odorless
2. Molecular weight	169.1
3. Density	0.5 g/cc for pure chemical
4. Melting point	200°C
5. Boiling point	Not determined
6. Vapor pressure	Negligible
7. Solubility	
Water	1-2% (25°C)
Other solvents	None reported
8. Partition coefficient in octanol/water	0.0017 at 20 ppm 0.0006 at 100 ppm

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<sup>1/</sup> Items 1 through 7 from Herbicide Handbook, 1979. Item 8 from Ghassemi et al., 1982.

## APPENDIX 4

### ENVIRONMENTAL FATE

Limited information is available to assess the fate of glyphosate and its formulated products in the environment. The lack of simple analytical methods has limited most investigations to small-scale greenhouse and laboratory studies. The Oregon field study of forestry use (Newton, 1980) and the U. S. Fish and Wildlife study of aquatic toxicology (Folmar et al., 1979) relied upon the manufacturer to perform the difficult and expensive chemical analytical work.

No published information has been found to describe the environmental fate of the ROUNDUP surfactant (MON 0818) or the RODEO additive (ORTHO X-77). A small-scale lab study on degradation of MON 0818 was performed. Although the study is classified by the manufacturer as confidential, SWRCB staff appraised it in preparing this assessment.

The three main processes controlling the environmental fate of glyphosate are the following (Figure A4.1):

1. Microbial degradation;
2. Soil adsorption;
3. Plant uptake.

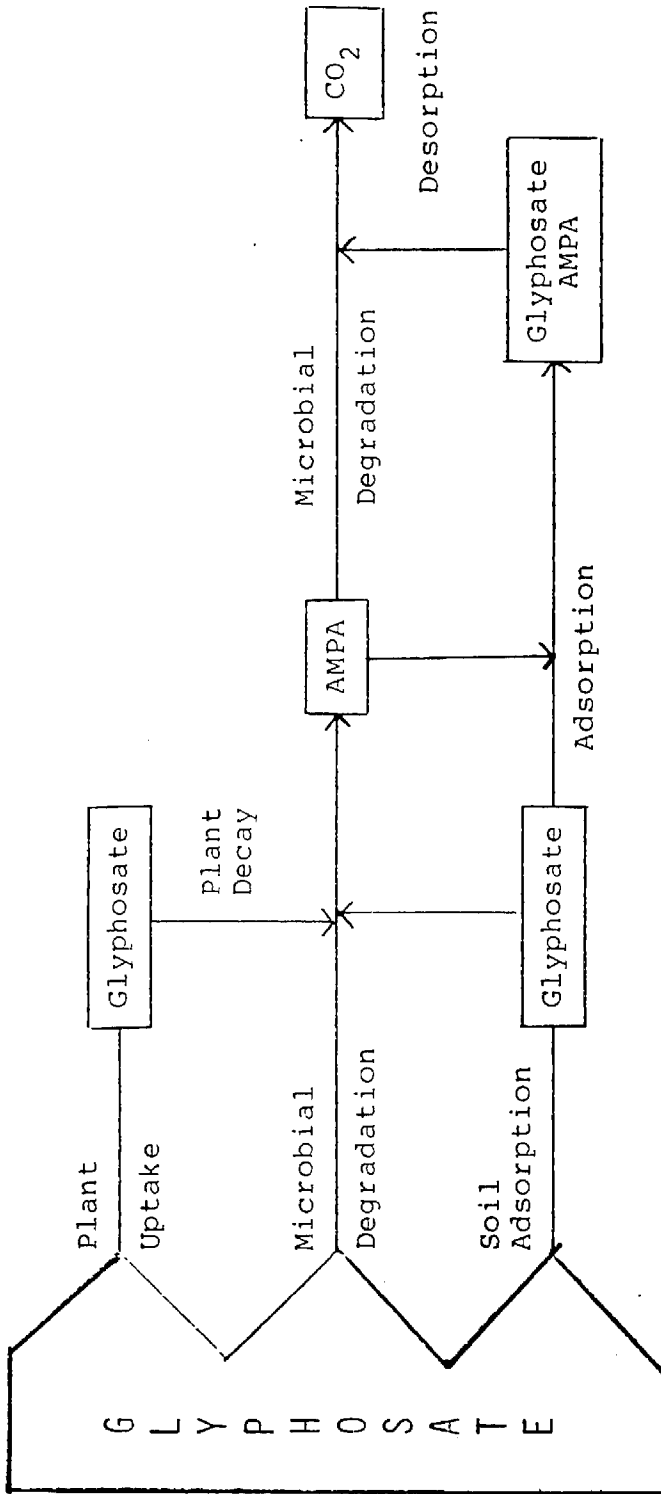
Other breakdown processes are considered to be less significant. Chemical degradation is thought to occupy a minor role (Rueppel et al., 1977; Sprankle et al., 1975a). No evidence exists for photochemical degradation (Tortensson and Aamisaep, 1977) or volatilization (Rueppel et al., 1977).

#### 1. Microbial Degradation

This process is the major breakdown pathway. Adsorption to soil can limit the rate of microbial degradation (Moshier and Penner, 1978). No studies were found which describe the extent to which adsorption of glyphosate to soil or desorption from soil influences microbial degradation. The major metabolic pathway is to the intermediate breakdown product aminomethyl phosphonic acid (AMPA) and, finally, to CO<sub>2</sub> and inorganic elements (Nomura and Hilton, 1977; Rueppel et al., 1977). Initially, there is a rapid decomposition of available glyphosate followed by slower breakdown of the adsorbed residues (Sprankle et al., 1975a; Nomura and Hilton, 1977; Rueppel et al., 1977). Factors which influence the

Figure A-4.1

MAJOR FACTORS AFFECTING THE ENVIRONMENTAL DISSIPATION OF GLYPHOSATE





rate of microbial degradation include soil moisture, temperature, organic substrate, nutrient levels, herbicide availability, pH, and microbial population (Moshier and Penner, 1978). The latter three are the most important causes of glyphosate degradation.

## 2. Soil Adsorption

Glyphosate and its major metabolite AMPA show a high degree of binding to all soils (Sprankle et al., 1975b). Glyphosate adsorption begins immediately after soil application and increases slowly after one hour. Soil pH and phosphate concentration have been shown to affect glyphosate adsorption measured as plant yield. The phosphonic acid segment of the glyphosate molecule is thought to act like inorganic phosphate in soil (Hance, 1976). Since inorganic phosphate can exclude glyphosate from soil sorption sites, glyphosate adsorption can be directly related to the inorganic phosphate sorption capacity of a soil. The binding of glyphosate to clay has been related to the presence of available iron and aluminum (Sprankle et al., 1975b). Clay adsorption has been shown to occur with minerals such as kaolinite, illite, and bentonite. This type of adsorption depends upon the soil pH. As the soil becomes more acidic (decreases in pH), more adsorption sites become available. The pH of the soil will also affect the charge on the glyphosate molecule itself. This lends further support to the theory that glyphosate binds in a manner similar to inorganic phosphate in the pH range typical of many California soils (pH 5 to 8).

The half-life of glyphosate in soil was reported to range from two weeks in forest soils (Newton, 1980) to 19 weeks in "sandy" soils (Ghassemi et al., 1981). Ghassemi et al. (1982) reported that the registrant (Monsanto) has conducted soil column leaching studies with glyphosate which indicate little potential for leaching. As this study is classified "confidential", no discussion of the experimental conditions is possible.

Chelation may also play a role in glyphosate inactivation. The chelated form of glyphosate may not be available for microbial breakdown. Bioassay studies have shown a significant correlation between glyphosate inactivation and the concentrations of  $\text{FeCl}_3$  and  $\text{AlCl}_3$  (Hensley et al., 1978) and soil anion capacity (Hance, 1976). Development of a  $\text{FeCl}_3$  precipitate with glyphosate has been observed with the precipitate formation being directly proportional to the  $\text{FeCl}_3$  concentration (Hensley et al., 1978). Studies by Moshier and Penner (1978) show a reduction

in microbial degradation in the presence of the ferric ion ( $\text{Fe}^{+3}$ ) but not ferrous oxide ( $\text{Fe}_2\text{O}_3$ ). Aluminum has been shown to react in a manner similar to iron.

To further support these observations, the soils described below have shown very limited glyphosate degradation.

<u>Soil</u>	<u>ph</u>	<u>% O.M.</u>	<u>Related Factors</u>	<u>Phosphate kg/ha</u>	<u>Rate of Degradation</u>
Norfolk Loamy Sand	4.4	1.2	52 ppm Fe "High" Al	72	3% $\text{CO}_2$ in 32 days (Moshier, 1978)
Toledo	3.8	7.4	71.7% Clay	15	13% $\text{CO}_2$ in 28 days (Spankle et al., 1975b)

These acid (low pH) soils with elevated iron and aluminum or clay would be expected to bind strongly to glyphosate and, thereby, slow the rate of microbial degradation. California soils, however, are generally less acidic, lower in soluble iron and aluminum, and contain lower levels of organic matter. Therefore, microbial degradation should occur more rapidly here than in other soil types.

### 3. Plant Uptake

This process can play a significant role in the dissipation and transformation of glyphosate. Some of the major factors which influence the rate of plant absorption include: herbicide formulation, method of application, weather, soil type, plant species, and size of plant canopy.

Direct application of glyphosate to plants results in effective weed control. The basic route of uptake is thought to be through foliage (Jaworski, 1972), although absorption through the roots may also take place depending upon soil type (Sprankle et al., 1975a). Absorption is followed by glyphosate translocation to all parts of the plant (Herbicide Handbook, 1979). Studies of glyphosate plant metabolism show no detectable metabolites (Gottrup et al., 1976; Wyrill and Burnside, 1976). This suggests that the glyphosate acid is not changed once inside the plant until the tissues decay and undergo microbial degradation.

Surfactants can cause a significant increase in foliar absorption of glyphosate under humid conditions (Gottrup et al., 1976). In the presence of the surfactant, absorption increased from 17 percent under conditions of relatively low humidity to 85 percent with high humidity. These experiments were conducted in a greenhouse using Canadian thistle (Cirsium arvense) and leafy spurge (Euphorbia esula). Not all weeds are equally affected, however. Tests on common milkweed (Asclepias syriaca) and hemp dogbane (Apocynum cannabinum) did not show a significant increase in foliar diffusion when a surfactant was used (Wyrill and Burnside, 1976)

### Nitrosation

Production of N-nitrosamine has been found to occur in soils as a result of the interaction of nitrite with agricultural chemicals (Kahn and Young, 1977). The formulated products of glyphosate can contain low levels of N-nitrosoglyphosate. Although treatment of soil with large amounts of sodium nitrite and glyphosate could form N-nitrosoglyphosate (Khan and Young, 1977), this reaction would not be expected under normal field conditions (Khan and Young, 1977; Young and Khan, 1978).

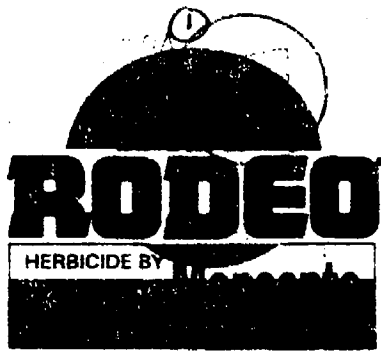
The concentration of glyphosate required for the formation of N-nitrosoglyphosate was high (740 ppm acid equivalent). At the recommended use rate (3.75 lbs glyphosate/acre), the calculated soil concentration of glyphosate would be less than 2 ppm. (The weight of one acre of soil to a six-inch depth is 2 million pounds (Bohn et al., 1979). At the normally low levels of glyphosate and nitrite (2 ppm) present in soil, the formation of nitrosoglyphosate was not observed (Khan and Young, 1977). Both EPA and DFA do not consider N-nitrosoglyphosate to be carcinogenic or persistent (Federal Register, 1978; Wang, 1983).

### Summary

Glyphosate strongly adsorbs to soil and sediment. Microbial degradation appears to be the major route of breakdown. The average half-life in soil is about two months (Ghassemi et al., 1981; Hance, 1976). Little information is available concerning the half-life in surface waters. It is, however, expected to be less in water than in soils due to the removal of water-borne residues by adsorption to suspended substances and sediments and their subsequent benthic deposition (Ghassemi et al., 1981 Comes, et al., 1976). The formation of N-nitrosoglyphosate does not appear to be probable as a result of normal application practices.

APPENDIX 5

PRODUCT LABELS FOR  
ROUNDUP AND RODEO



For broad-spectrum control of emerged weeds.

Complete Directions for Use in Aquatic Sites.

EPA Reg. NO. 524-343

AVOID CONTACT WITH FOLIAGE, GREEN STEMS, OR  
FRUIT OF CROPS, DESIRABLE PLANTS AND TREES.  
SINCE SEVERE INJURY OR DESTRUCTION MAY  
RESULT

\* RODEO is a registered trademark of Monsanto  
Company

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Rodeo<sup>®</sup> herbicide is protected by U.S. Pat. No.  
3,199,758 and U.S. Pat. No. 4,405,536.

In case of an emergency involving this product,  
Call Collect, day or night, (314) 694-4000.

MONSANTO COMPANY 1984

MONSANTO COMPANY  
AGRICULTURAL PRODUCTS  
ST. LOUIS, MISSOURI 63167 U.S.A.



2

Read the entire label.

Use only according to label instructions.

NOT FOR REFORMULATION OR REPACKAGING

Read "LIMIT OF WARRANTY AND LIABILITY" before  
buying or using.

If terms are not acceptable, return at once unopened.

**LIMIT OF WARRANTY AND LIABILITY**

This company warrants that this product conforms to  
the chemical description on the label and is  
reasonably fit for the purposes set forth in the Com-  
plete Directions for Use label booklet ("Directions")  
when used in accordance with those Directions under  
the conditions described therein. NO OTHER EXPRESS  
OR IMPLIED WARRANTY OF FITNESS FOR PAR-  
TICULAR PURPOSE OR MERCHANTABILITY IS MADE.  
This warranty is also subject to the conditions and  
limitations stated herein.

Buyer and all users shall promptly notify this company  
of any claims whether based in contract, negligence,  
strict liability, other tort or otherwise.

Buyer and all users are responsible for all loss or  
damage from use or handling which results from con-  
ditions beyond the control of this company, including  
but not limited to incompatibility with products other  
than those set forth in the Directions, application to or  
contact with desirable vegetation, unusual weather (i  
weather conditions which are outside the range con-  
sidered normal at the application site and for the time  
period when the product is applied with the normal  
range being determined on the basis of the average  
range for the prior 40 years computed from the best  
available information and ii, weather perils including  
but not limited to hurricanes, tornadoes and floods) as  
well as weather considerations set forth in the Direc-  
tions, application in any manner not explicitly set  
forth in the Directions, moisture conditions outside  
the moisture range specified in the Directions, or the  
presence of products other than those set forth in the  
Directions in or on the soil, crop or treated vegetation.

THE EXCLUSIVE REMEDY OF THE USER OR BUYER,  
AND THE LIMIT OF THE LIABILITY OF THIS COMPANY  
OR ANY OTHER SELLER FOR ANY AND ALL LOSSES,  
INJURIES OR DAMAGES RESULTING FROM THE USE  
OR HANDLING OF THIS PRODUCT (INCLUDING  
CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT  
LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE  
THE PURCHASE PRICE PAID BY THE USER OR BUYER  
FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR,  
AT THE ELECTION OF THIS COMPANY OR ANY OTHER  
SELLER, THE REPLACEMENT OF SUCH QUANTITY OF,  
IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF  
SUCH QUANTITY. IN NO EVENT SHALL THIS COMPANY  
OR ANY OTHER SELLER BE LIABLE FOR ANY IN-  
CIDENTAL OR CONSEQUENTIAL DAMAGES.

The buyer and all users are deemed to have accepted  
the terms of this LIMIT OF WARRANTY AND LIABILITY  
which may not be varied by any verbal or written  
agreement.

3

**PRECAUTIONARY STATEMENTS**

**Hazards to Humans and Domestic Animals**

Keep out of reach of children.

**CAUTION!**

**MAY CAUSE EYE IRRITATION.**

Avoid contact with eyes, skin or clothing.

FIRST AID: IF IN EYES, flush with plenty of water for  
at least 15 minutes. Call a physician.

IF ON SKIN, flush with water. Wash clothing before  
reuse.

**Physical or Chemical Hazards**

Solutions of this product should be mixed, stored and  
applied only in stainless steel, aluminum, fiberglass,  
plastic and plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR  
SPRAY SOLUTIONS OF THIS PRODUCT IN GALVAN-  
IZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS  
STEEL) CONTAINERS OR SPRAY TANKS. This product  
or spray solutions of this product react with such con-  
tainers and tanks to produce hydrogen gas which may  
form a highly combustible gas mixture. This gas mix-  
ture could flash or explode, causing serious personal  
injury, if ignited by open flame, spark, welder's torch,  
lighted cigarette or other ignition source.

**Environmental Hazards**

Do not contaminate water by disposal of waste or  
cleaning of equipment.

In case of

SPILL or LEAK, soak up and remove to a landfill.

**Storage and Disposal**

STORE ABOVE 10°F. (-12°C) TO KEEP FROM  
CRYSTALLIZING. Crystals will settle to the bottom. If  
allowed to crystallize, place in a warm room 68°F.  
(20°C) for several days to redissolve and mix well  
before using.

Avoid contamination of seed, feed and foodstuffs.

This product, spray mixture or rinsate, that cannot be  
used or chemically reprocessed, should be disposed of  
according to applicable federal, state or local pro-  
cedures.

Triple rinse container, then dispose of in a sanitary  
landfill, or by incineration if allowed by state and local  
authorities. Do not reuse container.

Consult federal, state or local disposal authorities for  
approved alternative procedures.

**ACTIVE INGREDIENT:**

*Isopropylamine salt of glyphosate	53.5%
INERT INGREDIENTS	46.5%
	100.0%

Contains 648 grams per litre or 5.4 pounds of the ac-  
tive ingredient isopropylamine salt of N-(phosphono-  
methyl) glycine per U.S. gallon. Equivalent to 480  
grams per litre or 4 pounds per U.S. gallon of the acid  
glyphosate.

**GENERAL**

This product, a water-soluble herbicide, is applied with water and nonionic surfactant as a foliage spray for the control of most annual and biennial broadleaf weeds and grasses. It is also effective on many standard industrial or field crop weeds. Application and thorough mixing are essential in accordance with label directions.

This product moves through the plant tissue from point of foliage contact to the growing point. It has a residual effect on most annual weeds and grasses, but on most perennial weeds it may require 2 or more applications. Extremely cool or cloudy weather following treatment may slow the action of the herbicide and delay visual effects of control. In some cases there is a gradual wilting and yellowing of the foliage which advances to complete browning and death. Growth and deterioration of undesirable plants.

Unless otherwise directed, do not apply this product until vegetation has reached the stages described for control in the "Weeds Controlled" section of this label. Unemerged plants arising from underground rhizomes or roots may not be affected by the spray. For this reason best control is obtained when treatment is made at the growth stage approaching maturity.

Always use the higher rate of the product per acre within the recommended range when weed growth is heavy or dense.

Do not treat weeds under poor growing conditions such as drought stress, as reduced weed control may result. Reduced results may also occur when flowering weeds are covered with dust.

Reduced control may result when applications are made to any weed or brush species that have been mowed, grazed, or cut, and have not been allowed to regrow to the recommended stage for treatment.

Rainfall or irrigation occurring within 2 hours after application may reduce effectiveness. Heavy rainfall or irrigation within 2 hours after application will wash the product off the foliage. Additional applications may be required.

This product does not contain any volatile solvents. For subsequent residual control, use a label-approved herbicide. Observe the cautionary statements and other information appearing on the label. Buyer and all users should be aware of the damage in connection with the use of mixtures of this product with herbicides not expressly recommended on this label.

**AT**

**AVOID DRIFT. EXTREMELY TOXIC TO DESIRABLE PLANTS.**

Do not allow the herbicide or splash onto desirable plants.

Destruction of the crop, plants, or other areas on which treatment was not intended. The likelihood of drift or crop injury resulting from the use of this product is greatest when winds are gusty or in excess of 5 miles per hour or when other conditions, including lesser wind velocities, will allow spray drift to occur. When spraying, avoid combinations of pressure and nozzle type that will result in splatter or fine particles (mist) which are likely to drift. **AVOID APPLYING AT EXCESSIVE SPEED OR PRESSURE.**

**NOTE:** That other products in the mixture not consistent with this label may be injurious to persons, animals or crops. If such a combination is used, the container should be closed to prevent spray drift.

Do not use this product in areas where it may be injurious to desirable plants or water.

**MIXING AND APPLICATION INSTRUCTIONS**

**PREPARED SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT SHOULD BE DELIVERING DESIRED VOLUMES AND THE APPLICATION SHOULD BE PROPERLY DIRECTED TO AVOID SPRAYING DESIRABLE PLANTS. NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS WATER FROM PONDS AND UNLINED DITCHES.**

**MIXING**

The product mixes readily with water. Mix spray solutions of this product as follows: Fill the mixing or spray tank with the required amount of water while adding the required amount of this product (see "Directions for Use" and "Weeds Controlled" sections of this label). Near the end of the filling process, add the required surfactant and mix well. Remove hose from tank immediately after filling to avoid siphoning back into the water source. During mixing and application, foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, place the filling hose below the surface of the spray solution, terminate by pass and return lines at the bottom of the tank and if needed use an approved anti-foam or defoaming agent.

Place the spray line on or near bottom of tank to minimize foaming. Screen size in nozzle or line should be no finer than 50 mesh. Carefully select correct nozzle to avoid spraying a fine mist. For best results with conventional ground application equipment, use fan nozzles. Check for even distribution of spray droplets.

**NOTE:** For the most efficient application, use coarse sprays only. For specific rates of application and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label.

**EQUIPMENT**

**BOOM EQUIPMENT**  
Use coarse sprays only

Use the recommended rates of this product and surfactant in 3 to 20 gallons of water per acre as a broadcast spray. See the "Weeds Controlled" section of this label for specific rates. Aerial applications of this product may only be made as specifically recommended on this label.

**AVOID DRIFT — DO NOT APPLY DURING INVERSION CONDITIONS, WHEN WINDS ARE GUSTY, OR UNDER ANY OTHER CONDITION WHICH WILL ALLOW DRIFT. DRIFT MAY CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES MUST BE MAINTAINED.**

Coarse sprays are less likely to drift, therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label.

Ensure uniform application — To avoid streaked, uneven or overlapped application, use appropriate marking devices.

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE. The maintenance of an organic coating (Paint) which meets aerospace specification MIL-C-38413 may prevent corrosion.

**BOOM EQUIPMENT**

For control of weed or brush species listed on this label using conventional boom equipment — Use the recommended rates of this product and surfactant in 3 to 20 gallons of water per acre as a broadcast spray. See the "Weeds Controlled" section of this label for specific rates. As density of weeds increases, spray volume should be increased within the recommended range to insure complete coverage. Carefully select correct nozzle to avoid spraying a fine mist. For best results with ground application equipment, use flat fan nozzles. Check for even distribution of spray droplets.

**HAND-HELD and HIGH-VOLUME EQUIPMENT**

Use coarse sprays only

For control of weeds listed on this label using knapsack sprayers or high volume spraying equipment utilizing handguns or other suitable nozzle arrangements — Prepare a ¼ to 1½ percent solution of this product in water, add surfactant and apply to foliage of vegetation to be controlled. For specific rates of application and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label.

Applications should be made on a spray-to-wet basis. Spray coverage should be uniform and complete. Do not spray to point of runoff.

Prepare the desired volume of spray solution by mixing the amount of this product in water shown in the following table.

Spray solution

DESIRED VOLUME	AMOUNT OF RODEO*			
	¼%	1%	1½%	2%
1 gallon	1 oz.	1½ oz.	2 oz.	2 oz.
25 gallons	1½ pt.	1 qt.	1½ qt.	1½ qt.
100 gallons	3 qt.	1 gal.	1½ gal.	1½ gal.

2 tablespoons = 1 ounce

For use in knapsack sprayers, it is suggested that the recommended amount of this product be mixed with water in a larger container. Fill sprayer with the mixed solution and add the correct amount of surfactant.

## WEEDS CONTROLLED

### ANNUAL WEEDS

Apply to actively growing annual grasses and broadleaf weeds.

Allow at least 3 days after application before disturbing treated vegetation. After this period the weeds may be mowed, tilled or burned. See "Directions for Use," "General Information" and "Mixing and Application Instructions" for labeled uses and specific application instructions.

**Broadcast Application** — Use 1½ pints of this product per acre plus ¼ to ½ percent surfactant by total spray volume if weeds are less than 6 inches tall. If weeds are greater than 6 inches tall, use 2½ pints of this product per acre plus ¼ to ½ percent surfactant by total spray volume.

**Hand-Held High Volume Application** — Use a ¼ percent solution of this product in water plus ¼ to ½ percent surfactant by total spray volume and apply to foliage of vegetation to be controlled.

When applied as directed under the conditions described in this label, this product plus nonionic surfactant will CONTROL the following ANNUAL WEEDS:

<b>Barley</b> <i>Hordeum vulgare</i>	<b>Panicum</b> <i>Panicum</i> spp.
<b>Bluegrass (annual)</b> <i>Poa annua</i>	<b>Pennycress (field)</b> <i>Thlaspi arvense</i>
<b>Brome (downy)</b> <i>Bromus tectorum</i>	<b>Pigweed, Redroot</b> <i>Amaranthus retroflexus</i>
<b>Cocklebur</b> <i>Xanthoxum pennsylvanicum</i>	<b>Pigweed (smooth)</b> <i>Amaranthus hybridus</i>
<b>Corn (volunteer)</b> <i>Zea mays</i>	<b>Ragweed (common)</b> <i>Achillea artemisiifolia</i>
<b>Crabgrass</b> <i>Eragrostis</i> spp.	<b>Ragweed (giant)</b> <i>Achillea trifida</i>
<b>Falseflax (smallseed)</b> <i>Elaeagnus multiflora</i>	<b>Rye</b> Spike cereal
<b>Fiddleneck</b> <i>Ammannia</i> spp.	<b>Ryegrass (Italian)</b> <i>Lolium rigidulum</i>
<b>Fleabane</b> <i>Eupatorium</i> spp.	<b>Sandbar (field)</b> <i>Cenchrus</i> spp.
<b>Foxtail</b> <i>Setaria</i> spp.	<b>Shattercane</b> <i>Sorghum bicolor</i>
<b>Kochia</b> <i>Kochia scudovnikii</i>	<b>Smartweed (Pennsylvania)</b> <i>Polygonum persicaria</i>

- Lambsquarters (common)**  
Chenopodium album
- Spanishneedles\***  
Bidens bipinnata
- Lettuce (prickly)**  
Lactuca serriola
- Sunflower**  
Helianthus annuus
- Mustard (tansy)**  
Descurainia pinnata
- Thistle (Russian)**  
Salsola kali
- Oats (wild)**  
Avena fatua
- Yehweiteal**  
Abutilon theophrasti

\*Apply 3 pints of this product per acre  
Annual weeds will generally continue to germinate from seed throughout the growing season. Repeat treatments will be necessary to control later germinating weeds

**PERENNIAL WEEDS**

Apply this product as follows to control or destroy most vigorously growing perennial weeds. Unless otherwise directed, allow at least 7 days after application before disturbing vegetation.

Add ¼ to ½ percent nonionic surfactant by total spray volume to the rates of this product given in this list. See the "General Information," "Directions for Use," "Mixing and Application" sections of this label for specific uses and application instructions.

NOTE: If weeds have been mowed or tilled, do not treat until regrowth has reached the recommended stages. Fall treatments must be applied before a killing frost.

Repeat treatments may be necessary to control weeds regenerating from underground parts or seed.

When applied as recommended under the conditions described, this product plus surfactant WILL CONTROL the following PERENNIAL WEEDS:

- Alfalfa**  
Medicago sativa
- Knapweed**  
Centaurea repens
- Alligatorweed\***  
Alternanthera philoxeroides
- Lantana**  
Lantana camara
- Artichoke (Jerusalem)**  
Helianthus tuberosus
- Maidencane**  
Panicum hematomon
- Bahiagrass**  
Paspalum notatum
- Milkweed**  
Asclepias spp.
- Bermudagrass**  
Cynodon dactylon
- Muhly (wirestem)**  
Muhlenbergia frondosa
- Bindweed (field)**  
Convolvulus arvensis
- Mullein (common)**  
Verbascum thapsus
- Bluegrass (Kentucky)**  
Poa spp.
- Napierrgrass**  
Pennisetum purpureum
- Brackenfern**  
Pteridium aquilinum
- Nightshade (silverleaf)**  
Solanum elaeagnifolium
- Bromegrass (smooth)**  
Bromus inermis
- Nutsedge (purple, yellow)**  
Cyperus rotundus  
Cyperus esculentus
- Cattail**  
Typha spp.
- Orchardgrass**  
Dactylis glomerata
- Clover (red)**  
Trifolium pratense
- Paragrass**  
Brachiaria mutica
- Clover (white)**  
Trifolium repens
- Phragmites\*\***  
Phragmites spp.
- Cutgrass (giant)\***  
Zizaniopsis miliacea
- Quackgrass**  
Agropyron repens
- Dallisgrass**  
Paspalum dilatatum
- Reed canarygrass**  
Phalaris arundinacea

- Dandelion**  
Taraxacum officinale
- Ryegrass (perennial)**  
Lolium perenne
- Dock (curly)**  
Rumex crispus
- Smartweed (swamp)**  
Polygonum coccineum
- Dogbane (hemp)**  
Apocynum cannabinum
- Spatterdock**  
Nuphar luteum
- Fescues**  
Festuca spp.
- Texas Blueweed**  
Helianthus ciliaris
- Guineagrass**  
Panicum maximum
- Thistle (Canada)**  
Cirsium arvense
- Horse-nettle**  
Solanum carolinense
- Timothy**  
Phleum pratense
- Horseradish**  
Armoracia rusticana
- Terpedograss\***  
Panicum repens
- Johnsongrass**  
Sorghum halepense
- Yaseygrass**  
Paspalum urvillei
- Kikuyugrass**  
Pennisetum clandestinum
- Water Hyacinth**  
Eichornia crassipes
- Wheatgrass (western)**  
Agropyron smithii

\*Partial control.  
\*\*Partial control in Southeastern states. See specific recommendation below

**Alligatorweed** — Apply 6 pints of this product per acre as a broadcast spray or as the 1 ¼ percent solution with hand-held equipment to provide partial control of alligatorweed. Apply when most of the target plants are in bloom. Repeat applications will be required to maintain such control.

**Bermudagrass** — Apply 7 ½ pints of this product per acre as a broadcast spray or as a 1 ½ percent solution with hand-held equipment. Apply when target plants are actively growing and when seed heads appear.

**Brackenfern** — Apply 4 ½ to 6 pints of this product per acre as a broadcast spray or as a ¼ to 1 percent solution with hand-held equipment. Apply to fully expanded fronds which are at least 18 inches long.

**Canada Thistle** — Apply 3 to 4 ½ pints of this product per acre as a broadcast spray or as a 1 ½ percent solution with hand-held equipment. Apply when target plants are actively growing and are at or beyond the bud stage of growth. Allow 3 or more days after application before tillage.

**Cattail** — Apply 4 ½ to 6 pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equipment. Apply when target plants are actively growing and are at or beyond the early-to-full bloom stage of growth. Best results are achieved when application is made during the summer or fall months.

**Cutgrass (giant)** — Apply 6 pints of this product per acre as a broadcast spray or as a 1 percent solution with hand-held equipment to provide partial control of giant cutgrass. Repeat applications will be required to maintain such control, especially where vegetation is partially submerged in water. Allow for substantial regrowth to the seven-to-ten leaf stage prior to retreatment.

**Field Bindweed / Silverleaf Nightshade / Texas Blueweed** — Apply 6 to 7 ½ pints of this product per acre as a broadcast spray west of the Mississippi River and 4 ½ to 6 pints of this product per acre east of the Mississippi River. With hand-held equipment, use a 1 ½ percent solution. Apply when target plants are actively growing and are at or beyond full bloom for

silverleaf nightshade. Best results can be obtained when application is made after berries are formed. Do not treat when weeds are under drought stress. New leaf development indicates active growth. For best results apply in late summer or fall.

**Guineagrass** — Apply 4 ½ pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equipment. Apply when target plants are actively growing and when most have reached at least the 7-leaf stage of growth.

**Hemp Dogbane / Knapweed / Horseradish** — Apply 6 pints of this product per acre as a broadcast spray or as a 1 ½ percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the late bud-to-flower stage of growth. For best results, apply in late summer or fall.

**Johnsongrass / Bromegrass (smooth) / Reed Canarygrass / Ryegrass (perennial) / Timothy / Wheatgrass (western)** — Apply 3 to 4 ½ pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the boot-to-head stage of growth. When applied prior to the boot stage, less desirable control may be obtained. Allow Johnsongrass to reach at least 18 inches average height. In the fall, apply before plants have turned brown.

**Lantana** — Apply this product as a ¼ to 1 percent solution with hand-held equipment. Apply to actively growing lantana at or beyond the bloom stage of growth. Use the higher application rate for plants that have reached the woody stage of growth.

**Maidencane / Paragrass** — Apply 6 pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equipment. Repeat treatments will be required, especially to vegetation partially submerged in water. Under these conditions, allow for regrowth to the seven-to-ten leaf stage prior to retreatment.

**Milkweed (common)** — Apply 4 ½ pints of this product per acre as a broadcast spray or as a 1 ½ percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached the late bud-to-flower stage of growth.

**Nutsedge (purple, yellow)** — Apply 4 ½ pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equipment to control existing nutsedge plants and immature nutlets attached to treated plants. Apply when target plants are in flower or when new nutlets can be found at rhizome tips. Nutlets which have not germinated will not be controlled and may germinate following treatment. Repeat treatments will be required for long-term control.

**Phragmites** — In SC, GA, AL, FL, MS, LA, or TX, apply 7 ½ pints of this product per acre as a broadcast spray or as a 1 ½ percent solution with hand-held equipment to provide partial control of Phragmites. In all other states, apply 6 pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equipment to provide control. Apply when most of the target plants are in full bloom, or during the fall months. Repeat treatments will be required to maintain control.

**Quackgrass / Wirestem Muhly / Kikuyugrass** — Apply 3 to 4 ½ pints of this product per acre as a broadcast spray or as a ¾ percent solution with hand-held equip-



meat when most quackgrass or wirestem muhly is at least 8 inches in height (3- or 4-leaf stage of growth) and actively growing. Allow 3 or more days after application before tillage.

**Spatterdock** - Apply 6 pints of this product per acre as a broadcast spray or as a 1/4 percent solution with hand-held equipment. Apply when most plants are in full bloom. For best results, apply during the summer or fall months.

**Torpedograss** - Apply 6 to 7 1/2 pints of this product per acre as a broadcast spray or as a 1/4 to 3/4 percent solution with hand-held equipment to provide partial control of torpedograss. Use the lower rates under terrestrial conditions, and the higher rates under partially submerged or a floating mat condition. Repeat treatments will be required to maintain such control.

**Water Hyacinth** - Apply 5 to 6 pints of this product per acre as a broadcast spray or as a 1 percent solution with hand-held equipment. Apply when target plants are actively growing and at or beyond the early bloom stage of growth. After application, visual symptoms may require 3 or more weeks to appear with complete necrosis and decomposition usually occurring within 60 to 90 days.

**Other perennials listed on this label** - Apply 4 1/2 to 7 1/2 pints of this product per acre as a broadcast spray or as a 1/4 to 1 1/2 percent solution with hand-held equipment. Apply when target plants are actively growing and most have reached early head or early bud stage of growth.

**WOODY BRUSH AND TREES**

Apply this product as follows to control actively growing woody brush and trees listed below. Unless otherwise specified, allow at least 7 days after application before disturbing treated vegetation.

Add 1/2 percent surfactant by total spray volume to the rate of this product given in this list. See the "General Information," "Directions for Use," and "Mixing and Application" sections of this label for specific uses and application instructions.

When applied as recommended under the conditions described, this product plus surfactant **CONTROLS** the following woody brush plants and trees:

- |                    |                        |
|--------------------|------------------------|
| <b>Alder</b>       | <b>Oak***</b>          |
| Alnus spp.         | Quercus spp.           |
| <b>Berries</b>     | <b>Multiflora rose</b> |
| Rubus spp.         | Rosa multiflora        |
| <b>Elderberry</b>  | <b>Poison Ivy</b>      |
| Sambucus spp.      | Rhus radicans          |
| <b>Honeysuckle</b> | <b>Poison Oak</b>      |
| Lonicera spp.      | Rhus toxicodendron     |
| <b>Kudzu</b>       | <b>Trumpet creeper</b> |
| Pueraria lobata    | Campsis radicans       |
| <b>Maple</b>       | <b>Willow</b>          |
| Acer spp.          | Salix spp.             |

\*Includes blackberry, dewberry and raspberry.  
\*\*Includes sugar maple and red maple.  
\*\*\*Includes red oak, white oak and Northern pin oak.

Apply this product when plants are vigorously growing, and unless otherwise directed, after full leaf expansion. Use the higher rate for larger plants and/or dense areas of growth. On vines, use the higher rate for plants that have reached the woody stage of growth. Best results are obtained when application is made in late summer or fall after fruit formation. Ensure

thorough coverage when using hand-held equipment. Symptoms may not appear prior to frost or senescence with fall treatments.

Repeat treatments may be necessary to control plants regenerating from underground parts or seed. Some autumn colors on undesirable deciduous species are acceptable provided no major leaf fall has occurred.

Apply this product as follows to control the following listed plants and trees:

**Alder/Berries / Elderberry / Honeysuckle** - Apply 4 1/2 to 6 pints of this product per acre as a broadcast spray or as a 1/4 to 1 percent solution with hand-held equipment.

**Kudzu** - Apply 6 pints of this product per acre as a broadcast spray or as a 1/2 percent solution with hand-held equipment.

**Maples / Oaks** - Apply this product as a 1/4 to 1 percent solution with hand-held equipment. Apply when at least 50 percent of the new leaves are fully developed. Use the higher rate for large mature trees.

**Multiflora Rose** - Apply 3 pints of this product per acre as a broadcast spray or as a 1/4 percent solution with hand-held equipment. Treatments should be made prior to leaf deterioration by leaf-feeding insects.

**Poison Ivy / Poison Oak** - Apply 6 to 7 1/2 pints of this product per acre as a broadcast spray or as a 1 1/2 percent solution with hand-held equipment. Treatments must be applied before leaves lose green color. Repeat applications may be required to maintain control.

**Trumpet Creeper** - Apply 3 to 4 1/2 pints of this product per acre as a broadcast spray or as a 1/4 to 1 percent solution with hand-held equipment.

**Willow** - Apply this product as a 1/4 percent solution with hand-held equipment.

**DIRECTIONS FOR USE**

It is a violation of Federal law to use this product in any manner inconsistent with its labeling.

**AQUATIC SITES**

When applied as directed under conditions described, this product plus nonionic surfactant will control emerged annual weeds and control or partially control emerged perennial weeds, woody brush and trees listed in this label. This product does not control plants which are either completely submerged or have a majority of the foliage under water. See the "Weeds Controlled" section of this label for rates and degree of control provided.

This product may be used in and around aquatic sites, including all bodies of fresh and brackish water, which may be flowing, non-flowing, or transient. This includes lakes, rivers, streams, ponds, seeps, irrigation and drainage ditches, canals, reservoirs, and similar sites. There is no restriction on the use of water for irrigation, recreation, or domestic purposes.

Consult local state fish and game agency and water control authorities before applying this product to public water. Permits may be required to treat such water.

**NOTE:** Do not apply this product within 1/2 mile up stream of potable water intakes.

Do not apply this product on rice levees when flood water is present.

Do not apply in open water areas.

For treatments after drawdown of water or in dry ditches, allow 7 or more days after treatment before reintroduction of water. Apply this product within one day after drawdown to ensure application to actively growing weeds.

When using this product in aquatic sites where water is present, add 1 to 2 quarts of Ortho X-77™ surfactant per 100 gallons of spray solution (1/4 to 1/2% surfactant by total spray volume).

When using this product in sites where water is not present (dry ditches, ditchbanks, dry canals), use 1 to 2 quarts of nonionic surfactant per 100 gallons of spray solution (1/4 to 1/2% surfactant by total spray volume).

Floating mats of vegetation may require retreatment. Avoid washoff of sprayed foliage by spray boat or recreational boat backwash or by rainfall within six hours of application. Do not retreat within 24 hours following the initial treatment.

Applications made to moving bodies of water must be made while traveling upstream to prevent concentration of this herbicide in water. When making any bankside applications, do not overlap more than 1 foot into open water. Do not spray across open moving bodies of water, or where weeds do not exist. The maximum application rate of 7 1/2 pints per acre must not be exceeded in any single application.

When emerged infestations require treatment of the total surface area of impounded water, treating the area in strips may avoid oxygen depletion due to decaying vegetation. Oxygen depletion may result in fish kill.

\*Ortho X-77 is a trademark of Chevron Chemical Company.

EPA Reg. No. 524-343

In case of emergency involving this product, Call Collect, day or night, (314) 694-4000.

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1984 I 892 38-000 03 / 53

MONSANTO COMPANY  
AGRICULTURAL PRODUCTS  
ST. LOUIS, MISSOURI, 63167 U.S.A.



# Roundup

Herbicide by Monsanto

## Complete Directions for Use

EPA Reg. No. 524-308-AA

AVOID CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, SINCE SEVERE INJURY OR DESTRUCTION MAY RESULT.

This product has been approved for use in California except as stated otherwise on pages 104 and 105.

1984-1

897.10-002.19/53

Read each of these sections of this label for essential product performance information.

### USE THESE CONVENIENT SECTION MARKERS.



2

Read the entire label.

Use only according to label instructions.

Read "LIMIT OF WARRANTY AND LIABILITY" before buying or using. If terms are not acceptable, return at once unopened.

### LIMIT OF WARRANTY AND LIABILITY

(Not applicable to consumer applications applied by the homeowner for noncommercial purposes as permitted by the supplemental labeling for one-quart containers.)

This company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes set forth in the complete Directions for Use label booklet ("Directions") when used in accordance with those Directions under the conditions described therein. NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE. This warranty is also subject to the conditions and limitations stated herein.

Buyer and all users shall promptly notify this company of any claims whether based in contract, negligence, strict liability, other tort or otherwise.

Buyer and all users are responsible for all loss or damage from use or handling which results from conditions beyond the control of this company, including but not limited to incompatibility with products other than those set forth in the Directions, application to or contact with desirable vegetation, unusual weather (i. weather conditions which are outside the range con-

sidered normal at the application site and for the time period when the product is applied with the normal range being determined on the basis of the average range for the prior 40 years computed from the best available information, and ii. weather perils, including but not limited to hurricanes, tornadoes and floods) as well as weather considerations set forth in the Directions, application in any manner not explicitly set forth in the Directions, moisture conditions outside the moisture range specified in the Directions, or the presence of products other than those set forth in the Directions in or on the soil, crop or treat vegetation.

THE EXCLUSIVE REMEDY OF THE USER OR BUYER, AND THE LIMIT OF THE LIABILITY OF THIS COMPANY OR ANY OTHER SELLER FOR ANY AND ALL LOSSES, INJURIES OR DAMAGES RESULTING FROM THE USE OR HANDLING OF THIS PRODUCT (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL BE THE PURCHASE PRICE PAID BY THE USER OR BUYER FOR THE QUANTITY OF THIS PRODUCT INVOLVED, OR, AT THE ELECTION OF THIS COMPANY OR ANY OTHER SELLER, THE REPLACEMENT OF SUCH QUANTITY OR, IF NOT ACQUIRED BY PURCHASE, REPLACEMENT OF SUCH QUANTITY IN NO EVENT SHALL THIS COMPANY OR ANY OTHER SELLER BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

The buyer and all users are deemed to have accepted the terms of this LIMIT OF WARRANTY AND LIABILITY which may not be varied by any verbal or written agreement.

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**PRECAUTIONARY STATEMENTS**


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**Hazards to  
Humans and Domestic Animals**


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Keep out of reach of children.

**WARNING!**

**CAUSES EYE IRRITATION.  
HARMFUL IF SWALLOWED.  
MAY CAUSE SKIN IRRITATION.**

Do not get in eyes, on skin or on clothing.  
Wash thoroughly after handling

**FIRST AID:** IF IN EYES, immediately flush with plenty of water for at least 15 minutes. Call a physician

IF ON SKIN, immediately flush with plenty of water. Remove contaminated clothing. Wash clothing before reuse.

IF SWALLOWED, this product will cause gastro-intestinal tract irritation. Immediately dilute by swallowing water or milk. Call a physician.

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000

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**Physical or Chemical Hazards**


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Spray solutions of this product should be mixed, stored and applied only in stainless steel, aluminum, fiberglass, plastic and plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

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**Environmental Hazards**


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Avoid direct applications to any body of water. Do not contaminate water by disposal of waste or cleaning of equipment.

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**Storage and Disposal**


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Avoid contamination of seed, feed, and foodstuffs.  
Do not reuse container, destroy when empty

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**ACTIVE INGREDIENT:**

*Isopropylamine salt of glyphosate	41.0%
<b>INERT INGREDIENTS:</b>	<b>59.0%</b>
	100.0%

\*Contains 480 grams per litre or 4 pounds of the active ingredient isopropylamine salt of N-(phosphonomethyl) glycine per U.S. gallon Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

Roundup herbicide is protected by  
U.S. Pat. No. 3,799,758 and  
U.S. Pat. No. 4,405,531.  
Other patents are pending.  
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In case of an emergency involving this product,  
Call Collect, day or night, (314) 694-4000

MONSANTO COMPANY  
AGRICULTURAL PRODUCTS  
ST. LOUIS, MISSOURI 63167 U.S.A.



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**GENERAL INFORMATION**

DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT EXCEPT UNDER CONDITIONS AS SPECIFIED WITHIN THIS LABEL.

Roundup® herbicide, a water soluble liquid, mixes readily with water to be applied as a foliage spray for the control or destruction of most herbaceous plants. It may be applied through most standard industrial or field type sprayers after dilution and thorough mixing with water in accordance with label instructions.

This product moves through the plant from the point of foliage contact to and into the root system. Visible effects on most annual weeds occur within 2 to 4 days but on most perennial weeds may not occur for 7 days or more. Extremely cool or cloudy weather following treatment may slow down activity of this product and delay visual effects of control. Visible effects are a gradual wilting and yellowing of the plant which advances to complete browning of above ground growth and deterioration of underground plant parts.

Unless otherwise specified on this label delay application until vegetation has emerged and reached the stages described for control of such vegetation under the "Weeds Controlled" section of this label. Unemerged plants arising from unattached underground rhizomes or root stocks of perennials will not be affected by the spray and will continue to grow. For this reason best control of most perennial weeds is obtained when treatment is made at late growth stages approaching maturity.

Always use the higher rate of this product per acre within the recommended range when (1) weed growth is heavy or dense, or (2) weeds are growing in an undisturbed (non-cultivated) area.

Do not treat weeds under poor growing conditions such as drought stress, disease or insect damage, as reduced weed control may result. Reduced results may also occur when treating weeds heavily covered with dust.

Reduced control may result when applications are made to annual or perennial weeds that have been mowed, grazed, or cut, and have not been allowed to regrow for the recommended stage for treatment.

Rainfall or irrigation occurring within 6 hours after application may reduce effectiveness. Heavy rainfall or irrigation within 2 hours after application may wash the chemical off the foliage and a repeat treatment may be required.

Roundup herbicide does not provide residual weed control. For subsequent residual weed control, follow a label-approved herbicide program. Read and carefully observe the cautionary statements and all other information appearing on the labels of all herbicides used.

Nonionic surfactants which are labeled for use with herbicides may be used to improve wetting of foliage. Do not reduce rates of Roundup when adding surfactant. Use 0.5 percent surfactant concentration when using surfactants which contain at least 50 percent active ingredient or a 1 percent surfactant concentration for those surfactants containing less than 50 percent

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active ingredient. Read and carefully observe surfactant cautionary statements, and other information appearing on the surfactant label.

Buyer and all users are responsible for all loss or damage in connection with the use or handling of mixtures of Roundup with herbicides or other materials that are not expressly recommended in this labeling. Mixing this product with herbicides or other materials not recommended on this label, may result in reduced Roundup performance.

For best results, spray coverage should be uniform and complete. Do not spray weed foliage to the point of runoff.

Keep people and pets off treated areas until spray solution has dried to prevent transfer of this product onto desirable vegetation.

\*Registered Trademark of Monsanto Company

**ATTENTION**

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift, or splash onto desirable vegetation since minute quantities of this herbicide can cause severe damage or destruction to the crop, plants, or other areas on which treatment was not intended. The likelihood of injury occurring from the use of this product is greatest when winds are gusty or in excess of 5 miles per hour or when other conditions, including lesser wind velocities, will allow spray drift to occur. When spraying avoid combinations of pressure and nozzle type that will result in splatter or fine particles (mist) which are likely to drift. AVOID APPLYING AT EXCESSIVE SPEED OR PRESSURE.

NOTE: Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences. Keep container closed to prevent spills and contamination.

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8. Add individual formulations to the spray tank as follows: wettable powder, flowable, emulsifiable concentrate, drift control additive, water soluble liquid followed by surfactant.

Maintain good agitation at all times until the contents of the tank are sprayed. If the spray mixture is allowed to settle, thorough agitation is required to resuspend the mixture before spraying is resumed.

Keep by-pass line on or near bottom of tank to minimize foaming. Screen size in nozzle or line strainers should be no finer than 50 mesh. Carefully select proper nozzle to avoid spraying a fine mist. For best results with conventional ground applications equipment, use flat fan nozzles.

Clean sprayer and parts immediately after using this product by thoroughly flushing with water.

**MIXING AND APPLICATION INSTRUCTIONS**

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES. DO NOT APPLY UNDER WIND OR OTHER CONDITIONS WHICH ALLOW DRIFT TO OCCUR. HAND GUN APPLICATIONS SHOULD BE PROPERLY DIRECTED TO AVOID SPRAYING DESIRABLE PLANTS. NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, such as WATER FROM PONDS AND UNLINED DITCHES.

**MIXING**

This product mixes readily with water. Mix spray solutions of this product as follows: Fill the mixing or spray tank with the required amount of water. Add the proper amount of this product (see "Directions for Use" and "Weeds Controlled" sections of this label) near the end of the filling process and mix well. Remove hose from tank immediately after filling to avoid siphoning back into the carrier source. During mixing and application foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, place the filling hose below the surface of the spray solution, terminate by-pass and return lines at the bottom of the tank and if needed use an approved anti-foam or defoaming agent.

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**TANK MIXTURES**

Always predetermine the compatibility of labeled tank mixtures of this herbicide with water carrier by mixing small proportional quantities in advance.

Mix labeled tank mixtures of Roundup herbicide with water as follows:

1. Place a 20 to 35 mesh screen or wetting basket over filling port.
2. Through the screen, fill the sprayer tank one-half full with water and start agitation.
3. If a wettable powder is used, make a slurry with the water carrier, and add it SLOWLY through the screen into the tank. Continue agitation.
4. If a flowable formulation is used, pre-mix one part flowable with one part water. Add diluted mixture SLOWLY through the screen into the tank. Continue agitation.
5. If an emulsifiable concentrate formulation is used, pre-mix one part emulsifiable concentrate with two parts water. Add diluted mixture slowly through the screen into the tank. Continue agitation.
6. Continue filling the sprayer tank with water and add the required amount of Roundup herbicide near the end of the filling.
7. Where nonionic surfactant is recommended add this to the spray tank before completing the filling process.

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**SOIL TEXTURE**

The recommended use rates of other herbicides labeled for use with this product in tank mixtures generally vary with soil texture. Rate tables throughout this label, unless the soil texture is specifically named, refer to only three soil texture groups: Coarse, Medium and Fine. The following is a complete listing of soil textures included in each of these three soil texture groups:

SOIL TEXTURE GROUP	SOIL TEXTURE
COARSE:	sand, loamy sand, sandy loam
MEDIUM:	loam, silt loam, silt, sandy clay loam
FINE:	silty clay loam, clay loam, sandy clay, silty clay, clay

Refer to the above table to determine the corresponding soil texture group for the soil to be treated.

**APPLICATION EQUIPMENT AND TECHNIQUES**

This product may be applied with the following application equipment:

**Aerial** — fixed wing and helicopter

**Boom** — conventional broadcast spray

**Controlled Droplet Applicator (CDA)** — hand held or boom mounted applicators which produce a spray consisting of a narrow range of droplet sizes

**Hand-held and high-volume spray equipment** — knapsack and backpack sprayers, pump-up pressure sprayers, handguns, handwands, lances, and other hand-held spray equipment used to direct the spray onto weed foliage and vehicle mounted high-volume spray equipment for spray-to-wet applications

**Selective equipment** — recirculating sprayers, shielded sprayers and wiper applicators.

See the appropriate part of this section for specific rates of application and instructions

## AERIAL EQUIPMENT

Use the recommended rates of this herbicide in 10 to 15 gallons of water per acre unless otherwise specified on this label. See "WEEDS CONTROLLED" section of this label for specific rates. **Aerial applications of this product may only be made in fallow and reduced tillage systems, silvicultural sites, and rights-of-way. Refer to the individual use area sections of this label for recommended volumes and application rates.**

Avoid direct application to any body of water.

**AVOID DRIFT — DO NOT APPLY DURING INVERSION CONDITIONS, WHEN WINDS ARE GUSTY, OR UNDER ANY OTHER CONDITION WHICH WILL ALLOW DRIFT. DRIFT MAY CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES MUST BE MAINTAINED**

Coarse sprays are less likely to drift, therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label.

**Ensure uniform application — To avoid streaked, uneven or overlapped application, use appropriate marking devices**

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runoff Use a 1 percent solution, unless otherwise specified. For best results, use a 2 percent solution on harder-to-control perennials, such as bermudagrass, dock, field bindweed, hemp dogbane, milkweed and Canada thistle.

Less than complete coverage of weeds may result from the use of spray equipment designed for motorized spot treatments. Where less than complete coverage of annual weeds occurs, use a 5 percent solution. Do not reduce recommended concentrations of Roundup when adding surfactant.

Prepare the desired volume of spray solution by mixing the amount of this product in water, shown in the following table

### Spray solution

DESIRED VOLUME	AMOUNT OF ROUNDUP®			
	1%	1½%	2%	5%
1 gallon	1½ oz	2 oz	2½ oz	6½ oz
25 gallons	1 qt	1½ qt	2 qt	5 qt
100 gallons	1 gal	1½ gal	2 gal	5 gal

2 tablespoons = 1 ounce

For use in knapsack sprayers, it is suggested that the proper amount of this product be mixed with water in a larger container. Fill sprayer with the mixed solution.

For hand-held WIPER APPLICATORS see the "Selective Equipment" section and for hand-held CONTROLLED DROPLET APPLICATORS see the "Controlled Droplet Applicator (CDA)" section of this label.

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Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. **PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE.** The maintenance of an organic coating (Paint) which meets aerospace specification MIL-C-38413 may prevent corrosion.

## BOOM EQUIPMENT

For control of annual or perennial weeds listed on this label using conventional boom equipment — Use the recommended rates of this product in 10 to 40 gallons of water per acre as a broadcast spray unless otherwise specified on this label. See "Weeds Controlled" section of this label for specific rates. As density of weeds increases, spray gallonage should be increased within the recommended range to insure complete coverage. Carefully select proper nozzle to avoid spraying a fine mist. For best results with ground application equipment, use flat fan nozzles. Check for even distribution of spray droplets

## CONTROLLED DROPLET APPLICATION (CDA)

The rate of this product applied per acre by vehicle mounted CDA equipment must not be less than the amount recommended in this label when applied by conventional broadcast equipment. For vehicle mounted CDA equipment apply 3 to 15 gallons of water per acre.

For the control of labeled annual weeds with hand-held CDA units, apply a 20 percent solution of this product at a flow rate of 2 fluid ounces per minute and a walking speed of 1.5 MPH (1 quart per acre). For the control of labeled perennial weeds, apply a 20 to 40 percent solution of this product at a flow rate of 2 fluid ounces per minute and a walking speed of 0.25 MPH (2 to 4 quarts per acre).

Controlled droplet application equipment produces a spray pattern which is not easily visible. Extreme care must be exercised to avoid spray or drift contacting the foliage or any other green tissue of desirable vegetation as damage or destruction may result.

## HAND-HELD and HIGH-VOLUME EQUIPMENT

Use coarse sprays only

Mix this product in water and apply to foliage of vegetation to be controlled. For applications made on a spray-to-wet basis, spray coverage should be uniform and complete. Do not spray to the point of

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## SELECTIVE EQUIPMENT

This product may be applied through a recirculating spray system, a shielded applicator, or a wiper applicator after dilution and thorough mixing with water to listed weeds growing in any non-crop site specified on this label and only when specifically recommended in cropping systems.

A recirculating spray system directs the spray solution onto weeds growing above desirable vegetation, while spray solution not intercepted by weeds is collected and returned to the spray tank for reuse.

A shielded applicator directs the herbicide solution onto weeds while shielding desirable vegetation from the herbicide.

A wiper applicator applies the herbicide solution onto weeds by rubbing the weed with an absorbent material containing the herbicide solution.

### AVOID CONTACT WITH DESIRABLE VEGETATION.

Contact of the herbicide solution with the desirable vegetation may result in damage or destruction. Applicators used above desired vegetation should be adjusted so that the lowest spray stream or wiper contact point is at least 2 inches above the desirable vegetation. Droplets, mist, foam, or splatter of the herbicide solution settling on desirable vegetation may result in discoloration, stunting, or destruction.

Applications made above the crops should be made when the weeds are a minimum of 6 inches above the desirable vegetation. Better results may be obtained when more of the weed is exposed to the herbicide

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solution. Weeds not contacted by the herbicide solution will not be affected. This may occur in dense clumps, severe infestations, or when the height of the weeds varies so that not all weeds are contacted. In these instances, repeat treatment may be necessary. See the "Weeds Controlled" section of this label for recommended stage of growth for specific weeds

### NOTE

- Maintain equipment in good operating condition. Avoid leakage or dripping onto desirable vegetation
- Adjust height of applicator to insure adequate contact with weeds.
- Keep nozzle tips and wiping surfaces clean
- Keep spray patterns aligned into recovery chamber of the recirculating sprayer
- Keep shields on shielded applicators adjusted to protect desirable vegetation.
- Maintain recommended roller RPM on roller applicators while in use.
- Keep wiper material at proper degree of saturation with herbicide solution.
- DO NOT use wiper equipment when weeds are wet
- DO NOT operate equipment at ground speeds greater than 5 mph. Weed control may be affected by speed of application equipment. As weed density increases, reduce equipment ground speed to insure good coverage of weeds

- Be aware that on sloping ground the herbicide solution may migrate, causing dripping on the lower end and drying on the upper end of a wiper applicator.
- Variation in equipment design may affect weed control. With wiper applicators, the wiping material and its orientation must allow delivery of sufficient quantities of the recommended herbicide solution directly to the weed.
- Care must be taken with all types of wipers to insure that the absorbent material does not become oversaturated, causing the herbicide to drip on desirable vegetation.
- Mix only the amount of solution to be used during a one day period, as reduced activity may result from use of leftover solutions. With all equipment, drain and clean sprayer and wiper parts immediately after using this product by thoroughly flushing with water.

**RECIRCULATING SPRAYERS**

Recirculating sprayer calibration is made on the basis of ground speed and delivery volume. Two procedures can be used to calibrate: (1) determine the discharge being delivered per minute, then operate at the designated ground speed, or (2) select the desired ground speed and then adjust the sprayer to deliver the recommended volume per minute (this may require nozzle changes). Use the appropriate table below.

Do not operate at nozzle pressure above 20 PSI

Table 1. Use this table when calibrating Box or Row type recirculating sprayers. Box or Row type sprayer calibration is based on the total discharge collected per row. Use only straight stream or 15° fan type nozzles.

**\*VOLUME PER MINUTE PER ROW**

MPH	Quinces
2	26 to 35
3	38 to 51
4	51 to 68
5	65 to 86

\*NOTE: Be certain the amount collected is for all spray streams treating one row.

Table 2. Use this table when calibrating Broadcast type recirculating sprayers. Broadcast recirculating sprayer calibration is based on the discharge collected per minute from one nozzle on a 20 inch spacing

**VOLUME PER MINUTE PER NOZZLE**

MPH	Quinces
2	7 to 9
3	10 to 13
4	13 to 18
5	16 to 22

When applied as recommended under the conditions described for recirculating sprayers, this product will control the following weeds growing a minimum of 6 inches above desirable vegetation

**Perennial Broadleaf Weeds** — To SUPPRESS the following weeds, mix in a ratio of 4 quarts of this product in 20 gallons of water and apply as directed

<b>Dogbane (hoop)</b>	<b>Milkweed</b>
Apocynum cannabinum	Asclepias syriaca

**Perennial Grasses and Annual Broadleaf Weeds** — To control the following weeds, mix in a ratio of 3 quarts of this product in 20 gallons of water and apply as directed:

<b>Cocklebur</b>	<b>Figweed, Redroot</b>
Xanthium pennsylvanicum	Amaranthus retroflexus
<b>Johnsongrass</b>	<b>Sunflower</b>
Sorghum halepense	Helianthus annuus

**Annual Grasses** — To control the following weeds, mix in a ratio of 2 quarts of this product in 20 gallons of water and apply as directed:

<b>Corn (volunteer)</b>	<b>Shattercane</b>
Zea mays	Sorghum bicolor

**SHIELDED APPLICATORS**

When applied as directed under conditions described for shielded applicators, this product will control those weeds listed in the "Weeds Controlled" section of this label.

Shielded applicators which apply the herbicide solution as a spray band should be calibrated on a broadcast equivalent rate and volume basis. To determine these:

$$\frac{\text{Band width in inches}}{\text{Row width in inches}} \times \text{Herbicide Broadcast RATE per acre} = \text{Herbicide Band RATE per acre}$$

$$\frac{\text{Band width in inches}}{\text{Row width in inches}} \times \text{Broadcast VOLUME of solution per acre} = \text{Band VOLUME of solution per acre}$$

Use nozzles that provide uniform coverage within the treated area. **EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT WITH DESIRABLE VEGETATION.**

For specific rates of application and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label.

**WIPER APPLICATORS**

Wiper applicators include either roller or wick devices which physically wipe appropriate concentrations or amounts of this product directly onto the weed. Equipment must be designed, maintained and operated to prevent the herbicide solution from contacting desirable vegetation. Operate this equipment at ground speeds no greater than 5 mph. Performance may be improved by reducing speed in areas of heavy weed infestations to insure adequate wiper saturation. Better results may be obtained if 2 applications are made in opposite directions.

Do not add surfactant to the herbicide solution

**For Roller Applicators** — Mix 1 gallon of this product in enough water to prepare 10 gallons of herbicide solution (10% solution). Apply this solution to perennial weeds or annual broadleaf weeds listed in this "Wiper Applicators" section.

Mix 1 gallon of this product in enough water to provide 20 gallons of herbicide solution (5% solution). Apply this solution to annual grasses listed in this "Wiper Applicators" section.

Roller speed should be maintained at 40 to 60 RPM.

**For Wick or other Wiper Applicators** — Mix 1 gallon of this product in 2 gallons of water to prepare a 33% solution. Apply this solution to weeds listed in this "Wiper Applicators" section.

In severe infestations, reduce equipment ground speed to insure that adequate amounts of this product are wiped on the weeds. A second treatment in the opposite direction may be beneficial.

Do not permit herbicide solution to contact desirable vegetation.

When applied as recommended under the conditions described for "Wiper Applicators", this product **CONTROLLED** the following weeds:

**ANNUAL GRASSES**

Corn (volunteer)	Shattercane
Zea mays	Sorghum bicolor
Rye (common)	Texas panicum
Secale cereale	Panicum toxicaria

**ANNUAL BROADLEAVES**

Bristly starbur	Sicklepod
Acanthospermum hispidum	Cassia obtusifolia
Spanishneedles	
Bidens bipinnata	

When applied as recommended under the conditions described for "Wiper Applicators", this product **SUPPRESSES** the following weeds:

**ANNUAL BROADLEAVES**

Dog fennel	Ragweed (giant)
Eupatorium capillifolium	Ambrosia trifida
Florida beggarweed	Sunflower
Desmodium tortuosum	Helianthus annuus
	Thistle (musk)
	Carduus nutans

Pigweed, Redroot	Velvetleaf
Amaranthus retroflexus	Abutilon theophrasti

Ragweed, (common)  
Ambrosia artemisiifolia

**PERENNIAL GRASSES**

Barnyardgrass	Smartgrass
Cynodon dactylon	Sporobolus porretii
Coixegrass	Vaseygrass
Panicum maximum	Paspalum urvillei
Johnsongrass	
Sorghum halepense	

**PERENNIAL BROADLEAVES**

Dogbane (hemp)	Nightshade (silverleaf)
Apocynum cannabinum	Solanum elaeagnifolium
Milkweed	Thistle (Canada)
Asclepias syriaca	Cirsium arvense

**WEEDS CONTROLLED**

This herbicide controls many annual and perennial grasses and broadleaf weeds.

**ANNUAL WEEDS**

Apply to actively growing grasses and broadleaf weeds. Use 1 quart of this product per acre if weeds are less than 6 inches tall. If weeds are over 6 inches tall, apply 1.5 quarts of this product per acre. Allow at least 3 days after treatment before tillage. See "Directions for Use" for specific volumes of water.

When applied as recommended under the conditions described, this product **WILL CONTROL** the following **ANNUAL WEEDS**:

Barley	Mustard (tumble)
Hordeum spp	Sisymbrium altissimum
Barnyardgrass	Oats (wild)
Echinochloa crus-galli	Avena fatua
Bassia (fivehook)	Panicum
Bassia hyssopifolia	Panicum spp
Bluegrass (annual)	Pennycress (field)
Poa annua	Thlaspi arvense
Brome	Pigweed, Redroot
Bromus spp	Amaranthus retroflexus
Chickweed	Pigweed (smooth)
Stellaria media	Amaranthus hybridus
Cocklebur	Ragweed (common)
Xanthium pensylvanicum	Ambrosia artemisiifolia
Corn (volunteer)	Ragweed (giant)
Zea mays	Ambrosia trifida

Crabgrass	Rye
Digitaria spp	Secale cereale
Falsetflax (smallseed)	Ryegrass (Italian)*
Camelina microcarpa	Lolium multiflorum
Fiddleneck	Sandbar (field)
Amsinckia spp	Cenchrus spp.
Flax-leaf fleabane	Shattercane
Coryza bonariensis	Sorghum bicolor
Fleabane	Shepherdspurse
Erigeron spp.	Capsella bursa-pastoris
Festail	Smartweed (Pennsylvania)
Setaria spp.	Polygonum
Groundsel (common)	pensylvanicum
Senecio vulgaris	Smartweed
Horseweed	Sonchus oleraceus
Coryza canadensis	Spanishneedles*
Kochia	Bidens bipinnata
Kochia scoparia	Sunflower
Lambquarters (common)	Helianthus annuus
Chenopodium album	Thistle (Russian)
Lettuce (prickly)	Salsola kali
Lactuca serriola	Velvetleaf
London rocket	Abutilon theophrasti
Sisymbrium irio	Wheat (volunteer)
Mustard (tame)	Triticum aestivum
Descurainia pinnata	

\*Apply 2 quarts of this product per acre.

Annual weeds generally will continue to germinate from seed throughout the growing season. Repeat treatments may be necessary to control later germinating weeds. Repeat treatments must be made prior to crop emergence.

**PERENNIAL WEEDS**

Apply this product as follows to control or destroy most perennial weeds:

NOTE: If weeds have been mowed or tilled, do not treat until regrowth has reached the recommended stages.

Repeat treatments may be necessary to control weeds regenerating from underground parts or seed. Repeat treatments must be made prior to crop emergence.

When applied as recommended under the conditions described, this product **WILL CONTROL** the following **PERENNIAL WEEDS**:

<b>Ailanthus</b>	<b>Empweed</b>
Medicago sativa	Centaurea repens
<b>Milkweed*</b>	Lantana
Albarrathera philoxeroides	Lanta camara
<b>Artichoke (Jerusalem)</b>	<b>Milkweed</b>
Helianthus tuberosus	Asclepias spp.
<b>Bahiagrass</b>	<b>Mulberry (weston)</b>
Paspalum notatum	Muhlenbergia frondosa
<b>Barnyardgrass</b>	<b>Mullein (common)</b>
Cynodon dactylon	Verbascum thapsus
<b>Blindweed (field)</b>	<b>Nutsedge</b>
Convolvulus arvensis	Pennisetum purpureum
<b>Blugrass (Kentucky)</b>	<b>Nightshade (silverleaf)</b>
Poa spp.	Solanum elaeagnifolium
<b>Blackburn</b>	<b>Rutabaga (purple, yellow)</b>
Pteridium aquilinum	Cyperus rotundus
	Cyperus esculentus

<b>Bromegrass (smooth)</b>	<b>Orchardgrass</b>
Bromus inermis	Dactylis glomerata
<b>Cattail</b>	<b>Paragrass</b>
Typha spp.	Brachiaria mutica
<b>Clover (red)</b>	<b>Quackgrass</b>
Trifolium pratense	Agropyron repens
<b>Clover (white)</b>	<b>Reed canarygrass</b>
Trifolium repens	Phalaris arundinacea
<b>Dallisgrass</b>	<b>Ryegrass (perennial)</b>
Paspalum dilatatum	Lolium perenne
<b>Dandelion</b>	<b>Smartweed (swamp)</b>
Taraxacum officinale	Polygonum coccineum
<b>Dock (curly)</b>	<b>Sweet potato, wild*</b>
Rumex crispus	Ipomoea pandurata
<b>Dogbane (hemp)</b>	<b>Tall fescue</b>
Apocynum cannabinum	Festuca arundinacea
<b>Fescues</b>	<b>Texas blueweed</b>
Festuca spp.	Helianthus ciliaris
<b>Goosegrass</b>	<b>Thistle (Canada)</b>
Panicum maximum	Cirsium arvense
<b>Horse-nettle</b>	<b>Timothy</b>
Solanum carolinense	Phleum pratense
<b>Horse-radish</b>	<b>Torpedograss*</b>
Amaracia rusticana	Panicum repens
<b>Johnsongrass</b>	<b>Vaseygrass</b>
Sorghum halepense	Paspalum urvillei
<b>Kilburygrass</b>	<b>Wheatgrass (western)</b>
Pennisetum clandestinum	Agropyron smithii
	<b>Woollyleaf burrage</b>
	Franseria tomentosa

\*Partial control.

**Alligatorweed** — Apply 4 quarts of this product per acre or apply a 1½ percent solution with hand-held equipment to provide partial control. Apply when most of the plants are in bloom. Repeat applications will be required to maintain such control.

**Bermudagrass** — For control, apply 5 quarts of this product per acre and for partial control, apply 3 quarts per acre. Treat when bermudagrass is actively growing and seedheads are present. Retreatment may be necessary to maintain control. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Bluegrass (Kentucky) / Bromegrass (smooth) / Orchardgrass** — Apply 2 quarts of this product in 10 to 40 gallons of water per acre when the grasses are actively growing and most plants have reached boot-to-early seedhead stage of development. For partial control in pasture or hay crop renovation apply 1 to 1½ quarts of this product plus 0.5% by total spray volume of nonionic surfactant in 5 to 10 gallons of water per acre. Apply to actively growing plants when most have reached 4 to 12 inches in height. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections and "PASTURES" in the "Cropping Systems" section of this label for labeled uses and specific application instructions.

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**Brackenfern** — Apply 3 to 4 quarts of this product per acre as a broadcast spray or as a 1 to 1½ percent solution with hand-held equipment. Apply to fully expanded fronds which are at least 18 inches long.

**Canada Thistle** — Apply 2 to 3 quarts of this product per acre. Apply to actively growing thistles when most are at or beyond the bud stage of growth. After harvest, mowing or tillage in the late summer or fall, allow at least 4 weeks for initiation of active growth and rosette development prior to the application of this product. Fall treatments must be applied before a killing frost. Allow 3 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Field Bindweed / Silverleaf Nightshade / Texas Blueweed** — Apply 4 to 5 quarts of this product per acre east of the Mississippi River and 3 to 4 quarts per acre west of the Mississippi River. Apply when weed is actively growing and is at or beyond full bloom. For silverleaf nightshade, best results can be achieved when application is made after berries are formed. Do not treat when weed is under drought stress as good soil moisture is necessary for active growth. New leaf development indicates active growth. For best results, apply in late summer or fall. Fall treatments must be applied before a killing frost. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Guineagrass** — Apply 3 quarts of this product per acre or use a 1 percent solution with hand-held equipment. Apply to actively growing guineagrass when most has reached at least the 7-leaf stage of growth. Ensure thorough coverage when using hand-held equipment. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Hemp Dogbane / Knapweed / Horseradish** — Apply 4 quarts of this product per acre. Apply when actively growing and most weeds have reached the late bud to flower stage of growth. Following crop harvest or mowing, allow weeds to regrow to a mature stage prior to treatment. For best results, apply in late summer or fall. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Johnsongrass** — Apply 1 to 3 quarts of this product per acre. In annual cropping systems apply 1 to 2 quarts of this product per acre. Apply 1 quart of this product plus 0.5 to 1 percent nonionic surfactant by total spray volume in 5 to 10 gallons of water per acre. Use 0.5 percent surfactant concentration when using surfactants which contain at least 50 percent active ingredient or a 1 percent surfactant concentration for those surfactants containing less than 50 percent active ingredient. Use 2 quarts of this product when applying 10 to 40 gallons of water per acre. In non-crop or areas where annual tillage (no till) is not per-

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formed, apply 2 to 3 quarts of this product in 10 to 40 gallons of water per acre. For best results, apply to actively growing plants when most are at least 18 inches in height and have reached the boot-to-head stage of growth. Allow 7 or more days after application before tillage. Do not tank mix with residual herbicides when using the 1 quart per acre rate. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Lantana** — Apply this product as a 1 to 1½ percent solution using hand-held equipment only. Apply to actively growing lantana at or beyond the bloom stage of growth. Use the higher application rate for plants that have reached the woody stage of growth. Allow 7 or more days after application before tillage.

**Milkweed (common)** — Apply 3 quarts of this product per acre. Apply when actively growing and most of the milkweed has reached the late bud to flower stage of growth. Following small grain harvest or mowing, allow milkweed to regrow to a mature stage prior to treatment. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Nutsedge (purple, yellow)** — Apply 3 quarts of this product per acre as a broadcast spray, or apply a 1 percent solution from hand-held equipment to control existing nutsedge plants and immature nutlets attached to treated plants. Treat when plants are in flower or when new nutlets can be found at rhizome tips. Nutlets which have not germinated will not be

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controlled and may germinate following treatment. Repeat treatments will be required for long-term control. Wait 7 days after treatment before tillage. Tillage will stimulate nutlet germination.

**Quackgrass** — Apply 1 to 3 quarts of this product per acre. In annual cropping systems apply 1 to 2 quarts of this product per acre. Apply 1 quart of this product plus 0.5 to 1 percent nonionic surfactant by total spray volume in 5 to 10 gallons of water per acre. Use 0.5 percent surfactant concentration when using surfactants which contain at least 50 percent active ingredient or a 1 percent surfactant concentration for those surfactants containing less than 50 percent active ingredient. Use 2 quarts of this product when applying 10 to 40 gallons of water per acre. In pastures, areas coming out of sod, areas which are not tilled or areas where annual crops are not grown, apply 2 to 3 quarts of this product in 10 to 40 gallons of water per acre. Spray when quackgrass is 8 to 12 inches in height (3 to 4-leaf stage) and growing. Do not till between harvest and fall applications or in the fall or spring prior to spring applications. Allow 3 or more days after application before tillage. Do not tank mix with residual herbicides when using the 1 quart per acre rate. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Red Cocksfoot / Ryegrass (perennial) / Timothy / Wheatgrass (wheat)** — Apply 2 to 3 quarts of this product per acre. For best results, apply to actively growing plants when most have reached the boot to head stage of growth. Allow 7 or more days after ap-

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plication before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

**Sweet Potato, Wild** — Apply this product as a 2% solution using hand-held equipment. Apply to actively growing weeds that are at or beyond the bloom stage of growth. Repeat applications will be required. Allow the plant to reach the recommended stage of growth before retreatment. Allow 7 or more days before tillage.

**Tall Fescue** — Apply 3 quarts of this product in 10 to 40 gallons of water per acre to actively growing plants when most have reached boot-to-early seedhead stage of development. For partial control in pasture or hay renovation apply 2 quarts of this product plus 0.5% by total spray volume of nonionic surfactant in 5 to 10 gallons of water per acre. Apply to actively growing plants when most have reached 4 to 12 inches in height. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections and "PASTURES" in the "Cropping Systems" section of this label for labeled uses and specific application instructions.

**Torpedograss** — Apply 4 to 5 quarts of this product per acre to provide partial control of torpedograss. Apply to actively growing torpedograss when most plants are at or beyond the seedhead stage of growth. Repeat applications will be required to maintain control. Fall treatments must be applied before frost. Allow 7 or more days after application before tillage. See "Directions for Use" and "Mixing and Application" sections of this label for labeled uses and specific application instructions.

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**WOODY BRUSH AND TREES**

When applied as recommended under the conditions described, this product **CONTROLS** or **PARTIALLY CONTROLS** the following woody brush plants and trees:

<b>Alder</b>	<b>Mullein Rose</b>
Alnus spp.	Rosa multiflora
<b>Oak*</b>	<b>Oak:</b>
Fraxinus spp.	Black*
<b>Aspen (quaking)</b>	Quercus velutina
Populus tremuloides	<b>Northern Pin</b>
<b>Birch</b>	Quercus palustris
Betula spp.	<b>Red</b>
<b>Blackberry</b>	Quercus spicata
Rubus spp.	<b>Red</b>
<b>Cascara*</b>	Quercus rubra
Rhamnus purshiana	<b>Southern Red</b>
<b>Ceanothus</b>	Quercus falcata
<del>Diospyros</del>	<b>White*</b>
Ceanothus	Quercus alba
<del>integrifolia</del>	<b>Parasitimon*</b>
<del>sp. nov.</del>	Diospyros spp.
Ceanothus integerrimus	<b>Poison Ivy</b>
<b>Cherry:</b>	Rhus radicans
<b>Bitter</b>	<b>Poison Oak</b>
Prunus emarginata	Rhus toxicodendron
<b>Black</b>	<b>Poplar* (yellow)</b>
Prunus serotina	Liriodendron tulipifera
<b>Pin</b>	<b>Raspberry</b>
Prunus Pennsylvanica	Rubus spp.

<b>Cape hush</b>	<b>Salmonberry</b>
Baccharis conyzifera	Rubus spectabilis
<b>Dewberry</b>	<b>Sassafras</b>
Rubus trivialis	Sassafras albidum
<b>Elderberry</b>	<b>Sourwood*</b>
Sambucus spp.	Ostrya virginiana
<b>Elm*</b>	<b>Semec:</b>
<del>Ulmus spp.</del>	<b>Poison*</b>
<b>Marble</b>	Rhus vernix
Cotoneaster spp.	<b>Smooth*</b>
<b>Hazel</b>	Rhus glabra
Corylus spp.	<b>Winged*</b>
<b>Honeysuckle</b>	Rhus copallina
Lonicera spp.	<b>Sweetgum</b>
<b>Kudzu</b>	Liquidambar styraciflua
Pueraria lobata	<b>Swordfern*</b>
<b>Lacust* (black)</b>	Polystichum munium
Robinia pseudoacacia	<b>Thimbleberry</b>
<b>Maple:</b>	Rubus parviflorus
<b>Red**</b>	<b>Trumpet Creeper</b>
Acer rubrum	Campsis radicans
<b>Sugar</b>	<b>Willow</b>
Acer saccharum	Salix spp.
<b>Vine*</b>	
Acer circinatum	

\*Partial control  
\*\*See below for Control or Partial Control instructions

**NOTE:** If brush has been mowed or tilled or trees have been cut, do not treat until regrowth has reached the recommended stages of growth.

Apply this product when plants are actively growing, and unless otherwise directed, after full leaf expansion. Use the higher rate for larger plants and/or dense areas of growth. On vines, use the higher rate for plants that have reached the woody stage of growth. Best results are obtained when application is made in late summer or fall after fruit formation. Ensure thorough coverage when using hand-held equipment. Symptoms may not appear prior to frost or senescence with fall treatments.

Allow 7 or more days after application before tillage, mowing or removal. Repeat treatments may be necessary to control plants regenerating from underground parts or seed. Some autumn colors on undesirable deciduous species are acceptable provided no major leaf drop has occurred. Reduced performance may result if fall treatments are made following a frost.

See "Directions for Use" and "Mixing Application" sections of this label for labeled uses and specific application instructions.

Apply this product as follows to control or partially control the following woody brush and trees.

**Alder/Blackberry/Dewberry/Honeysuckle/Poison Oak/Raspberry** — For control, apply 3 to 4 quarts per acre of this product as a broadcast spray or as a 1 to 1½ percent solution with hand-held equipment.

**Aspen (quaking) Bitter Cherry/Black Cherry/Northern Pin Cherry/Southern Red Oak/Sweetgum/Trumpet Creeper** — For control, apply 2 to 3 quarts of this product per acre as a broadcast spray or as a 1 to 1½ percent solution with hand-held equipment.

**Birch/Elderberry/Maple/Salmonberry/Thimbleberry** — For control, apply 2 quarts per acre of this product as a broadcast spray or as a 1 percent solution with hand-held equipment.

**Cape hush** — For control, apply a 1½ to 2 percent solution with hand-held equipment when at least 50 percent of the new leaves are fully developed.

**Kudzu** — For control, apply 4 quarts of this product per acre as a broadcast spray or as a 2 percent solution with hand-held equipment. Repeat applications will be required to maintain control.

**Mullein Rose** — For control, apply 2 quarts of this product per acre as a broadcast spray or as a 1 percent solution with hand-held equipment. Treatments should be made prior to leaf deterioration by leaf-feeding insects.

**Poison Ivy/Poison Oak** — For control, apply 4 to 5 quarts of this product per acre as a broadcast spray or as a 2 percent solution with hand-held equipment. Repeat applications may be required to maintain control. Fall treatments must be applied before leaves lose green color.

**Red Maple\*\*** — For control, apply as a 1 to 1½ percent solution with hand-held equipment when at least 50 percent of the new leaves are fully developed.

For partial control, apply 2 to 4 quarts of this product per acre as a broadcast spray.

**Sugar Maple/Northern Pin Oak/Red Oak** — For control, apply as a 1 to 1½ percent solution with hand-held equipment when at least 50 percent of the new leaves are fully developed.

**Willow** — For control, apply 3 quarts of this product per acre as a broadcast spray or as a 1% solution with hand-held equipment.

**Other Woody Brush and Trees listed on this label\*** — For partial control, apply 2 to 4 quarts of this product per acre as a broadcast spray or as a 1 to 1½ percent solution with hand-held equipment. Apply when plants are actively growing and after full leaf expansion. Use the higher rate for larger plants and/or dense areas of growth. Best results are achieved when application is made in late summer or fall after fruit formation. Fall treatments must be applied before a killing frost. Symptoms may not appear prior to frost or senescence with fall treatments.

**DIRECTIONS FOR USE**

It is a violation of Federal law to use this product in any manner inconsistent with its labeling.

**NON-CROP USES**

See "General Information" and "Mixing and Application Instructions" sections of this label for essential product performance information and the following NON-CROP SECTIONS for specific recommended uses

**EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT OF SPRAY WITH FOLIAGE OF DESIRABLE TURFGRASSES, TREES, SHRUBS, OR OTHER DESIRABLE VEGETATION SINCE SEVERE DAMAGE OR DESTRUCTION MAY RESULT.**

**NOTE** If spraying areas adjacent to desirable plants, use a shield made of cardboard, sheet metal or plywood while spraying to help prevent spray from contacting foliage of desirable plants

Repeat treatments may be necessary to control weeds regenerating from underground parts or seeds

Roundup herbicide does not provide residual weed control. For subsequent weed control, follow a label approved herbicide program.

Read and carefully observe the cautionary statements and all other information appearing on the labels of all herbicides used

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**INDUSTRIAL, RECREATIONAL AND PUBLIC AREAS**

When applied as directed for "Non-Crop Uses", under conditions described, this product controls annual and perennial weeds listed on this label growing in areas such as airports, ditch banks, dry ditches, dry canals, fencerows, golf courses, highways, industrial plant sites, lumberyards, parking areas, parks, petroleum tank farms and pumping installations, pipelines, power and telephone rights-of-way, railroads, roadsides, schools, storage areas, other public areas and similar industrial or non-crop areas.

For specific rates of application and instructions for control of various annual and perennial weeds and woody brush and trees, see the "Weeds Controlled" section of this label.

This product may be applied with recirculating sprayers, shielded applicators, or wiper applicators in any non-crop site specified on this label. See the "Selective Equipment" part of "APPLICATION EQUIPMENT AND TECHNIQUES" section of this label for information on proper use and calibration of this equipment.

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**TANK MIXTURES NON-CROP SITES**

When applied as a tank mixture, this product provides control of the emerged annual weeds and partial control of the emerged perennial weeds listed in this label. When applied as a tank mixture, the following residual herbicides will provide pre-emergence control of the weeds listed in the individual product labels -

- ROUNDUP® plus KROVAR™ I ■
- ROUNDUP plus KROVAR II ■
- ROUNDUP plus PRINCEP™ CALIBER™ 90 ■
- ROUNDUP plus PRINCEP 4L ■
- ROUNDUP plus PRINCEP 80W ■
- ROUNDUP plus SURFLAN 75W ■

When tank mixing with residual herbicides add an agriculturally approved nonionic surfactant at 0.5% by volume of spray solution. See the "Mixing and Application Instructions" section of this label before preparing these tank mixtures.

Read and carefully observe the label claims, cautionary statements, recommended use rates and all other information on the labels of all products used in these tank mixtures. Use according to the most restrictive label directions for each product in the mixture

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**CONTROL OF EMERGED WEEDS**

**Annual Weeds** - Apply 1 quart per acre of this product in these tank mixtures when weeds are less than 6 inches tall and 1.5 quarts per acre when weeds are more than 6 inches tall

**Perennial Weeds** - For partial control of perennial weeds using these tank mixtures apply 2 to 5 quarts per acre of this product. Follow the recommendations in the "Weeds Controlled" section of this label for stage of growth and rate of application for specific perennial weeds.

**PREEMERGENCE WEED CONTROL**

The following are the labeled rates for the recommended residual herbicides for non-crop uses:

PRODUCT	RATE / ACRE
Krovar I	4 to 6 lbs.
Krovar II	2 to 5 lbs.
Princep Caliber 90	5.3 to 11.1 lbs.
Princep 80W	6 to 12½ lbs.
Princep 4L	4.8 to 10.0 qts.
Surflan 75W	2½ to 5½ lbs.

Refer to the individual product labels for specific noncrop sites, rates, carrier volumes and precautionary statements.

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Mix only the quantity of spray solution which can be used during the same day. Do not allow these tank mixtures to stand overnight as this may result in reduced weed control.

**APPLY THESE TANK MIXTURES THROUGH CONVENTIONAL BROADCAST EQUIPMENT ONLY**

™Krovar is a trademark of E. I. du Pont de Nemours and Company  
 ™Princep is a trademark of Ciba-Geigy Corporation  
 ™Caliber is a trademark of Ciba-Geigy Corporation  
 ™Surflan is a trademark of Elanco Products Company

**Tank Mixture**

■ **ROUNDUP® PLUS BANVEL** ■

**Use in GROUND APPLICATION EQUIPMENT ONLY**

Refer to the specific product labels for cautionary statements of all products used in these tank mixtures.

See the "Control of Perennial Weeds" part of the "Weeds Controlled" section of this label for the weed growth stage needed to obtain best results.

Apply 2 quarts of this product and 0.5 pound a.i. of Banvel™ in 10 to 20 gallons of water per acre

When applied as directed under the conditions described, this product plus Banvel, will control the following perennial broadleaf weed:

**Blindweed (field)**  
*Cornololus arvensis*

™Banvel is a trademark of the Yelacol Chemical Company.

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**FARMSTEAD WEED CONTROL**

When applied as directed for "Non-Crop Uses," under conditions described, this product controls undesirable vegetation listed on this label around farmstead building foundations, along and in fences, shelterbelts, and for general nonselective farmstead weed control.

For specific rates of application and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label

**ORNAMENTALS**

THIS PRODUCT IS NOT RECOMMENDED FOR USE AS AN OVER-THE-TOP BROADCAST SPRAY IN ORNAMENTALS.

When applied as directed for the conditions described for "Non-Crop Uses", this product controls undesirable vegetation listed on this label prior to planting ornamentals, in established ornamentals, and within and around greenhouses and shadehouses.

For specific rates of application and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label.

Where repeat applications are necessary, do not exceed 10.6 quarts of this product per acre per year.

**Site Preparation** — Following preplant applications of this product, any ornamental species may be planted. Precautions should be taken to protect non-target plants during site preparation applications.

**Greenhouse/Shadehouse Use** — This product may be used to control weeds listed on this label which are growing in greenhouses. Desirable vegetation must not be present during application and air circulation fans must be turned off.

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**Post Directed Spray** — Use as a directed spray toward the base of established woody ornamentals species listed below.

- |                   |                 |
|-------------------|-----------------|
| <b>Arbutus</b>    | <b>Lilac</b>    |
| Thuja spp.        | Syringa spp.    |
| <b>Azalea</b>     | <b>Magnolia</b> |
| Rhododendron spp. | Magnolia spp.   |
| <b>Burwood</b>    | <b>Maple</b>    |
| Buxus spp.        | Acer spp.       |
| <b>Crabapple</b>  | <b>Oak</b>      |
| Malus spp.        | Quercus spp.    |
| <b>Eunymus</b>    | <b>Privet</b>   |
| Eunymus spp.      | Ligustrum spp.  |
| <b>Fir</b>        | <b>Pine</b>     |
| Abies spp.        | Pinus spp.      |
| Pseudotsuga spp.  | <b>Spruce</b>   |
| Hollies           | Picea spp.      |
| Ilex spp.         | <b>Yew</b>      |
|                   | Taxus spp.      |

**SILVICULTURAL SITES RIGHTS-OF-WAY and CHRISTMAS TREES**

NOTE: NOT RECOMMENDED FOR USE AS AN OVER-THE-TOP BROADCAST SPRAY IN SILVICULTURAL NURSERIES, OR CHRISTMAS TREE PLANTATIONS.

When applied as directed for "Non-Crop Uses" under conditions described, this product controls undesirable vegetation listed on this label. This product also suppresses or controls undesirable vegetation listed on this label when applied at recommended rates for release of established coniferous species listed on this label.

For specific rates of application and instructions for control of various brush, annual and perennial weeds, see the "Weeds Controlled" section of this label. For specific rates of application for release of listed coniferous species, see the "Conifer Release" part of this section of the label.

Where repeat applications are necessary do not exceed 10.6 quarts of this product per acre per year.

**Aerial Application** — This product may be applied using aerial spray equipment for silvicultural site preparation, conifer release and rights-of-way treatments. See the "Application Equipment and Techniques" part of the "Mixing and Application" section of this label for information on how to properly spray this product by air.

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Do not apply this product by air to rights-of-way sites in California.

In order to reduce the drift hazard to non-targeted plants and aquatic species when making aerial applications, maintain the following buffer zones:

- 1 Do not apply this product within 200 feet of any agricultural, horticultural, park, golf course, homestead or any populated areas.
- 2 For applications using more than 2 quarts per acre of this product, do not apply within 125 feet of lakes, ponds and streams used for significant domestic purposes or angling.
- 3 For applications using 2 quarts or less per acre of this product, do not apply within 75 feet of lakes, ponds and streams used for significant domestic purposes or angling.
- 4 When making applications on rights-of-way from 75 feet or more above ground level, do not apply within 400 feet of any agricultural, horticultural, park, golf course, homestead, populated areas, lakes, ponds and streams used for significant domestic purposes or angling.

**SITE PREPARATION**

Following preplant applications of this product, any silvicultural species may be planted.

**POST DIRECTED SPRAY**

In established silvicultural sites, use as a spray on the foliage of undesirable vegetation. Care must be exercised to avoid contact of spray, drift or mist with foliage or green bark of desirable species.

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**CONIFER RELEASE**

For release, apply only where conifers have been established for more than one year. Vegetation should not be disturbed prior to treatment or until visual symptoms appear after treatment. Symptoms of treatment are slow to appear, especially in woody species treated in late fall. Injury may occur to conifers treated for release, especially where spray patterns overlap or the higher rates are applied or when applications are made during periods of active conifer growth.

Applications must be made after formation of final conifer resting buds in the fall or prior to initial bud swelling in spring. Some autumn colors on undesirable deciduous species are acceptable provided no major leaf drop has occurred. Use the following rates for conifer release to control or partially control the weeds listed in the "Weeds Controlled" section of this label.

For release of the following conifer species:

- |                       |               |
|-----------------------|---------------|
| <b>Douglas fir</b>    | <b>Pines*</b> |
| Pseudotsuga menziesii | Pinus spp.    |
| <b>Fir</b>            | <b>Spruce</b> |
| Abies spp.            | Picea spp.    |
| <b>Manilock</b>       |               |
| Buga spp.             |               |

\*Includes all species except Eastern White Pine, Loblolly Pine or Slash Pine.

Apply 1½ to 2 quarts of this product per acre except west of the crest of the Cascade Mountains. For spring treatments west of the crest of the Cascade Mountains apply 1 quart of this product per acre before conifer

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bud swell for control of annual weeds. For fall treatments west of the crest of the Cascade Mountains, apply 1 to 1½ quarts of this product per acre before any major leaf drop of deciduous species.

For release of western hemlock apply 1 quart of this product per acre.

For release of the following conifer species:

- |  |                                     |
|--|-------------------------------------|
| <b>Loblolly Pine</b><br>Pinus taeda        | <b>Slash Pine</b><br>Pinus elliotii |
| <b>Eastern White Pine</b><br>Pinus strobus |                                     |

**Late Season Application** — Apply 1½ to 2 quarts of this product in a minimum of 5 gallons of spray solution per acre during early autumn. Applications made prior to September 1 or when conditions are conducive to rapid growth of conifers will result in potential for increased injury in the form of tip and/or needle burn. Injury may decrease with later applications. Some autumn colors are acceptable at time of application. Apply prior to frost or leaf drop of undesirable plants. Applications made according to label direction will release Loblolly Pine, Eastern White Pine and Slash Pine by reducing competition from the following species:

- |  |  |
|--|--|
| <b>Ash</b><br>Fraxinus spp.                | <b>Persimmon</b><br>Diospyros spp.               |
| <b>Cherry:</b><br>Black<br>Prunus serotina | <b>Poplar (yellow)</b><br>Liquidambar tulipifera |

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- |   |  |
|---|--|
| <b>Pine</b><br>Prunus Pansytronica            | <b>Sassafras</b><br>Sassafras albidum      |
| <b>Elm</b><br>Ulmus spp.                      | <b>Sweetwood</b><br>Liquidambar arborea    |
| <b>Hawthorn</b><br>Crataegus spp.             | <b>Sweetgum</b><br>Liquidambar styraciflua |
| <b>Lacust (black)</b><br>Robinia pseudoacacia | <b>Sycamore</b><br>Platanus occidentalis   |
| <b>Maple (red)</b><br>Acer rubra              | <b>Winged</b><br>Rhus copallina            |
| <b>Oak:</b><br>Black<br>Quercus velutina      |  |
| <b>Post</b><br>Quercus stellata               |  |
| <b>Southern Red</b><br>Quercus falcata        |  |
| <b>White</b><br>Quercus alba                  |  |

Apply only to those sites where woody brush and trees listed in this label constitute the majority of the undesirable species.

**NOTE TO USER**

This product must not be used in areas where adverse impact on Federally designated endangered / threatened plant or aquatic species is likely.

Prior to making applications the user of this product must determine that no such species are located in or immediately adjacent to the area to be treated.

**INJECTION AND FRILL APPLICATIONS**

Woody vegetation may be controlled by injection or frill application of this product. Apply this product using suitable equipment which must penetrate into living tissue. Use this product without dilution and apply at least 1 ml (1 / 29 oz.) of herbicide solution for each 2 to 3 inches of trunk diameter breast height (DBH). Space applications evenly around the circumference of the trunk. Application should be made during periods of active growth and full leaf expansion.

This treatment WILL CONTROL the following woody species:

- |                               |  |
|-------------------------------|--|
| <b>Oak</b><br>Quercus spp.    | <b>Sweetgum</b><br>Liquidambar styraciflua |
| <b>Poplar</b><br>Populus spp. | <b>Sycamore</b><br>Platanus occidentalis   |

This treatment WILL SUPPRESS the following woody species:

- |                                     |                                   |
|-------------------------------------|-----------------------------------|
| <b>Black gum</b><br>Nyssa sylvatica | <b>Hickory</b><br>Carya spp.      |
| <b>Dogwood</b><br>Cornus spp.       | <b>Maple (red)</b><br>Acer rubrum |

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**TURFGRASSES AND GRASSES FOR SEED PRODUCTION**

**PREPLANT AND RENOVATION**

When applied as directed for "Non-Crop Uses," under conditions described this product controls most existing vegetation prior to the planting or renovation of either turfgrasses or grass seed production areas.

For specific rates of application and instructions for control of various annual and perennial weeds, and woody brush and trees, see the "Weeds Controlled" section of this label.

For maximum control of existing vegetation, delay planting to determine if any regrowth from escaped underground plant parts occurs. Where repeat treatments are necessary, sufficient regrowth must be attained prior to application. For warm-season grasses, such as bermudagrass, summer or fall application provide best control.

**DO NOT DISTURB SOIL OR UNDERGROUND PLANT PARTS BEFORE TREATMENT.** Tillage or renovation techniques such as vertical mowing, coring or slicing should be delayed for 7 days after application to allow proper translocation into underground plant parts.

**TURFGRASSES**

Where existing vegetation is growing in a field or mowed situation, apply this product to actively growing weeds at the stages of growth given in the "Weeds Controlled" section of this label.

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Where existing vegetation is growing under mowed turfgrass management, apply this product after omitting at least one regular mowing to allow sufficient growth for good interception of the spray.

Desirable turfgrasses may be planted following the above procedures.

**GRASSES FOR SEED PRODUCTION**

Apply this product to actively growing weeds at the stages of growth given in the "Weeds Controlled" section of this label prior to planting or renovation of turf or forage grass areas grown for seed production.

**DO NOT feed or graze treated areas within 8 weeks after application.**

**ANNUAL WEED CONTROL IN DORMANT BERMUDAGRASS TURF**

**Annual Bluegrass (Poa annua)** — Apply ¼ pint (12 fl. oz.) of this product plus 0.5% by total spray volume nonionic surfactant in 5 to 20 gallons of water per acre. Application to actively growing annual bluegrass in dormant bermudagrass turf must be made prior to initiation of bermudagrass greenup in the spring.

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**ROADSIDE BERMUDAGRASS RELEASE**

When applied as directed for "Non-Crop Uses" this product will provide partial control of rhizome Johnsongrass in bermudagrass growing on roadsides. See the "Johnsongrass" part of the "WEEDS CONTROLLED" section of Roundup "Complete Directions for Use" booklet for the correct growth stage and specific application conditions needed to obtain best results.

Use 1.0 to 1.5 quarts of this product in 10 to 40 gallons of water per acre. Apply to Johnsongrass growing on roadsides where bermudagrass (common and coastal varieties) exists and is desired for ground cover. Bermudagrass injury may result from treatment, but regrowth will occur under most conditions. Repeat applications during the same season are not recommended, since severe bermudagrass injury may result.

**CROPPING SYSTEMS**

See "General Information" and "Mixing and Application Instructions" sections of this label for essential product performance information.

See the following CROPPING SYSTEM SECTIONS for specific recommended uses

EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT OF SPRAY WITH FOLIAGE, GREEN STEMS OR FRUIT OF DESIRABLE CROPS, PLANTS, TREES OR OTHER DESIRABLE VEGETATION SINCE SEVERE DAMAGE OR DESTRUCTION MAY RESULT.

Repeat treatments may be necessary to control weeds regenerating from under ground parts or seed. Except as otherwise specified on this label, repeat treatments must be made before the crop emerges in accordance with the instructions of this label.

Except as otherwise specified in a Crop section of this label the combined total of all treatments must not exceed 8 quarts per acre of this product per year.

Do not plant subsequent crops other than those on the label for one year following application.

Do not graze treated cotton fields or feed treated cotton forage to livestock. For other cropping systems, except following spot treatment in forage grasses and legumes, do not harvest or feed treated crops for 8 weeks after application. Allow 14 days following spot treatment or selective equipment use before grazing domestic livestock or harvesting forage grasses and legumes

When applied as directed for "Cropping Systems", under the conditions described, this product controls annual and perennial weeds listed on this label, prior to the emergence of these crops

- |              |                |
|--------------|----------------|
| ALFALFA      | KALE           |
| ARTICHOKE    | LENTILS        |
| (JERUSALEM)  | LETTUCE        |
| BARLEY*      | MUSTARD        |
| BEANS (All)  | GREENS         |
| BEEF GREENS  | OATS*          |
| BEETS        | OKRA           |
| (Red, Sugar) | ONION          |
| BROCCOLI     | PARSNIPS       |
| CABBAGE      | PEANUTS*       |
| CARROT       | PEAS (All)     |
| CAULIFLOWER  | POTATO         |
| CELERY       | (Irish, Sweet) |
| CHICORY      | RADISH         |
| CORN (All)*  | RICE**         |
| COTTON*      | RUTABAGA       |
| FORAGE       | SORGHUM        |
| GRASSES*     | (Milo)*        |
| FORAGE       | SOYBEANS*      |
| LEGUMES*     | SPINACH        |
| HORSERADISH  | WHEAT*         |

\*Spot treatments may be applied in these crops.  
 \*\*Do not treat rice fields or levees when the fields contain flood water.

Spot Treatment (Only those crops with "\*" can be spot treated) — Applications in growing crops must be made prior to heading of small grains and milo, initial pod set in soybeans, silking of corn, boll opening on cotton and pegging of peanuts.

For forage grasses and forage legumes see Spot Treatment in the "Pastures" section of "CROPPING SYSTEMS" in this label.

For dilution and rates of application using Boom or Hand-Held Equipment, see "Mixing and Application" and "Weeds Controlled" sections of this label!

NOTE: FOR FORAGE GRASSES AND FORAGE LEGUMES, NO MORE THAN ONE-TENTH OF ANY ACRE SHOULD BE TREATED AT ONE TIME. FOR ALL OTHER CROPS, DO NOT TREAT MORE THAN 10% OF THE TOTAL FIELD AREA TO BE HARVESTED.

THE CROP RECEIVING SPRAY IN TREATED AREA WILL BE KILLED. TAKE CARE TO AVOID DRIFT OR SPRAY OUTSIDE TARGET AREA FOR THE SAME REASON

Selective Equipment — This product may be applied through recirculating sprayers, shielded applicators, or wiper applicators in cotton and soybeans. Shielded and wiper applicators may also be used in tree crops and grapes. Wiper applicators may be used in forage grasses and forage legumes including pasture sites.

See the "Selective Equipment" part of the "APPLICATION EQUIPMENT AND TECHNIQUES" section of this label for information on proper use and calibration of this equipment

Allow at least the following time intervals between application and harvest

- Cotton Soybeans . . . . . 7 days
- Apples, Avocado, Cherry, Citrus,  
Grapes, Parsnips, Pear
- Rutabagas, Stone Fruit . . . . . 14 days
- Nut Crops . . . . . 21 days

**ASPARAGUS**

When applied as directed for "Cropping Systems" under the conditions described, this product controls weeds listed on this label in asparagus.

For specific rates of applications and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label.

Prior to Crop Emergence — Apply this product prior to crop emergence for the control of emerged labeled annual and perennial weeds. DO NOT APPLY WITHIN A WEEK BEFORE THE FIRST SPEARS EMERGE.

Post Harvest — Apply this product after the last harvest and all spears have been removed. If spears are allowed to regrow, delay application until ferns have developed. Delayed treatments should be applied as a directed or shielded spray in order to avoid contact of the spray with ferns, stems or spears. Direct contact of the spray with the asparagus may result in serious crop injury.

NOTE: Select and use recommended types of spray equipment for post-emergence post harvest applications. A directed spray is any application where the spray pattern is aligned in such a way as to avoid direct contact of the spray with the crop. A shielded spray is any application where a physical barrier is positioned and maintained between the spray and the crop to prevent contact of spray with the crop.

**CRANBERRIES**

Wiper applicators may be used in cranberries in accordance with instructions in this section.

See "General Information" and "Mixing and Application Instructions" sections of this label for essential product performance information.

See the "Selective Equipment" part of the "APPLICATION EQUIPMENT AND TECHNIQUES" section of this label for information on recommended use and calibration of this equipment.

For Wick or other Wiper Applicators — Mix 1 gallon of this product in 4 gallons of water to prepare a 20 percent solution. Apply the solution to emerged weeds. Apply after cranberry fruit set and no later than 30 days before harvest.

In severe infestations, reduce equipment ground speed to insure that adequate amounts of this product are wiped on the weeds. A second treatment in the opposite direction may be beneficial.

Do not permit herbicide solution to contact desirable vegetation.

**FALLOW AND REDUCED TILLAGE SYSTEMS**

FOR AERIAL APPLICATION IN CALIFORNIA, REFER TO SUPPLEMENTAL LABEL.

**EMERGED ANNUAL WEEDS**

Use this product in fallow and reduced tillage systems prior to the emergence of crops listed in this label. Refer to specific product labels for crop rotation restrictions of all products recommended for tank mixing as outlined in this section.

This product does not provide residual weed control, therefore, delay herbicide applications until maximum emergence of annual weeds, but before weeds are greater than 6 inches tall. Reduced control may be observed when application is made to weeds which have been cut to less than 6 inches tall.

Avoid spraying when weeds are subject to moisture stress, when dust is on foliage, or when straw canopy covers the weeds.

This product may be applied using ground or aerial spray equipment for weed control in fallow or reduced tillage systems. See the "Application Equipment and Techniques" section of this label for instructions.

For Ground Applications: Apply in 3 to 10 gallons of water per acre.

For Aerial Applications: Apply in 3 to 5 gallons of water per acre.

Mixing Instructions: Fill spray tank with the required amount of water. Add the recommended amounts of herbicide and surfactant, and mix well before using.

**SPRAY SOLUTION RATE TABLE**

Volume gallons/acre	Nonionic Surfactant Rate fl. oz. / acre	
	0.5%	1%
3	2	4
5*	3.2	6.4
10	6.5	13

\*Maximum aerial application volume.

When applied as directed under the conditions described for fallow and reduced tillage systems, this product, plus an approved agricultural nonionic surfactant will control the following emerged annual weeds. Use 0.5 percent surfactant concentration when using surfactants which contain at least 50 percent active ingredient or a 1 percent surfactant concentration for those surfactants containing less than 50 percent active ingredient.

Apply 1/2 pint of this product plus 0.5 to 1 percent non-ionic surfactant by total spray volume per acre to control the following emerged annual weed:

- Furtails**
- Setaria spp

Apply 1/4 pint of this product plus 0.5 to 1 percent non-ionic surfactant by total spray volume per acre to control the following emerged annual weeds:

- Bluegrass (annual)**
- Poa annua**
- Brome (downy)\***
- Bromus tectorum
- Mustard (tansy)**
- Descurainia pinnata
- Mustard (tumble)**
- Sisymbrium altissimum

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- Barley (volunteer)**
- Hordeum vulgare
- Barnyardgrass**
- Echinochloa crus-galli
- Chickweed (jagged)**
- Holosteum unbellatum
- Mustard (blue)**
- Chorispora tenella
- Mustard (wild)**
- Brassica kaber
- Rye**
- Secale cereale
- Stinkgrass**
- Eragrostis ciliaris
- Wheat**
- Triticum aestivum

\*For control in no-till systems use 16 fluid ounces per acre.

Apply 1 pint of this product plus 0.5 to 1 percent non-ionic surfactant by total spray volume per acre to control the additional emerged annual weeds:

- Bulbous bluegrass**
- Poa bulbosa
- Chickweed**
- Corastium vulgatum
- Cocklebur**
- Xanthium pennsylvanicum
- Cymbium**
- Digitaria spp.
- Falcatifolium (smallseed)**
- Camelina microcarpa
- Gambusia (common)**
- Sanicla vulgaris
- Johnsongrass (seedling)**
- Sorghum halepense
- Lambsquarters**
- Chenopodium album
- Lamb's Quarters**
- Sisymbrium irio
- Oats (wild)**
- Avena fatua
- Panicum (field)**
- Fenweed
- Thlaspi arvense
- Pigweed, Redroot**
- Amaranthus retroflexus
- Ryegrass (annual)**
- Lolium multiflorum
- Sheepchickweed**
- Capsella bursa-pastoris
- Witchgrass**
- Panicum capillare

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- TANK MIXTURES**
- ROUNDUP® plus NONIONIC SURFACTANT plus BANVEL**
- ROUNDUP NONIONIC SURFACTANT plus 2,4-D AMINE**

DO NOT APPLY BANVEL OR 2,4-D AMINE TANK MIXTURES BY AIR IN CALIFORNIA.

The addition of Banvel in a mixture with this product may provide short-term residual control of selected weed species. Some crop injury may occur if Banvel is applied within 45 days of planting. For use instructions, refer to Banvel label.

These recommended tank mixtures may be applied using ground or aerial spray equipment. Use only the following recommended rates of Roundup in these tank mixtures. See the "Application Equipment and Techniques" section of this label for instructions.

Mixing instructions: Fill the spray tank with the required amount of water. Add the recommended amounts of herbicide and surfactant, and mix well before using.

This product plus Banvel or 2,4-D amine will control the annual grasses and broadleaf weeds previously listed for Roundup alone (except 1/2 pint applications) plus the following broadleaf weeds. For those weeds previously listed at 1/2 pint per acre, use the 1/4 pint rate in these tank mixtures.

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Apply 1/4 pint of this product plus 0.25 lb. a.i. of Banvel plus 0.5 to 1 percent nonionic surfactant by total spray volume per acre to control the following broadleaf weeds.

- Kochia**
- Kochia scoparia
- Lambsquarters**
- Chenopodium album
- Lettuce (prickly)**
- Lactuca serriola
- Pigweed, Redroot**
- Amaranthus retroflexus
- Thistle (Russian)**
- Salsola kali

Apply 1 pint of this product plus 0.25 lb. a.i. of Banvel or 0.5 lb. a.e. of 2,4-D amine plus 0.5 to 1 percent nonionic surfactant by total spray volume per acre to control dense populations of the following annual broadleaf weeds:

- Kochia\***
- Kochia scoparia
- Lettuce (prickly)**
- Lactuca serriola
- Thistle (Russian)**
- Salsola kali

\*Controlled with Banvel tank mixture only.

**EMERGED PERENNIAL WEEDS**

When applied as directed under the conditions described, this product plus Banvel will control the following perennial broadleaf weed:

- Bindweed (field)**
- Convolvulus arvensis

- Tank Mixture**
- ROUNDUP® plus BANVEL**

**PRIOR TO PLANTING SMALL GRAINS**

Use in GROUND APPLICATION EQUIPMENT ONLY. Refer to the specific product labels for crop rotation restrictions and cautionary statements of all products used in tank mixtures.

See the "Control of Perennial Weeds" part of the "Weeds Controlled" section of this label for the weed growth stage needed to obtain best results.

Apply 2 quarts of this product and 0.5 pound a.i. of Banvel in 10 to 20 gallons of water per acre. Some crop injury may occur if Banvel is applied within 45 days of planting.

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**PASTURES**

Apply this product prior to planting forage grasses and legumes.

**Pasture or Hay Crop renovation** — When applied as a broadcast spray this product controls the annual and perennial weeds listed in this label prior to planting forage grasses or legumes. Remove domestic livestock before application and wait 8 weeks after application before grazing or harvesting.

**Spot Treatment** — When applied as a spot treatment as recommended, this product controls annual and perennial weeds listed in this label which are growing in pastures, forage grasses and forage legumes composed of bahiagrass, bermudagrass, bluegrass, brome, fescue, orchardgrass, ryegrass, timothy, wheatgrass, alfalfa or clover.

**Wiper Application** — When applied as directed this product controls or suppresses the weeds listed under "Wiper Applicators" in the "Selective Equipment" section of this label. Remove domestic livestock before application and wait 14 days after application before grazing or harvesting.

Apply in areas where the movement of domestic livestock can be controlled. No more than one-tenth of any acre should be treated at one time. Further applications may be made in the same area at 30 day intervals. Remove domestic livestock before application and wait 14 days after application before grazing livestock or harvesting.

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See "General Information", "Mixing and Application Instructions" and "Weeds Controlled" sections of this label.

## SUGARCANE

When applied as directed for "Cropping Systems," under the condition described, this product controls those emerged annual and perennial weeds listed on this label growing in or around sugarcane or in fields to be planted to sugarcane. This product will also control undesirable sugarcane.

**NOTE:** Where repeat treatments are necessary, do not exceed a total of 10.6 quarts of this product per acre per year. Do not apply to vegetation in or around ditches, canals or ponds containing water to be used for irrigation.

**Broadcast Treatment** — Apply this product in 10 to 40 gallons of water per acre on emerged weeds growing in fields to be planted to sugarcane.

For specific rates of application and instructions for control of various annual and perennial weeds see the "Weeds Controlled" section of this label.

For removal of last stubble or ratoon cane, apply 4 to 5 quarts of this product in 10 to 40 gallons of water per acre to new growth having at least 7 or more new leaves. Allow 7 or more days after application before tillage.

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**Spot Treatment in or Around Sugarcane Fields** — For dilution and rates of application using Hand-Held Equipment, see "Mixing and Application" and "Weeds Controlled" sections of this label.

For control of volunteer or diseased sugarcane, make a 1 percent solution of this product in water and spray to wet the foliage of vegetation to be controlled.

**NOTE:** When spraying volunteer or diseased sugarcane, the plants should have at least 7 new leaves.

Avoid spray contact with healthy cane plants since severe damage or destruction may result.

## TANK MIXTURES Minimum Tillage Systems CORN

When applied as recommended under the conditions described, these tank mixtures control many emerged weeds, and give preemergence control of many annual weeds when corn will be planted directly into a cover crop, established sod, or in previous crop residues.

Refer to specific product labels for crop rotation restrictions and cautionary statements of all products used in these tank mixtures. Lasso<sup>®</sup> EC herbicide may be substituted for Lasso herbicide in these tank mixtures. For mixing instructions, see the "Mixing and Application Instructions" section of this label.

### ■ BOUNDUP<sup>®</sup> plus LASSO<sup>®</sup> ■

Do not use these tank mixtures on sand or loamy sand soils.

### ■ BOUNDUP plus LASSO plus ATRAZINE ■

or

### ■ BOUNDUP plus LASSO plus BLADEX™ ■

or

### ■ BOUNDUP plus LASSO plus PRINCEP™ ■

or

### ■ BOUNDUP plus ATRAZINE plus PRINCEP ■

Apply these tank mixtures in 10 to 40 gallons of water per acre after planting or during planting in such manner that the planter does not disturb the treated soil. Do not apply these mixtures after crop emergence.

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REDUCED CONTROL MAY RESULT IF THIS PRODUCT IS USED IN TANK MIXTURES CONTAINING FLUID FERTILIZERS

### CONTROL OF EMERGED WEEDS

**Annual Weeds** — Apply to actively growing grasses and broadleaf weeds. Use 1 quart of Roundup herbicide per acre in these tank mixtures if weeds are less than 6 inches tall. If weeds are over 6 inches tall, apply 1.5 quarts of this product per acre. For emerged annual weeds controlled, see the "Weeds Controlled" section of this label.

**Perennial Weeds** — At normal application dates in minimum tillage systems, perennial weeds may not be at the proper stage of growth for control. See the "General Information" section of this label for the proper stage of growth for perennial weeds.

Use of 2 to 4 quarts of Roundup herbicide per acre in these tank mixtures, under these conditions provides top kill and reduces competition from many emerged perennial grass and broadleaf weeds. For emerged perennial weeds controlled, see the "Weeds Controlled" section of this label. To obtain control, follow recommendations on this label for stage of growth and rate of application for specific perennial weeds. To obtain the desired stage of growth, it may be necessary to apply Roundup herbicide alone in the late summer or fall and then follow with a label approved seedling weed control program at planting.

**NOTE:** When using these tank mixtures, do not exceed 4 quarts of Roundup herbicide per acre.

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USE OF THESE TANK MIXTURES FOR BERMUDA-GRASS OR JOHNSONGRASS CONTROL IN MINIMUM TILLAGE SYSTEMS IS NOT RECOMMENDED. For bermudagrass control, follow the instructions under "Control of Perennial Weeds" section of this label and then use a label approved seedling weed control program in a minimum tillage or conventional tillage system. For johnsongrass control, follow the instructions under the "Control of Perennial Weeds" section of the label, and then use a label approved seedling weed control program with conventional tillage.

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## PREEMERGENCE WEED CONTROL

### ■ LASSO<sup>®</sup> ■

For weeds controlled preemergence see the "Weed Control with Lasso<sup>®</sup>" section of the label for Lasso herbicide.

See the following table for recommended rates of Lasso in this tank mixture with Roundup herbicide on various soil types.

Lasso<sup>®</sup>

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso <sup>®</sup> (Quarts)	
COARSE	2.5 to 3	
MEDIUM	3	
FINE	3.5 to 4	

\*Refer to the Soil Texture section of the label to determine the corresponding soil texture group for the soil to be treated.

Use the higher rate of Lasso herbicide in the recommended ranges in areas of heavy grass infestation or when organic matter content is 3 percent or more.

**LISSO® plus ATRAZINE**

For weeds controlled preemergence, see the "Weed Control with Lasso and Lasso plus atrazine (Tank Mixture)" sections of the label for Lasso herbicide.

See the following table for recommended rates of Lasso plus atrazine 80W in this tank mixture with Roundup herbicide on various soil types.

**Lasso® plus atrazine**

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso® (Quarts)	atrazine 80W** (Pounds)
COARSE		
Sandy Loam only	2 to 2.5	1.25 to 1.5
MEDIUM	2.5 to 3	1.5 to 2
FINE	2.5 to 3	2 to 2.5

\*Refer to the Soil Texture section of the label to determine the corresponding soil texture group for the soil to be treated

\*\*When using atrazine 4L or AAtrex™ 4LC use equivalent rates. One quart equals 1.25 pound of atrazine 80W

Use the higher rate of Lasso herbicide in the recommended ranges in areas of heavy grass infestation or when fall panicum or crabgrass will be present.

Use the higher rate of atrazine in the recommended ranges on soils with greater than 3% organic matter.

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**LISSO® plus BLADEx**

For weeds controlled preemergence see the "Weed Control with Lasso and Lasso plus Bladex (Tank Mixture)" sections of the label for Lasso herbicide.

See the following table for recommended rates of Lasso plus Bladex in this tank mixture with Roundup herbicide on various soil types.

**Lasso® plus Bladex**

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso® (Quarts)	Bladex** 4L (Quarts)
COARSE	2 to 2.5	1 to 1.6
MEDIUM	2.5 to 3	1.2 to 1.6
FINE	2.5 to 3	1.6 to 2.2

\*Refer to the Soil Texture section of the label to determine the corresponding soil texture group for the soil to be treated

\*\*When using Bladex 80W use equivalent rates. One quart Bladex 4L equals 1.25 lbs of Bladex 80W

Use the higher rate of Lasso herbicide in the recommended ranges in areas of heavy grass infestation or when fall panicum or crabgrass will be present

Use the higher rate of Bladex in the recommended ranges on soils with greater than 3% organic matter

NOTE: Do not use this mixture on sand or loamy sand soils with less than 2% organic matter.

\*\*Bladex is a trademark of the Shell Chemical Company

**LISSO® plus PRINCEP™**

For weeds controlled preemergence see the "Weed Control" sections of the labels for Lasso and Princep

See the following table for recommended rates of Lasso plus Princep in this tank mixture with Roundup herbicide on various soil types.

**Lasso® plus Princep**

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso® (Quarts)	Princep 80W** (Pounds)
COARSE		
Sandy Loam only	2 to 2.5	1.25 to 1.5
MEDIUM	2.5 to 3	1.5 to 2
FINE	2.5 to 3	2 to 2.5

\*Refer to the Soil Texture section of the label to determine the corresponding soil texture group for the soil to be treated

\*\*When using Princep 4L use equivalent rates. One quart equals 1.25 pounds of Princep 80W

Use the higher rate of Lasso herbicide in the recommended ranges in areas of heavy grass infestation or when fall panicum or crabgrass will be present

Use the higher rate of Princep herbicide in the recommended ranges on soils with greater than 3% organic matter

\*Lasso is a registered trademark of Monsanto Company

\*\*Princep is a trademark of Ciba-Geigy Corporation

\*\*AAtrex is a trademark of Ciba-Geigy Corporation

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**ATRAZINE PLUS PRINCEP**

For weeds controlled preemergence see the "Weed Control" sections of the labels for atrazine and Princep

See the following table for recommended rates of atrazine 80W and Princep 80W in this tank mixture with Roundup herbicide on various soil types.

**Atrazine 80W plus Princep 80W**

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	atrazine 80W** (Pounds)	Princep 80W** (Pounds)
COARSE		
Sandy Loam only	1.25	1.25
MEDIUM	1.25 to 1.75	1.25 to 1.75
FINE	1.5 to 2	1.5 to 2

\*Refer to the Soil Texture of the label to determine the corresponding soil texture group for the soil to be treated.

\*\*When using atrazine 4L, AAtrex 4LC or Princep 4L use equivalent rates. One quart equals 1.25 pounds of atrazine 80W or Princep 80W.

Use the higher rate of these products in the recommended ranges on soils with greater than 3% organic matter

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**TANK MIXTURES  
Minimum Tillage Systems  
SOYBEANS**

When applied as directed under the conditions described, these tank mixtures control many emerged annual weeds, suppress many emerged perennial weeds and give preemergence control of many annual weeds when soybeans will be planted directly into a cover crop, stale seed bed, or in previous crop residues such as wheat stubble. These tank mixtures will not control regrowth from perennial weeds.

Refer to specific product labels for crop rotation restrictions and cautionary statements of all products used in these tank mixtures. Lasso EC herbicide may be substituted for Lasso herbicide in these tank mixtures. For mixing instructions, see the "Mixing and Application Instructions" section of this label.

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**ROUNDUP® plus LISSO®**

or

**ROUNDUP plus LISSO plus LOROX™**

or

**ROUNDUP plus LISSO plus LEXONE™**

or

**ROUNDUP plus LISSO plus SENCOR™**

Apply these tank mixtures in 10 to 40 gallons of water per acre after planting or during planting in such manner that the planter does not disturb the treated soil. Do not apply these mixtures after crop emergence. REDUCED CONTROL MAY RESULT IF THIS PRODUCT IS USED IN TANK MIXTURES CONTAINING FLUID FERTILIZERS

**CONTROL OF EMERGED WEEDS**

**Annual Weeds** — Apply to actively growing grasses and broadleaf weeds. Use 1 quart of Roundup per acre in these tank mixtures if weeds are less than 6 inches tall. If weeds are over 6 inches tall, apply 1.5 quarts of this product per acre. For emerged annual weeds controlled, see the "Weeds Controlled" section of this label.

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**Perennial Weeds** — At normal application dates in minimum tillage systems, perennial weeds may not be at the proper stage of growth for control. See the "General Information" section of this label for the proper stage of growth for perennial weeds. Use of 2 to 4 quarts of Roundup herbicide per acre in these tank mixtures under these conditions provides top kill and reduces competition from many emerged perennial grass and broadleaf weeds. For emerged perennial weeds controlled, see the "Weeds Controlled" section of this label. To obtain control, follow recommendations on this label for stage of growth and rate of application for specific perennial weeds. To obtain the desired stage of growth, it may be necessary to apply Roundup herbicide alone in the late summer or fall and then follow with a label approved seedling weed control program at planting.

**NOTE** When using these tank mixtures, do not exceed 4 quarts of Roundup herbicide per acre.

**USE OF THESE TANK MIXTURES FOR BERMUDAGRASS OR JOHNSONGRASS CONTROL IN MINIMUM TILLAGE SYSTEMS IS NOT RECOMMENDED.** For bermudagrass control, follow the instructions under "Control of Perennial Weeds" section of this label and then use a label approved seedling weed control program in a minimum tillage or conventional tillage system. For Johnsongrass control, follow the instructions under the "Control of Perennial Weeds" section of the label, and then use a label approved seedling weed control program with conventional tillage.

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**PREEMERGENCE WEED CONTROL**

**LASSO®**

For weeds controlled preemergence, see the "Weed Control with Lasso" section of the label for Lasso herbicide.

See the following table for recommended rates of Lasso in this tank mixture on various soil types.

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso® (Quarts)	
COARSE	2.5 to 3	
MEDIUM	3	
FINE	3.5 to 4	

\*Refer to the Soil Texture section of the label to determine the corresponding soil texture group for the soil to be treated.

Use the higher rate of Lasso herbicide in the recommended ranges in areas of heavy grass infestation, or when organic matter content is 3 percent or more.

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**LASSO® plus LOROX**

For weeds controlled preemergence, see the "Weed Control with Lasso and Lasso plus Lorox 50WP" sections of the label for Lasso herbicide.

See the following table for recommended rates of Lasso plus Lorox 50WP in this tank mixture with Roundup herbicide on various soil types.

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso® (Quarts)	Lorox 50WP (Pounds)
COARSE		
Sandy Loam only	2 to 2.5	1 to 1.5
MEDIUM	2.5 to 3	1.5 to 2
FINE	2.5 to 3	2 to 3

\*Refer to the Soil Texture section of the label to determine the corresponding soil texture group for the soil to be treated.

Use the higher rate of Lasso in the recommended ranges in areas of heavy grass infestation or when fall panicum or crabgrass will be present.

Use the higher rate of Lorox 50WP in the recommended ranges on soils with greater than 3% organic matter.

Do not use this mixture on sand or loamy sand or on soil with less than 1% organic matter as crop injury from Lorox may occur.

\*Lorox is a trademark of E. I. duPont de Nemours and Company.

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**LASSO® plus LEXONE**

or

**LASSO® plus SENCOR**

For weeds controlled preemergence, see the "Weed Control with Lasso and Lasso plus Lexone or Sencor" sections of the label for Lasso herbicide.

See the following table for recommended rates of Lasso plus Lexone 50WP or Lasso plus Sencor 50WP in this tank mixture on various soil types.

**Lasso® plus Lexone 50WP or Lasso® plus Sencor 50WP**

SOIL TEXTURE GROUP*	BROADCAST RATE PER ACRE	
	Lasso® (Quarts)	Lexone 50WP** or Sencor 50WP** (Pounds)
COARSE		
Sandy Loam only	2 to 2.5	0.5 to 0.75
MEDIUM	2.5 to 3	0.75 to 1
FINE	2.5 to 3	1 to 1.5***

\*Refer to the Soil Texture section of this label to determine the corresponding soil texture group for the soil to be treated.

\*\*When using Lexone 4L or Sencor 4 Flowable use equivalent rates. One quart equals 2 pounds of Lexone 50WP or Sencor 50WP.

\*\*\*On the silty clay or heavy clay soils of the Mississippi Delta, use 1.5 to 2 pounds of Lexone or Sencor per acre.

Use the higher rate of Lasso herbicide in the recommended ranges in areas of heavy grass infestations or when fall panicum or crabgrass will be present.

Use the higher rate of Lexone or Sencor herbicides in the recommended ranges on soils with greater than 2% organic matter.

Do not use this mixture on sand or loamy sand soils as crop injury from Lexone or Sencor may occur.

Do not use on muck soils.

Do not apply on alkaline soils with a pH of more than 7.4.

Crop injury may occur if any atrazine was applied on the soil the year before use of this Lexone or Sencor tank mixture.

**DO NOT REPLANT CROPS OTHER THAN SOYBEANS FOR 120 DAYS AFTER APPLICATION.**

\*Lexone is a trademark of E. I. duPont de Nemours and Company.

\*\*Sencor is a trademark of the parent company of Farbenfabriken Bayer GmbH, Leverkusen.

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**PRE-HARVEST APPLICATIONS**

When applied as directed under the conditions described, this product controls annual and perennial weeds listed on this label prior to the harvest of COTTON.

For specific rates of application and instructions for control of various annual and perennial weeds, see the "Weeds Controlled" section of this label.

**Ground Applications** — Apply this product in 10 to 40 gallons of water per acre on emerged labeled annual and perennial weeds.

**Timing of Application** — Apply this product for pre-harvest weed control after 80% of the cotton bolls have opened.

**NOTE. DO NOT APPLY TO CROPS GROWN FOR SEED.** Allow a minimum of 7 days between application and harvest.

Do not feed or graze treated areas within 8 weeks after application.

## TREE AND VINE CROPS

This product is recommended for weed control in established groves, vineyards, or orchards, or for site preparation prior to transplanting crops listed in this section. Applications may be made with boom equipment, COA, shielded sprayers, hand-held and high-volume wands, lances, or orchard guns, or with wiper applicator equipment, except as directed in this section. See the "Application Equipment and Techniques" section of this label for specific information on use of equipment.

### NOTE

Repeat treatments may be necessary to control weeds originating from underground parts of untreated weeds or from seeds. This product does not provide residual weed control. For subsequent weed control, follow a program using residual herbicides or use repeated applications of this product. Do not apply more than 10.6 quarts of this product per acre per year.

**EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT OF HERBICIDE SOLUTION SPRAY, DRIFT, OR MIST WITH FOLIAGE OR GREEN BARK OF TRUNK, BRANCHES, SUCKERS, FRUIT, OR OTHER PARTS OF TREES OR VINES. CONTACT OF THIS PRODUCT WITH OTHER THAN MATURED BROWN BARK CAN RESULT IN SERIOUS CROP DAMAGE.**

Reduced control may result when applications are made to annual or perennial weeds that have been mowed, grazed or cut and have not been allowed to regrow to the recommended stage for treatment. For specific rates of applications and instructions, see the "Weeds Controlled" section of this label.

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Refer to the individual product labels for specific crops, rates, geographical restrictions and precautionary statements.

Read and carefully observe the label claims, cautionary statements, rates and all other information on the labels of all products. Use according to the most restrictive label directions for each product in the mixture.

For specific rates of application and instructions see the "Weeds Controlled" section of this label.

<sup>1</sup>Goal is a trademark of Rohm and Haas Company.

<sup>2</sup>Karmex is a trademark of E. I. du Pont de Nemours and Company.

<sup>3</sup>Krovax is a trademark of E. I. du Pont de Nemours and Company.

<sup>4</sup>Princep is a trademark of Ciba-Geigy Corporation.

<sup>5</sup>Caliber is a trademark of Ciba-Geigy Corporation.

<sup>6</sup>Solicam is a trademark of Sandoz, Inc.

<sup>7</sup>Surflan is a trademark of Elanco Products Company.

## TANK MIXTURES TREE AND VINE CROPS

When applied as a tank mixture, this product provides control of the emerged annual weeds and partial control of the emerged perennial weeds listed in this label. The following residual herbicides will provide pre-emergence control of those weeds listed in the individual product labels.

- ROUNDUP<sup>®</sup> plus GOAL<sup>™</sup> 1.6E ✓
- ROUNDUP plus KARMEX<sup>™</sup> WP
- ROUNDUP plus KROVAR<sup>™</sup> I
- ROUNDUP plus KROVAR<sup>™</sup> II
- ROUNDUP plus PRINCEP<sup>™</sup> CALIBER<sup>™</sup> 90
- ROUNDUP plus PRINCEP 4L
- ROUNDUP plus PRINCEP 80W
- ROUNDUP plus SOLICAM<sup>™</sup> 80WP
- ROUNDUP plus SURFLAN<sup>™</sup> AS
- ROUNDUP plus SURFLAN 75W
- ROUNDUP plus PRINCEP (80W, OR 4L, OR CALIBER 90) plus SURFLAN (AS OR 75W)

When tank mixing with residual herbicides add an agriculturally approved nonionic surfactant. Use 0.5 percent surfactant concentration when using surfactants which contain at least 50 percent active ingredient or a 1 percent surfactant concentration for those surfactants containing less than 50 percent active in-

gredient. See the "Mixing and Application Instructions" section of this label.

Do not apply these tank mixtures in Puerto Rico.

### CONTROL OF EMERGED WEEDS

**Annual Weeds** — Apply 1 quart per acre of this product in these tank mixtures when weeds are less than 12 inches tall. For weeds greater than 12 inches tall, apply 1.5 quarts per acre.

**Perennial Weeds** — For partial control of perennial weeds using these tank mixtures apply 2 to 5 quarts per acre of this product. Follow the recommendations in the "Weeds Controlled" section of this label for stage of growth and rate of application for specific perennial weeds.

### PREEMERGENCE WEED CONTROL

The following are the labeled rates for the recommended residual herbicides.

PRODUCT	RATE / ACRE
Goal 1.6E	1.25 to 5 qts ✓
Karmex WP	2 to 8 lbs
Krovax I	2 to 8 lbs
Krovax II	2 to 8 lbs
Princep Caliber 90	1.1 to 10.6 lbs
Princep 80W	1½ to 12 lbs
Princep 4L	2 to 9.6 qts
Solicam 80WP	2½ to 5 lbs
Surflan AS	2 to 4 qts
Surflan 75W	2½ to 5½ lbs.

**NOTE:** These residual herbicides may provide post-emergence activity on certain annual weed species.

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## TREE CROPS

**Citrus<sup>1</sup>:** grapefruit, kumquat, lemon, lime, orange, tangelo, tangerine.

**Nuts<sup>2</sup>:** almond, filbert, macadamia, pecan, pistachio, walnut.

**Pome Fruit<sup>3</sup>:** apple, pear.

**Stone Fruit<sup>4</sup>:** apricots, cherries, nectarines, peaches, plums/prunes.

For cherries, any application equipment listed in this section may be used in all states.

Any application equipment listed in this section may be used in apricots, nectarines, peaches, and plums/prunes growing in Arizona, California, Colorado, Idaho, Kansas, Kentucky, New Jersey, North Dakota, Oklahoma, Oregon, Texas, Utah, and Washington, except for peaches grown in the states specified in the following paragraph. In all other states use wiper equipment only.

For PEACHES grown in Alabama, Arkansas, Florida, Georgia, North Carolina, South Carolina, and Tennessee only, apply with a shielded boom sprayer or shielded wiper applicator which prevents any contact of this product with the foliage or bark of trees. Apply no later than 90 days after first bloom. Applications made after this time may result in severe damage. Remove suckers and low hanging limbs at least 10 days prior to application. Avoid applications near trees with recent pruning wounds or other mechanical injury. Apply only near

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trees which have been planted in the orchard for 2 or more years. **EXTREME CARE MUST BE TAKEN TO ENSURE NO PART OF THE PEACH TREE IS CONTACTED.**

**Tropical Fruit:** avocado<sup>5</sup>, banana, coffee<sup>6</sup>, guava, mango<sup>7</sup>, papaya, tea. Allow a minimum of 1 day between last application and harvest of guava and papaya. In coffee and banana delay applications 3 months after transplanting to allow the new coffee or banana plant to become established.

### NOTE

\*Allow a minimum of 14 days between last application and harvest.

\*\*Allow a minimum of 21 days between last application and harvest of these crops.

**VINE CROPS**

**Grapes\***: any variety of table, wine, or raisin grape may be treated with any equipment listed in this section. Applications should not be made when green shoots, canes, or foliage are in the spray zone.

In the northeast and Great Lakes regions, applications must be made prior to the end of bloom stage of grapes to avoid injury.

**NOTE:**

\*Allow a minimum of 14 days between last application and harvest

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ROUNDUP® Herbicide Complete Directions for Use  
 in NON DROP AREAS such as:  
 Industrial, Recreational, and Public areas  
 Farmstead Weed Control  
 Ornamentals  
 Silvicultural Sites and Rights of Way  
 Turfgrasses and Grasses for Seed Production

**in CROPPING SYSTEMS**

Alfalfa	Corn	Okra
Artichoke	Cotton	Onion
(Jerusalem)	Cranberries	Parsnips
Asparagus	Forage Grasses	Peanut
Berley	Forage legumes	Peas (English green)
Beans, Edible (all)	Horsebush	Potato (Irish sweet)
Beet Greens	Kale	Radish
Beets (red sugar)	Lentils	Rice
Broccoli	Lettuce	Rutabaga
Cabbage	Mustard greens	Sorghum (milo)
Carrot	Oats	Soybeans
Cauliflower		Squash
Celery		Sugarcane
Chicory		Wheat

**Fallow and Reduced Tillage Systems**

Pastures  
 Preharvest Applications to Cotton  
 Sugarcane

**in TREE CROPS**

Citrus (as listed)	Pome Fruit (as listed)
Cherry	Stone Fruit (as listed)
Nuts (as listed)	Tropical Fruit (as listed)

**in GRAPES - Wine, Table and Raisin**

**in MINIMUM TILLAGE SYSTEMS for Corn Soybeans**

This product has been approved for use in California except as stated otherwise on pages 104 and 105

EPA Reg. No. 524-308 AA

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In case of an emergency involving this product,  
 Call Collect, day or night, (314) 694-4000

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## REFERENCES



## REFERENCES

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**STATE WATER RESOURCES CONTROL BOARD**

**P. O. Box 100, Sacramento, CA 95801**

**CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS**

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Santa Rosa, California 95401  
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Oakland, California 94607  
(415) 464-1255

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San Luis Obispo, California 93401  
(805) 549-3147

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Los Angeles, California 90012  
(213) 620-4460

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Sacramento, California 95816  
(916) 445-0270

**Fresno Branch Office**

3374 East Shields Avenue, Rm. 18  
Fresno, California 93726  
(209) 445-5116

**Redding Branch Office**

100 East Cypress Avenue  
Redding, California 96002  
(916) 225-2045

**LAHONTAN REGION (6)**

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P. O. Box 9428  
South Lake Tahoe, California 95731  
(916) 544-3481

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(519) 245-6583

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Palm Desert, California 92260  
(619) 346-7491

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(714) 684-9330

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6154 Mission Gorge Road, Suite 205  
San Diego, California 92120  
(619) 265-5114

