Appendices for MMWD Herbicide Risk Assessment

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Appendix A: Example Calculation: Allometric Equations

Allometric equations are empirically derived from studies that look at different animals with a variety of body weights and measure the variable of interest (in this case, water intake, food intake or surface area).[1, 2] These allometric relationships take the form:

$$y = aW^x$$

where W is the weight of the animal (in grams), y is the variable to be estimated (usually surface area (in m^2) or food intake (in grams/day or kcal/day), and the model parameters a (sometimes called "alpha" in USFS documents) and x (sometimes called "beta") are empirically derived. For most allometric relationships of food intake, x ranges from approximately 0.65 to 0.75. Although there is some theory[3] about why the parameter x takes the exact value that it does, determining the coefficients a and x usually requires experimental data.

As an example, the following presents some sample calculations:

$$\textit{Food Intake for Large Mammal} = 1.518 \text{ x } (\textit{BodyWeight})^{0.73}$$
$$= 1.518 \text{ x } (70{,}000 \text{ grams})^{0.73} = 5{,}230 \text{ kcal/day}$$

Or for different species with smaller average body weight:

$$\textit{Food Intake} = 1.518 \text{ x } (60{,}000 \text{ grams})^{0.73} = 4{,}670 \text{ kcal/day}$$

where $a = 1.518$ and $x = 0.73$ for large mammals. The estimated food intake of 5,230 kcal/day may seem large compared to similar estimates for a 70-kg human (roughly 2,000 kcal/day). However, wildlife require more energy for thermoregulation and for daily activity.

Allometric relationships are meant to define the average food intake for the average individual within a species. However, there is considerable inter and intra-specific scatter in this relationship. The food intake of a species with average weight of 50 kg may not be well-described by this equation. Even when this equation describes the average food intake of the species well, individuals may differ considerably. For example, young individuals have a higher metabolic rate than older individuals.

Parameters a and x change for different types of animals, and food intake can be expressed in grams instead of calories. For example, small mammals eating a known food type (say insects with 1.5 kcal/g) have an allometric relationship with $a = 0.621$ and $x = 0.584$:

A 20 g small mammal consumes $= 0.621\ W^{0.584} = 3.57$ grams/day

Surface area is also a function of the organism's bodyweight. A single pair of a and x values are used to determine surface area for all animals in the risk assessment:

A 20 g small animal has a surface area of $= 0.11\ W^{0.65} = 0.771\ m^2$

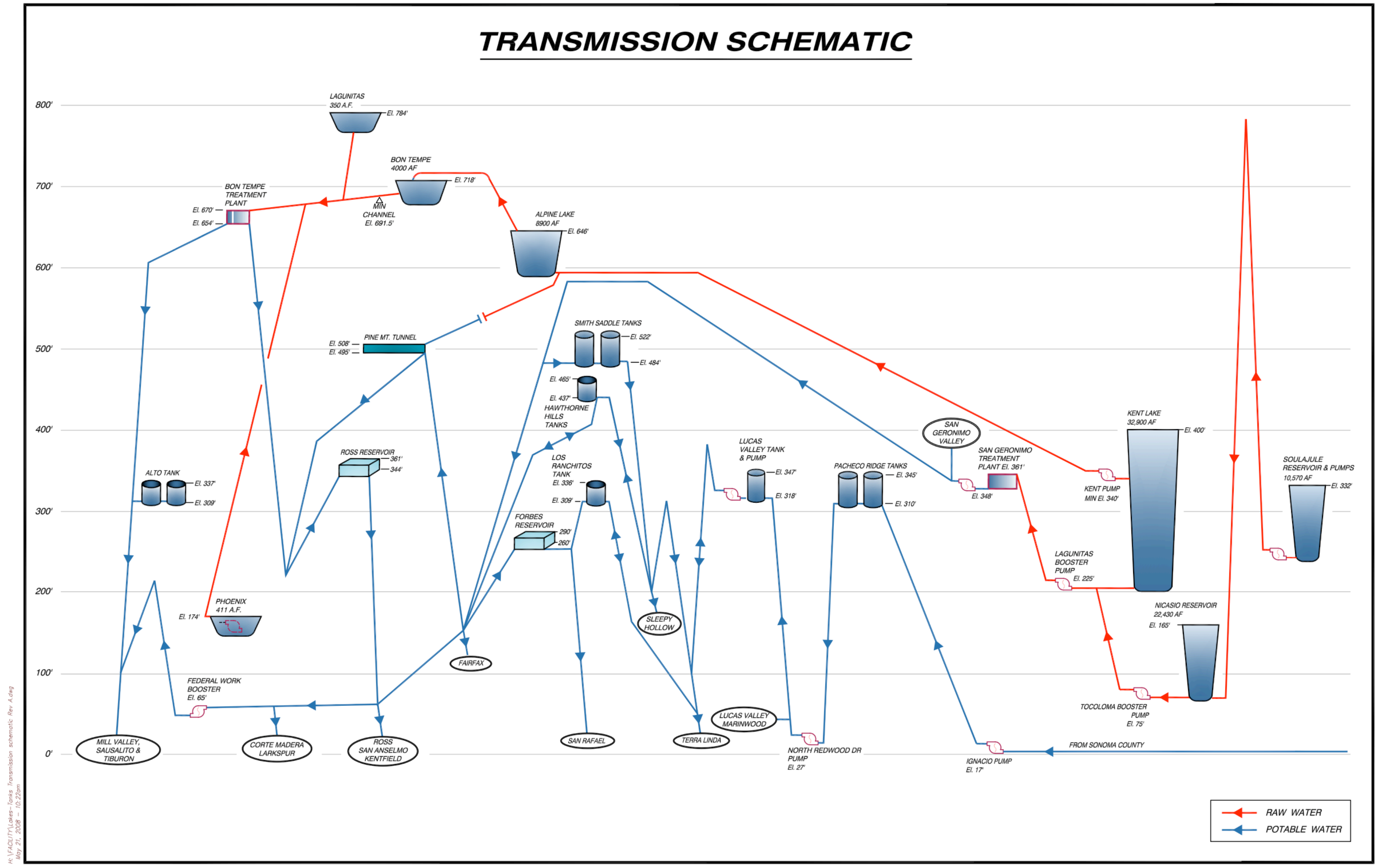
The following Table comes from Section 2.4.3 and presents all of the allometric equations used in the exposure estimates.

Table 2-12. Allometric Relationships for Surface Area, Food and Water Intake

Kcal/day consumed by	**Body weight** (grams)	**Allometric equation**	**Caloric intake** (kcal/day or g)
Small mammal	20	$0.621 * (\text{body weight in grams})^{0.584}$	3.36 grams
Large mammal	70,000	$1.518 * (\text{body weight in grams})^{0.73}$	5,230
Carnivore	Small: 20 Large: 5,000	$1.894 * (\text{body weight in grams})^{0.7}$	Small: 15 Large: 735
Carnivorous bird	1,000	$1.146 * (\text{body weight in grams})^{0.749}$	203
Piscivorous bird	1,000	$0.1 * (\text{body weight in grams})^{1}$	100 grams
All birds	Small: 10 Large: 4,000	$3.12 * (\text{body weight in grams})^{0.604}$	Small: 13 Large: 471

NA = not applicable

1.1 Appendix B: Transmission Schematic for MMWD Reservoirs



1.2 Appendix C: Parameter Sensitivity Test Results

The following tables present the results of the wildlife and human exposure parameter sensitivity tests. The exposure scenarios are described in Section 2.4.3 and the sensitivity tests are described in Section 2.4.4.

In the wildlife table, the subscript for *x* refers to the fact that there are three allometric relationships: surface area (SA), food intake (FI) and water intake (W). The percent increases are based on the central estimates in the original run compared to central estimates in the sensitivity run, or ([(sensitivity central estimate)/(original central dose)]-1) x 100%.

Table C-1: Wildlife Parameter Sensitivity Test Results: Percent change in exposure with change in parameter

		Sensitivity Test								
Scenario	**Receptor**	**Change allometric exponent: 90% original value, $x_{SA,W}$ 110% x_{FI}[1]**	**Change allometric exponent: 80% original value, $x_{SA,W}$ 120% x_{FI}[1]**	**Increase *a* by 110%**	**Increase *a* by 120%**	**Caloric Density 50% of Original Value**	**Caloric Density 75% of Original Value**	**Body weight 50% of Original Value**	**Body weight 80% of Original Value**	**Body weight 90% of Original Value**
Acute/Accidental Exposures		**Percent Increase in Central Exposure Estimate (mg/kg-event)**								
Direct Spray										
first-order absorption	Small mammal	29%	66%	10%	20%	0%	0%	27%	8%	4%
100% absorption	Small mammal	29%	66%	10%	20%	0%	0%	27%	8%	4%
100% absorption	Honey Bee	83%	234%	10%	20%	0%	0%	105%	8%	4%
Consumption of contaminated vegetation										
Fruit	Small Mammal	19%	42%	10%	20%	0%	0%	33%	10%	4%
Grass	Large Mammal	126%	410%	10%	20%	100%	33%	21%	6%	3%
Grass	Large Bird	65%	172%	10%	20%	100%	33%	32%	9%	4%
Consumption of contaminated Water										
Accidental spill	Small Mammal	42%	102%	10%	20%	0%	0%	7%	2%	1%
Peak runoff conc.		42%	102%	10%	20%	0%	0%	7%	2%	1%
Consumption of contaminated insects										
	Small Mammal	23%	52%	10%	20%	100%	33%	23%	7%	3%
	Small Bird	15%	32%	10%	20%	100%	33%	32%	9%	4%
Consumption of contaminated fish										
Accidental spill	Fish-eating bird	0%	0%	0%	0%	0%	0%	0%	0%	0%

Scenario	Receptor	Sensitivity Test: Change allometric exponent: 90% original value, $x_{SA,W}$ 110% x_{FI} [1]	Change allometric exponent: 80% original value, $x_{SA,W}$ 120% x_{FI} [1]	Increase *a* by 110%	Increase *a* by 120%	Caloric Density 50% of Original Value	Caloric Density 75% of Original Value	Body weight 50% of Original Value	Body weight 80% of Original Value	Body weight 90% of Original Value
Consumption of contaminated small mammal										
	Carnivorous mammal	134%	98%	21%	44%	100%	33%	57%	45%	19%
	Carnivorous bird	109%	58%	21%	44%	100%	33%	52%	43%	18%
Chronic/Long-Term Exposures		**Percent Increase in Central Exposure Estimate (mg/kg-day)**								
Consumption of contaminated vegetation										
On-site	Small mammal	19%	42%	10%	20%	0%	0%	33%	10%	4%
Off-site	Small mammal	19%	42%	10%	20%	0%	0%	33%	10%	4%
On-site	Large mammal	126%	410%	10%	20%	100%	33%	21%	6%	3%
Off-site	Large mammal	126%	410%	10%	20%	100%	33%	21%	6%	3%
On-site	Large bird	65%	172%	10%	20%	100%	33%	78%	9%	4%
Off-site	Large bird	65%	172%	10%	20%	100%	33%	78%	9%	4%
Contaminated Water										
Water consumption	Small mammal	42%	102%	10%	20%	0%	0%	7%	2%	1%
Consumption of contaminated Fish										
chronic	Fish-eating bird	0%	0%	0%	0%	0%	0%	0%	0%	0%

[1] SA = surface area, W = water, FI = food intake. This sensitivity analysis changed the allometric exponent. The subscript for *x* refers to the fact that there are three allometric relationships: surface area (SA), food intake (FI) and water intake (W). Changing the exponent affects water consumption differently than food consumption. To look at increases in exposure, the food consumption allometric exponent is increased and the water exponent is decreased.

		Percent Increase in Central Exposure Estimate (mg/kg-day)											
		Multiplier Parameters								**Exponent Parameters**			
	Un-adjusted Dose (mg/kg)	Increase child skin surface area to 6,600 cm^3	Increase child skin surface area to 7,200 cm^3	Adult male body-weight =63 kg	Adult male body-weight =56 kg	Only 75% of chem. drifts to fruit patch	Only 50% of chem. drifts to fruit patch	BCF is 10% high-er	BCF is 20% high -er	Chem. on legs for 2 hours after	Chem. on legs for 4 hours after	15% of chem is dis-lodged	20% of chem is dis-lodged
Worker Accidental/Incidental Exposures (dose in mg/kg/event)													
Contaminated Gloves, 1 min.	4.2×10^{-6}	0%	0%	11%	25%	0%	0%	0%	0%	0%	0%	0%	0%
Contaminated Gloves, 1 hour	0.00025	0%	0%	11%	25%	0%	0%	0%	0%	0%	0%	0%	0%
Spill on Hands, 1 hour	0.00055	0%	0%	11%	25%	0%	0%	0%	0%	0%	0%	0%	0%
Spill on lower legs, 1 hour	0.0014	0%	0%	11%	25%	0%	0%	0%	0%	200%	400%	0%	0%
General exposure, backpack	0.026	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
General exposure, ground spray	0.045	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
General Public Acute Exposures (dose in mg/kg/event)													
Direct Spray of Child, whole body	0.021	9.5%	19.5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Direct Spray of Woman, feet and lower legs	0.0021	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetation Contact, Woman, shorts and T-shirt	0.0022	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	55%	113%
Woman, contaminated Fruit	0.02352	0%	0%	0%	0%	-25%	-50%	0%	0%	0%	0%	0%	0%
Water consumption, child, spill	8.08×10^{-7}	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Water consumption, child, ambient	0.0030	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fish consumption, male, spill	4.43×10^{-9}	0%	0%	11%	25%	0%	0%	10%	20%	0%	0%	0%	0%
Fish consumption, male, spill	4.49×10^{-8}	0%	0%	11%	25%	0%	0%	10%	20%	0%	0%	0%	0%
General Public Chronic/Longer Term Exposures (dose in mg/kg/day)													
Contaminate Fruit	0.013	0%	0%	0%	0%	-25%	-50%	0%	0%	0%	0%	0%	0%
Water consumption	0.000057	0%	0%	11%	25%	0%	0%	0%	0%	0%	0%	0%	0%
Fish consumption	8.25×10^{-7}	0%	0%	11%	25%	0%	0%	10%	20%	0%	0%	0%	0%
Fish consumption	8.79×10^{-7}	0%	0%	11%	25%	0%	0%	10%	20%	0%	0%	0%	0%

1.3 Appendix D: Toxicity of Glyphosate to Animals and Other Organisms

There is a very large body of literature on glyphosate toxicity. This appendix summarizes studies provided in the EPA Ecotox datasets, Terretox and AQUIRE. Often the studies entered in the EPA database provided equivocal information on important variables that influence the concentration or dose that yields a given endpoint. Not every study reports all of these variables. If the variable is the same across all entries in the table, then it is reported in the table notes. If there is information on statistical significance, it is also included in the table notes. As a summary statistic (which ignores the variation in experimental conditions), we report the median dose that causes an observed effect for all tested organisms in the last line of the table.

A number of variables can affect a given endpoint: "Formulation" refers to the product or chemical mixture used; "Age" refers to the age of the organism; "Study duration" is the amount of time over which the organism was studied; "Type of Exposure" describes the route of exposure and the frequency of exposure to the chemical; "Endpoint" designates the type of endpoint observed (LOEL, NOEL, LC_{50}, etc.) at the specified dose; and "Effect" describes the type of toxicity observed. In aquatic studies, there is the additional "Water Flow" variable that describes the frequency with which water is renewed.

Table D-1: Glyphosate Field Toxicity to Small Mammals

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
	Voles							
Microtus oregoni	Creeping Vole	Glyphosate	LOEL	Abundance	1.3	2	Cole, E.C., W.C. McComb, M. Newton, J.P. Leeming, and C.L. Chambers	1998
Microtus oregoni	Creeping Vole	Roundup	NOEL	Abundance	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Abundance	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	LOEL	Survival	2.2	21 days	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Survival	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Weight	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Weight	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Weight	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Weight	2.2	3	Sullivan, T.P.	1990
Microtus oregoni	Creeping Vole	Roundup	NOEL	Survival	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Microtus oregoni	Creeping Vole	Roundup	NOEL	Survival	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Microtus oregoni	Creeping Vole	Roundup	NOEL	Survival	2.2	9	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Microtus oregoni	Creeping Vole	Roundup	NOEL	Reproducing organisms	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Microtus oregoni	Creeping Vole	Roundup	NOEL	Reproducing organisms	2.2	9	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Microtus oregoni	Creeping Vole	Roundup	NOEL	Population	2.2	9	Sullivan, T.P., D.S.	1997

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
				change			Sullivan, R.A. Lautenschlager, and R.G. Wagner	
Microtus pennsylvanicus	Meadow vole	Glyphosate	NOEL	Abundance	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Microtus montanus	Montane vole	Roundup	LOEL	Abundance	1.1	1	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Microtus montanus	Montane vole	Roundup	LOEL	Abundance	1.1	1	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Microtus montanus	Montane vole	Roundup	NOEL	Abundance	1.1	1	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Clethrionomys gapperi	Southern red-backed vole	Vision	LOEL	Abundance	1.3	2	Gagne, N., L. Belanger, and J. Huot	1999
Clethrionomys gapperi	Southern red-backed vole	Glyphosate	LOEL	Abundance	2.1	1	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Clethrionomys gapperi	Southern red-backed vole	Glyphosate	LOEL	Pregnant females in a population	2.1	1	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Clethrionomys gapperi	Southern red-backed vole	Glyphosate	NOEL	Survival	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Clethrionomys gapperi	Southern red-backed vole	Glyphosate	NOEL	Biomass	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Clethrionomys gapperi	Southern red-backed vole	Glyphosate	NOEL	Biomass	2.1	5	Sullivan, T.P., C. Nowotny, R.A.	1998

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
							Lautenschlager, and R.G. Wagner	
	Mice							
Peromyscus maniculatus	Deer mouse	Glyphosate	LOEL	Abundance	1.3	2	Cole, E.C., W.C. McComb, M. Newton, J.P. Leeming, and C.L. Chambers	1998
Peromyscus maniculatus	Deer mouse	Vision	NOEL	Abundance	1.3	2	Gagne, N., L. Belanger, and J. Huot	1999
Peromyscus maniculatus	Deer mouse	Glyphosate	LOEL	Abundance	1.2	1	Ritchie, D.C., A.S. Harestad, and R. Archibald	1987
Peromyscus maniculatus	Deer mouse (adult)	Glyphosate	NOEL	Weight	1.2	1	Ritchie, D.C., A.S. Harestad, and R. Archibald	1987
Peromyscus maniculatus	Deer mouse (adult)	Glyphosate	NOEL	Weight	1.2	1	Ritchie, D.C., A.S. Harestad, and R. Archibald	1987
Peromyscus maniculatus	Deer mouse (adult)	Glyphosate	NOEL	Injury, general	1.2	1	Ritchie, D.C., A.S. Harestad, and R. Archibald	1987
Peromyscus maniculatus	Deer mouse (adult)	Glyphosate	NOEL	Pregnant females in a population	1.2	1	Ritchie, D.C., A.S. Harestad, and R. Archibald	1987
Peromyscus maniculatus	Deer mouse	Roundup	LOEL	Abundance	2.2	3	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	LOEL	Weight	2.2	1	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	LOEL	Weight	2.2	1	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Abundance	2.2	3	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Survival	2.2	3	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Survival	2.2	3	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Weight	2.2	3	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Weight	2.2	3	Sullivan, T.P.	1990
Peromyscus maniculatus	Deer mouse	Roundup	LOEL	Sex ratio	1.6	48 wk	Sullivan, T.P., and D.S. Sullivan	1981
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Stage	1.6	48 wk	Sullivan, T.P., and D.S. Sullivan	1981
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Stage	1.6	48 wk	Sullivan, T.P., and D.S. Sullivan	1981

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Survival	1.6	80 wk	Sullivan, T.P., and D.S. Sullivan	1981
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Survival	1.6	80 wk	Sullivan, T.P., and D.S. Sullivan	1981
Peromyscus maniculatus	Deer mouse	Glyphosate	NOEL	Abundance	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Glyphosate	NOEL	Pregnant females in a population	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Glyphosate	NOEL	Survival	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Glyphosate	NOEL	Biomass	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Glyphosate	NOEL	Biomass	2.1	5	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Abundance	1.1	2	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Abundance	1.1	3	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Abundance	1.1	3	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Peromyscus maniculatus	Deer mouse	Roundup	LOEL	Reproducing organisms	2.2	9	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and	1997

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
							R.G. Wagner	
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Reproducing organisms	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Survival	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Population change (change in N/change in time)	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Survival	2.2	9	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Peromyscus maniculatus	Deer mouse	Roundup	NOEL	Population change (change in N/change in time)	2.2	9	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Mus musculus	House mouse (12-14 wk)	Roundup	NOEL	Chromosomal aberrations	1,080	120 hours	Dimitrov, B.D., P.G. Gadeva, D.K. Benova, and M.V. Bineva	2006
Mus musculus	House mouse (10-12 wk)	Roundup	NOEL	Polychromatic cells	200	48 hours	Grisolia, C.K.	2002
Notomys mitchelli	Mitchell's Hopping Mouse	Roundup	NR-ZERO	Mortality	≤ 3,700	33 days	Evans, D.D., and M.J. Batty	1986
Notomys alexis	Spinifex Hopping Mouse	Roundup	NR-ZERO	Mortality	≤ 3,700	33 days	Evans, D.D., and M.J. Batty	1986
	Shrews							
Sorex cinereus	Masked shrew	Vision	LOEL	Abundance	1.3	2	Gagne, N., L. Belanger, and J. Huot	1999
Sorex pacificus	Pacific Shrew	Glyphosate	LOEL	Abundance	1.3	2	Cole, E.C., W.C. McComb, M.	1998

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
							Newton, J.P. Leeming, and C.L. Chambers	
Sorex sp.	Red-toothed shrew	Glyphosate	LOEL	Abundance	2.1	1	Sullivan, T.P., C. Nowotny, R.A. Lautenschlager, and R.G. Wagner	1998
Sorex sp.	Red-toothed shrew	Roundup	NOEL	Abundance	1.6	11	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Sorex sp.	Red-toothed shrew	Roundup	NOEL	Abundance	2.2	9	Sullivan, T.P., D.S. Sullivan, R.A. Lautenschlager, and R.G. Wagner	1997
Sorex trowbridgii	Trowbridge's Shrew	Glyphosate	LOEL	Abundance	1.3	2	Cole, E.C., W.C. McComb, M. Newton, J.P. Leeming, and C.L. Chambers	1998
Sorex vagrans	Vagrant Shrew	Glyphosate	LOEL	Abundance	1.3	2	Cole, E.C., W.C. McComb, M. Newton, J.P. Leeming, and C.L. Chambers	1998
Other Small Rodents								
Sminthopsis macroura	Striped Face Dunnart (Australia)	Roundup	NR-ZERO	Mortality	< 3,700	33 days	Evans, D.D., and M.J. Batty	1986
Tamias townsendii	Townsend's Chipmunk	Glyphosate	LOEL	Abundance	1.3	2	Cole, E.C., W.C. McComb, M. Newton, J.P. Leeming, and C.L. Chambers	1998
Tamias amoenus	Yellow pine chipmunk	Roundup	NOEL	Abundance	1.1	3	Sullivan, T.P., D.S. Sullivan, E.J. Hogue, R.A. Lautenschlager, and R.G. Wagner	1998
Tamias amoenus	Yellow pine chipmunk	Roundup	NOEL	Abundance	1.1	3	Sullivan, T.P., D.S. Sullivan, E.J. Hogue,	1998

Scientific Name	Common Name	Test Substance	Endpoint	Effect	Dose (kg a.e./ha)	Study Time (yr)	Reference	Year
							R.A. Lautenschlager, and R.G. Wagner	

Table D-2: Glyphosate Toxicity to Birds: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Formulation	Age (days)	Concentration (mg/kg)	Study Duration (days)	Type of Exposure	Ref
Anas platyrhynchos	mallard duck	glyphosate	1	> 5,000	8	chemical always present in food	4
Anas platyrhynchos	mallard duck	glyphosate	10	> 5,200	8	chemical always present in food	4
Anas platyrhynchos	mallard duck	glyphosate	14	> 4,640	8	chemical always present in food	5
Colinus virginianus	northern bobwhite	glyphosate	5	> 5,000	8	chemical always present in food	4
Colinus virginianus	northern bobwhite	glyphosate	10	> 5,200	8	chemical always present in food	4
Colinus virginianus	northern bobwhite	glyphosate	14	> 4,640	8	chemical always present in food	5
Coturnix japonica	Japanese quail	Roundup	20	>3,700	5	oral, unreported frequency	6
Median concentration of glyphosate in food that caused 50% mortality in birds: >5000 mg/kg [α]							

NR = not reported.
None of the studies in the EPA database reported whether results were statistically significant.
[a] Since most studies report that the LC_{50} had not been reached with the highest treatment dose, the median dose reported at the end of the table is probably a lower limit on the true LC_{50}.

Table D-3: Glyphosate Toxicity to Birds: Mortality Using LD_{50} as an Endpoint

Scientific Name	Common Name	Formulation	Age (days)	Dose (mg/kg)	Study Duration (days)	Type of Exposure	Ref
Anas platyrhynchos	mallard duck	NR	168	950	21	oral, unreported frequency	4
Colinus virginianus	northern bobwhite	glyphosate	112	2,000	21	oral, unreported frequency	5
Colinus virginianus	northern bobwhite	NR	14	2,850	8	oral, unreported frequency	4
Median dose of glyphosate that caused 50% mortality in birds: 950 mg/kg							

NR = not reported.
None of the studies reported whether results were statistically significant.

Table D-4: Toxicity of Glyphosate to Birds: Effects Other than Mortality

Scientific Name	Common Name	End-point	Effect	Age (days)	Dose	Study Duration	Type of Exposure	Ref
Anas platyrhynchos [a]	mallard duck	LOEL	testosterone reduction	15	3.7 mg/kg [b]	15 days	oral, once daily	7
Anas platyrhynchos	mallard duck	LOEL	histological	15	3.7 mg/kg [b]	15 days	oral, once daily	7
Anas platyrhynchos	mallard duck	NOEL	weight	15	74 mg/kg [b]	15 days	oral, once daily	7
Anas platyrhynchos	mallard duck	NOEL	organ weight	15	74 mg/kg [b]	15 days	oral, once daily	7
Coturnix japonica	Japanese quail	NOEL	mortality	20	1,660 mg/kg [c]	5 days	always in food	6
Anas platyrhynchos	mallard duck	NOEL	reproductive	NR	1,000 ppm	5 days	oral	4
Colinus virginianus	bobwhite quail	NOEL	reproductive	NR	1,000 ppm	5 days	oral	4
Gallus domesticus	chicken	NOEL	hatching success & delay	egg, 0 [d]	18 µg/L	until hatch	dipped once	8
Gallus domesticus	chicken	NOEL	hatching success & delay	egg, 6 [d]	18 µg/L	until hatch	dipped once	8
Gallus domesticus	chicken	NOEL	hatching success & delay	egg,12 [d]	18 µg/L	until hatch	dipped once	8
Gallus domesticus	chicken	NOEL	hatching success & delay	egg,18 [d]	18 µg/L	until hatch	dipped once	8
Reproductive effects observed at 3.7 mg/kg day. No morbidity effects from dipping egg in 18 µg/L solution and no organ weight gain from ingesting 100 mg/kg day.								

NR = not reported.
All of the studies in this table used Roundup as the Chemical Formulation.
[a] This result was statistically significant.
[b] Dose in milligrams chemical per kilogram bodyweight.
[c] Dose in milligrams chemical per kilogram food.
[d] The experimental unit is an "egg", and the number of days since fertilization is reported.

Table D-5: Toxicity of Glyphosate to Honey Bees: Mortality Using an LD_{50} Endpoint

Scientific Name	Common Name	Formulation	Dose (µg/bee)	Study Duration (days)	Endpoint	Exposure Type	Ref
Apis mellifera [a]	honeybee	glyphosate	100	2	LD_{50}	one topical application	5
Apis mellifera [a]	honeybee	glyphosate	100	2	LD_{50}	one oral dose	5
Apis mellifera	honeybee	NR	62	4	LD_{50}	one topical application	4
Apis mellifera	honeybee	NR	50	4	NOEL	one topical application	44

NR = Not reported.
The significance level was not reported.
[a] Two studies are reported in the RED for this result.

Table D-6: Toxicity of Glyphosate to Arachnids and Insects: NOELs for Abundance and Diversity

Scientific Name	Common Name	Effect	Formulation	Concentration kg/ha	Study Duration (days)	Type of Exposure	Ref
Gonatium rubens	dwarf weaver spider	abundance	Roundup	0.13	122	1 application	9
Arachnida	Arachnids[a, b]	abundance	Roundup	0.13	122	1 application	9
Arachnida	Arachnids[a]	abundance	Roundup	0.27	122	1 application	9
Araneae	araneoid spiders	diversity[h]	Roundup	0.27	183	1 application	10
Lepthyphantes tenuis	dwarf weaver spider	abundance	Roundup	0.36	488	1 application	11
Lepthyphantes tenuis	dwarf weaver spider	abundance	Roundup	0.27	92	1 application	9
Insecta	5 insects[c]	abundance	Roundup	0.62	21	2 applications	12
Insecta	5 insects[c]	abundance	Roundup	0.62	35	2 applications	12
Anticarsia gemmatalis	velvetbean caterpillar[d]	abundance	Roundup	0.62	61	1 application	13
Insecta	4 insects[e]	abundance	Roundup	0.62	46	1 application	13
Nezara viridula	stink bug	abundance	Roundup	0.62	61	1 application	13
Pentatomidae	stink bug family	abundance	Roundup	0.62	46	1 application	13
Aphididae	aphid family [f]	abundance	Roundup	0.84	62-82	1 application	14
Oscinella frit	frit fly	abundance	Roundup	1.4	14	1 application	15
Araneae	araneoid spiders	diversity[h]	Roundup	1.1	153	1 application	10
Carabidae	26 ground beetles[g]	abundance	Vision	1.5	770	1 application	16
Carabidae	26 ground beetles[g]	diversity[h]	Vision	1.5	770	1 application	16
Carabidae[i]	ground beetle	abundance	glyphosate	1.2	14	2 applications	17
Carabidae[i]	ground beetle	mortality	glyphosate	1.2	335	1 application	17
Carabidae[i]	ground beetle	appetite	glyphosate	1.2	335	1 application	17
Lepthyphantes tenuis[i]	dwarf weaver spider	abundance	glyphosate	1.6	1	1 application	18
Lepthyphantes tenuis[i]	dwarf weaver spider	abundance	glyphosate	1.6	2	1 application	18
Lepthyphantes tenuis[i]	dwarf weaver spider	abundance	glyphosate	1.6	3	1 application	18
Median NOEL: 0.62 kg/ha							

NR = Not reported..

[a] Exact species were not reported.

[b] This study was duplicated by the author.

[c] The insects included in the study were: *Anticarsia gemmatalis*, *Cerotoma trifurcata*, *Geocoris punctipes*, *Plathypena scabra*, and *Spissistilus festinus*.

[d] This study was performed four times by the author.

[e] The four insects used in this study were: *Spissistilus festinus*, *Empoasca fabae*, *Nezara viridula*, and *Melanoplus sp*.

[f] Only species specifically mentioned was *Aphis glycines* and the author duplicated the study.

[g] The beetles included in the study were: *Agonum affine*, *Agonum cupripenne*, *Agonum retractum*, *Amara angustata*, *Amara confusa*, *Amara obesa*, *Amara quenseli*, *Amara sinuousa*, *Bembidion mutatum*, *Bradycellus semipubescens*, *Calathus gregarious*, *Calosoma calidum*, *Carabus maender*, *Carabus serratus*, *Chlaenius emarginatus*, *Cicindela tranquebarica*, *Cyminidis cribricollis*, *Harpalus nigritarsis*, *Harpalus somnulentus*, *Notiophilus semistriatus*, *Patrobus longicornis*, *Platynus decentis*, *Poecilus lucublandus*, *Pterostichus adstrictus*, *Pterostichus coracinus*, *Scaphinotus bilobus*, *Sphaeroderus canadensis*, *Sphaeroderus stemostomus*, *Synuchus impuntus*.

[h] "Diversity" refers to species rishness.Some studies report this as simply the number of species in the plot, other studies report Shannon or Simpson indices (that incorporate both species richness and evenness).

[i] Study organisms were adults.No other studies reported insect age or lifestage.

Table D-7: Toxicity of Glyphosate to Insects, Arachnids, Gastropods and Arthropods: LOELs for Abundance and Food Consumption

Scientific Name	Common Name	Effect	Formulation	Dose kg/ha	Study Duration (days)	Type of Exposure	Ref
Arachnida	arachnids[a]	abundance	Roundup	0.27	122	1 application	9
Lepthyphantes tenuis	dwarf weaver spider	abundance	Roundup	0.36	122	1 application	11
Aceria tosichella	wheat curl aphid	abundance	Roundup	0.47	10	1 application	19
Stylommatophora	Gastropod order	abundance	Roundup	1.1	56	1 application	20
Carabidae[c]	ground beetle	abundance	glyphosate	1.2	14	2 applications	17
Rhopalosiphum padi	aphid	abundance	Roundup	1.4	14	1 application	15
Philoscia muscorum	Striped woodlouse	food consumption	Roundup	2.1	188	in food[b]	21
Median LOEL: 1.07 kg/ha							

NR = Not reported.

[a] The author reports four studies: two general "arachnid" studies and one specific species studies *Gonatium rubens*.

[b] Leaves of chemically treated birch and cherry trees were fed to insects in the laboratory.

[c] Study organisms were adults.No other studies reported insect age or lifestage.

Table D-8: Glyphosate Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Chemical Formulation	No. of studies	Conc. (mg/L)	Dose Frequency	Duration (days)	Water Flow[b]	Ref
Cnesterodon decemmaculatus	10-spot livebearer	0.89, NR, 15	Roundup	1	74	daily	4	renewal	22
Cyprinus carpio	common carp	NR	glyphosate	1	115	NR	2	NR	23
Cyprinus carpio	common carp	3.6-4.2, 4-5.5, NR	glyphosate	1	620	NR	4	renewal	24
Cyprinus carpio	common carp	3.6-4.2, 4-5.5, NR	glyphosate	1	645	NR	2	renewal	24
Cyprinus carpio	common carp	3-5, NR, NR	Roundup	1	3.1	once	2	static	25
Cyprinus carpio	common carp	3-5, NR, NR	Roundup	1	3.1	once	4	static	25
Cyprinus carpio	common carp	3-5, NR, NR	Roundup	1	3.4	once	1	static	25
Ictalurus punctatus	channel catfish	5.1-7.6, NR, NR	Roundup	1	3.6	daily	4	renewal	26
Lepomis macrochirus	bluegill	5.1-7.6, NR, NR	Roundup	1	3.3	daily	4	renewal	26
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	MON 8709	4	18–65	once	1	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	technical	5	26-380	once	1	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	Vision	5	13–26	once	1	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	MON 8709	4	18–40	once	2	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	technical	5	14-245	once	2	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	Vision	5	13–24	once	2	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	MON 8709	4	18–36	once	3	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	technical	5	14-190	once	3	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	Vision	5	13–24	once	3	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	MON 8709	4	18–36	once	4	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	technical	5	14-190	once	4	static	27
Oncorhynchus gorbuscha	pink salmon	4.3, 0.5, 76	Vision	5	10–24	once	4	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	MON 8709	3	19–46	once	1	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	technical	4	16-202	once	1	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	Vision	4	13–23	once	1	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	MON 8709	3	19–43	once	2	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	technical	4	13-178	once	2	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	Vision	4	9-20	once	2	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	MON 8709	3	17–43	once	3	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	technical	4	10-157	once	3	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	Vision	4	8–18	once	3	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	MON 8709	3	17–43	once	4	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	technical	4	10-148	once	4	static	27
Oncorhynchus keta	chum salmon	4.3, 0.5, 76	Vision	4	8–15	once	4	static	27

Table D-8 (cont.): Glyphosate Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Formulation	No. of studies	Conc. (mg/L)	Dose Frequency	Duration (days)	Water Flow[b]	Ref
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	MON 8709	4	18–44	once	1	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	technical	4	40–210	once	1	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	Vision	5	10–38	once	1	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	MON 8709	4	18–42	once	2	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	technical	5	27-205	once	2	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	Vision	5	10–28	once	2	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	MON 8709	4	18–42	once	3	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	technical	5	27-182	once	3	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	Vision	5	9.6-26	once	3	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	Roundup		16	once	4	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	MON 8709	4	19-41	once	4	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	technical	5	27-174	once	4	static	27
Oncorhynchus kisutch	coho salmon	4.3, 0.5, 76	Vision	5	9.6-24	once	4	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	MON 8709	4	23-65	once	1	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	technical	5	21-220	once	1	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	technical	4	32-220	once	1	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	Vision	5	13-24	once	1	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	MON 8709	4	15-46	once	2	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	technical	5	11-220	once	2	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	Vision	5	13-24	once	2	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	MON 8709	4	13-36	once	3	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	technical	5	11-220	once	3	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	Vision	5	11-24	once	3	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, NR	Roundup	3	11-19	once	4	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, NR	Roundup	2	16-19	once	4	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	MON8709	4	13-36	once	4	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, NR	technical	5	10-197	once	4	static	27
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	Vision	1	7.7	once	4	renewal	28
Oncorhynchus mykiss	rainbow trout	4.3, 0.5, 76	Vision	1	10-24	once	4	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	MON 8709	4	24-62	once	1	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	technical	5	24-220	once	1	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	Vision	5	13-30	once	1	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	MON8709	4	24-59	once	2	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	Technical	5	22-220	once	2	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	Vision	5	13-24	once	2	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	MON8709	4	24-54	once	3	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	technical	5	22-211	once	3	static	27

Table D-8 (cont.): Glyphosate Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Formulation[a]	No. of studies	Conc. Range (mg/L)	Dose Frequency	Duration (days)	Water Flow[b]	Ref
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	Vision	5	13-24	once	3	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	Roundup	1	15	once	4	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	MON 8709	4	24-50	once	4	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	technical	5	19-211	once	4	static	27
Oncorhynchus tshawytscha	chinook salmon	4.3, 0.5, 76	Vision	5	13–24	once	4	static	27
Procambarus sp.	crawfish	NR	Roundup	1	16,000	daily	4	renewal	26
Tilapia nilotica	Nile tilapia	3, NR, NR	Roundup	1	2.3	once	1	static	25
Tilapia nilotica	Nile tilapia	3, NR, NR	Roundup	1	2.3	once	2	static	25
Tilapia nilotica	Nile tilapia	3-5, NR, NR	Roundup	1	2.3	once	4	static	25
Median dose that caused 50% mortality in fish: 24.45 mg/L									

NR = not reported.

An additional column has been added to describe the number of studies represented by a given row.For example, the first pink salmon entry reports an LC_{50} of 17.78-65.20 mg/L.This range represents 4 studies (two of which have LC_{50}s that fall in this range.

All of the above studies used freshwater and were performed in the laboratory.

[a] "Technical" means technical grade glyphosate at 88-95%."MON 8709" means that this is a Monsanto product.When a product is first registered, but before it has a product name it is given the designation "MON" in addition to an identification number.

[b] "Flow" means that the chemical was flowed through the chamber.

Table D-9: Glyphosate Toxicity to Fish: Effects Other than Mortality

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Formulation	Endpoint	Effect	Conc. (mg/L)	Dose Frequency	Duration (days)	Water Flow[a]	Ref
Oncorhynchus mykiss	rainbow trout	14.7, NR, NR	Roundup	LOEC	physiology	0.74	once	NR	direct	29
Oncorhynchus mykiss	rainbow trout	14.7, NR, NR	Roundup	LOEC	avoidance	7.4	once	0.021	static	29
Cyprinus carpio	common carp	3-5, NR, NR	Roundup	NOEC	multiple	1.7	once	4	static	25
Tilapia nilotica	Nile tilapia	3-5, NR, NR	Roundup	NOEC	multiple	0.31	once	4	static	25
Oncorhynchus mykiss	rainbow trout	11.5, NR, NR	glyphosate	NOEC	biochemical	0.11	daily	7	renewal	30
Oncorhynchus mykiss	rainbow trout	14.7, 32.7, NR	Roundup	NOEC	physiology	0.07	once	NR	direct	29
Oncorhynchus mykiss	rainbow trout	14.7, 32.7, NR	Roundup	NOEC	avoidance	0.74	once	0.021	static	29
Oncorhynchus mykiss[b]	rainbow trout	33.2, NR, NR	Vision	NOEC	feeding	0.03	constant	61	flow	28
Median LOEL in fish: 4.1 mg/L										
Median NOEC/NOEL in fish: 0.11 mg/L										

NR = not reported.
[a] "Flow" means that the chemical was flowed through the chamber."Direct" means that the chemical was directly applied to the organism.
[b] Author repeated the study twice.

Table D-10: Glyphosate Toxicity to Amphibians: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Size (g)	Formulation	Water Flow	Conc. (mg/L)	Duration (days)	Dose Frequency	Ref
Bufo americanus[a]	American toad	NR	Roundup	renewal	1.9	16	every 4 days	31
Bufo americanus[b]	American toad	NR	Roundup Original	static	9.6–19	4	once	32
Crinia insignifera	frog	NR	glyphosate IPA	renewal	466	2	daily	33
Crinia insignifera	frog	0.011	glyphosate	renewal	72	3	daily	34
Crinia insignifera[c]	frog	NR	NR	static	78	4	once	4
Crinia insignifera[d]	frog	NR	Roundup 360	renewal	29	4	daily	34
Crinia insignifera[d]	frog	NR	Roundup 360	renewal	38	2	daily	34
Crinia insignifera	frog	NR	Roundup Biactive	renewal	494	2	daily	33
Crinia insignifera	frog	0.011	Roundup	renewal	3.6	2	daily	33
Heleioporus eyrei	moaning frog	0.011	glyphosate IPA	renewal	373	2	daily	33
Heleioporus eyrei	moaning frog	0.058	Roundup Biactive	renewal	427	2	daily	33
Heleioporus eyrei	moaning frog	0.058	Roundup	renewal	6.3	2	daily	33
Hyla versicolor[a]	gray tree frog	0.058	Roundup	renewal	1.0	16	every 4 days	31
Limnodynastes dorsalis	western banjo frog	NR	glyphosate IPA	renewal	400	2	daily	33
Limnodynastes dorsalis	western banjo frog	0.021	Roundup Biactive	renewal	400	2	daily	33
Limnodynastes dorsalis	western banjo frog	0.021	Roundup	renewal	3	2	daily	33

Litoria moorei	western green frog	0.021	glyphosate	renewal	81	2	daily	33
Litoria moorei	western green frog	0.017	glyphosate IPA	renewal	343	2	daily	33
Litoria moorei	western green frog	0.017	glyphosate	renewal	111	4	daily	34
Litoria moorei	western green frog	NR	Roundup 360	renewal	5.7	4	daily	34
Litoria moorei	western green frog	NR	Roundup Biactive	renewal	328	2	daily	33
Litoria moorei	western green frog	0.017	Roundup	renewal	2.9	2	daily	33
Rana catesbeiana[a]	bullfrog	NR	Roundup	renewal	1.5	16	every 4 days	31
Rana clamitans	green frog	NR	Glyphos AU	static	21	4	once	32
Rana clamitans	green frog	NR	Glyphos BIO	static	43	4	once	32
Rana clamitans	green frog	NR	glyphosate	static	39	4	once	32
Rana clamitans[a]	green frog	NR	Roundup	renewal	1.6	16	every 4 days	31
Rana clamitans	green frog	NR	Roundup Biactive	static	43	4	once	32
Rana clamitans[b]	green frog	NR	Roundup Original	static	4.8–17	4	once	32
Rana clamitans	green frog	NR	Roundup Transorb	static	5.3	4	once	32
Rana clamitans[c]	green frog	NR	Vision	static	2.7–4.3	4	once	35
Rana pipiens[a]	leopard frog	NR	Roundup	renewal	1.8	16	every 4 days	31
Rana pipiens[b]	leopard frog	NR	Roundup Original	static	6.8–15	4	once	32
Rana pipiens[b]	leopard frog	NR	Vision	static	4.3–12	4	once	35
Rana sylvatica[b]	wood frog	NR	Roundup	renewal	0.41–0.98	16	every 4 days	31
Rana sylvatica[b]	wood frog	NR	Roundup Original	static	12–19	4	once	32
Median ROUNDUP or VISION dose range that caused 50%mortality in amphibians: 4.3–12 mg/L								
Median GLYPHOSATE or ROUNDUP BIACTIVE dose that caused 50%mortality in amphibians: 220 mg/L								

NR = not reported.IPA = Isopropylamine salt.
All of the above studies used freshwater.
Organism age was not reported because all tadpoles were in Gosner Stage 25 characterized by a fully formed tadpole with no limbs, absent external gills, and full formed feeding parts and mouth.
None of the studies in the EPA database reported whether results were statistically significant.
[a] Author repeated the study once.
[b] The range reported here represents only two studies, one study representing the minimum LC_{50} in the range and the other representing the maximum LC_{50} in the range.
[c] The age of this organism was reported to be 3 days old.Gosner stage was not reported.
[d] Organisms were collected from the field.

Table D-11: Glyphosate Toxicity to Amphibians: Mortality with LC_{100} Endpoints

Scientific Name	Common Name	Size (g)	End-point	Formulation	Water Flow	Conc. (mg/L)	Duration (days)	Dose Frequency	Ref
Crinia insignifera[c]	frog	NR	LC_{100}	glyphosate	renewal	135	4	daily	34
Litoria moorei[c]	western green frog	NR	LC_{100}	glyphosate	renewal	180	1	daily	34
Bufo americanus[b]	American toad	NR	LC_{100}	Roundup	renewal	3.7	16	every 4 days	31
Hyla versicolor[a]	gray tree frog	NR	LC_{100}	Roundup	renewal	3.7	16	every 4 days	31
Rana catesbeiana[b]	bullfrog	NR	LC_{100}	Roundup	renewal	3.7	16	every 4 days	31
Rana clamitans[a]	green frog	NR	LC_{100}	Roundup	renewal	3.7	16	every 4 days	31
Rana pipiens[b]	leopard frog	NR	LC_{100}	Roundup	renewal	3.7	16	every 4 days	31
Rana sylvatica[b]	wood frog	NR	LC_{100}	Roundup	renewal	3.7	1	every 4 days	31
Crinia insignifera[c]	frog	NR	LC_{100}	Roundup 360	renewal	67	4	daily	34
Crinia insignifera[c]	frog	NR	LC_{100}	Roundup 360	renewal	133	2	daily	34
Litoria moorei[c]	western green frog	NR	LC_{100}	Roundup 360	renewal	133	3	daily	34
Litoria moorei[a,c]	western green frog	NR	LC_{100}	Roundup 360	renewal	13–33	1	daily	34
Rana clamitans	green frog	NR	LC_{100}	Vision	static	8.1	1	once	10
Rana clamitans	green frog	NR	LC_{100}	Vision	static	9.3	7	once	10
Rana pipiens[a]	leopard frog	NR	LC_{100}	Vision	static	8.1–18	4	once	10
Median FORMULATION dose that caused 100% mortality in amphibians, respectively: 9.3 mg/L									
Median GLYPHOSATE dose that caused 100% mortality in amphibians, respectively: 157 mg/L									

NR = not reported.IPA = Isopropylamine salt.
All of the above studies used freshwater.
Organism age was not reported because alll tadpoles were in Gosner Stage 25 characterized by a fully formed tadpole with no limbs, absent external gills, and full formed feeding parts and mouth.
None of the studies in the EPA database reported whether results were statistically significant.
[a] The range reported here represents only two studies, one study representing the minimum LC_{50} in the range and the other representing the maximum LC_{50} in the range.
[b] The author repeated the study once.
[c] Organisms were collected from the field.

Table D-12: Glyphosate Toxicity to Amphibians: Effects Other than Mortality

Scientific Name	Common Name	Size (g)	End-point	Effect[a]	Formulation	Water Flow	Conc. (mg/L)	Duration (days)	Dose Frequency	Ref
Bufo americanus	American toad	0.056	LOEC	growth	Roundup	renewal	1.5	16	every 4 days	36
Rana cascadae	Cascades Frog	NR	LOEC	development	Roundup	renewal	0.71	27	every 7 days	37
Rana catesbeiana	Bullfrog	0.023	LOEC	growth	Roundup	renewal	1.5	16	every 4 days	36
Rana clamitans	Green frog	NR	LOEC	growth	Roundup Original	static	0.60	166	once	32
Rana clamitans	Green frog	NR	LOEC	development	Roundup Original	static	0.60	166	once	32
Rana clamitans	Green frog	NR	LOEC	morphology	Roundup Original	static	0.60	166	once	32
Rana clamitans	Green frog	NR	LOEC	growth	Roundup Transorb	static	0.60	166	once	32
Rana clamitans	Green frog	NR	LOEC	development	Roundup Transorb	static	0.60	166	once	32
Rana clamitans	Green frog	NR	LOEC	morphology	Roundup Transorb	static	1.8	166	once	32
Rana clamitans	Green frog	0.028	LOEC	growth	Roundup	renewal	1.5	16	every 4 days	36
Bufo americanus	American toad	0.056	NOEC	growth	Roundup	renewal	0.74	16	every 4 days	36
Hyla versicolor	Gray tree frog	0.073	NOEC	growth	Roundup	renewal	1.5	16	every 4 days	36
Rana catesbeiana	Bullfrog	0.023	NOEC	growth	Roundup	renewal	0.74	16	every 4 days	36
Rana clamitans	Green frog	NR	NOEC	growth	glyphosate	static	1.8	166	once	32
Rana clamitans	Green frog	NR	NOEC	development	glyphosate	static	1.8	166	once	32
Rana clamitans	Green frog	NR	NOEC	morphology	glyphosate	static	1.8	166	once	32
Rana clamitans	Green frog	NR	NOEC	genetic	glyphosate	static	1.8	120	once	32
Rana clamitans[b]	Green frog	NR	NOEC	genetic	Roundup Original	static	1.8	120	once	32
Rana clamitans	Green frog	NR	NOEC	morphology	Roundup Transorb	static	0.60	166	once	32
Rana clamitans	Green frog	0.028	NOEC	growth	Roundup	renewal	0.74	16	every 4 days	36
Rana clamitans[c]	Green frog	NR	NOEC	growth	Vision	static	14–18	56	once	35
Rana pipiens	Leopard frog	0.095	NOEC	growth	Roundup	renewal	1.5	16	every 4 days	36
Rana pipiens	Leopard frog	NR	NOEC	growth	Vision	static	14	1	once	35
Rana pipiens	Leopard frog	NR	NOEC	growth	Vision	static	18	56	once	35
Median growth or development LOEL: 0.71 mg/L										
Median growth or development NOEL: 1.8 mg/L										

NR = not reported.IPA = Isopropylamine salt.

All of the above studies used freshwater.

Organism age was not reported because alll tadpoles were in Gosner Stage 25 characterized by a fully formed tadpole with no limbs, absent external gills, and full formed feeding parts and mouth.

None of the studies in the EPA database reported whether results were statistically significant.

[a] "Growth" refers to either a change in the dimensions or weight of an organism."Development" refers to tissue development in growing progeny."Morphology" refers to the structure or form of the organism."Avoidance" refers to organisms altering their behavior to avoid the chemical."Genetic" refers to changes in the genetic makeup of cells or tissues.

[b] The author repeated the study once.

[c] The range reported here represents only two studies, one study representing the minimum LC_{50} in the range and the other representing the maximum LC_{50} in the range.

Table D-13: Glyphosate Toxicity to Aquatic Invertebrates: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Age	Formulation[a]	Conc. (mg/L)	Duration (days)	Ref
Ceriodaphnia dubia	water flea	<24 hr	Roundup	4.4	2	38
Ceriodaphnia dubia	water flea	<24 hr	Roundup	5.3	2	38
Ceriodaphnia dubia	water flea	<24 hr	Roundup	20	2	38
Ceriodaphnia dubia	water flea	<24 hr	Roundup	22	2	38
Ceriodaphnia dubia	water flea	<24 hr	Roundup	26	2	38
Ceriodaphnia dubia	water flea	<24 hr	Roundup	34	2	38
Ceriodaphnia dubia	water flea	<24 hr	Roundup	79	2	38
Daphnia magna	water flea	1st instar	glyphosate	780	NR	4
Chironomus plumosus	midge	NR	glyphosate	55	2	4
Nephelopsis obscura	leech	adult	Rodeo	857	4	39
Utterbackia imbecillis	Ppaper pondshell	mature glochidia	Roundup	14	1	40
Median dose that caused 50% mortality: 26 mg/L						

Table D-14: Glyphosate Toxicity to Aquatic Invertebrates: EC_{50} Endpoints

Scientific Name	Common Name	Age	Chemical Formulation[a]	Conc. (mg/L)	Effect	Duration (days)	Ref
Bosmina sp.	water flea	NR	Vision	1.5	population decrease	11	35
Chironomus riparius	midge	4th instar	Rodeo	4,400	response time increase	1	41
Chironomus riparius	midge	4th instar	Rodeo	970	response time increase	2	39
Chironomus riparius	midge	4th instar	Rodeo	4,150	response time increase	2	41
Cladocera	water flea order	NR	Vision	0.17	population decrease	7	35
Cladocera	water flea order	NR	Vision	1.4	population decrease	11	35
Copepoda	copepod subclass	NR	Vision	1.6	population decrease	4	35
Copepoda	copepod subclass	NR	Vision	0.43	population decrease	7	35
Copepoda	copepod subclass	NR	Vision	0.71	population decrease	7	35
Copepoda	copepod subclass	NR	Vision	0.74	population decrease	7	35
Daphnia magna	water flea	1st instar	Rodeo	404	response time increase	2	39
Daphnia pulex	water flea	mature	Roundup	5.9	response time increase	2	42
Diaphanosoma sp	water Flea	NR	Vision	0.32	population decrease	7	35
Hyalella azteca	scud	ADULT	Rodeo	540	response time increase	4	39
Rotifera	rotifer phylum	NR	Vision	5.3	population decrease	14	35
Median EC_{50} for ROUNDUP/VISION for population decreases or response time increases: 1.1 mg/L							
Median EC_{50} for RODEO for population decreases or response time increases: 970 mg/L							

Table D-15: Glyphosate Toxicity to Aquatic Invertebrates: NOEC Endpoint

Scientific Name	Common Name	Age	Chemical Formulation[a]	Conc. (mg/L)	Effect	Duration (days)	Ref
Ichthyophthirius multifilis	ciliate	NR	glyphosate	2,540	mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	glyphosate	1,270	mortality	1	43
Daphnia magna	water flea	NR	glyphosate	50-90	unknown	NR	44
Tetrahymena thermophila	ciliate protozoa	NR	Roundup	29	mortality	1	43
Tetrahymena thermophila	ciliate protozoa	NR	Roundup	57	mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	Roundup	29	mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	Roundup	15	mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	Roundup	7	mortality	1	43
Dytiscus	diving beetle	NR	Vision	0.96	mortality	23	45
Utterbackia imbecillis	paper pondshell	NR	Roundup	3.7	mortality	1	40
Simocephalus vetulus	water flea	1	Vision	1.5	mortality	8	46
Median NOEC for ROUNDUP/VISION: 11 mg/L							
Median NOEC for GLYPHOSATE: 1,270 mg/L							

Table D-16: Glyphosate Toxicity to Aquatic Invertebrates: LOEC Endpoint

Scientific Name	Common Name	Age (days)	Chemical Formulation[a]	Conc. (mg/L)	Effect	Duration (days)	Ref
Ichthyophthirius multifilis	ciliate	NR	glyphosate	2,540	Mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	glyphosate	5,070	Mortality	1	43
Simocephalus vetulus	water flea	10	Vision	0.75	Mortality	8	46
Ichthyophthirius multifilis	ciliate	NR	Roundup	57	Mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	Roundup	0.85	Mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	Roundup	29	Mortality	1	43
Ichthyophthirius multifilis	ciliate	NR	Roundup	15	Mortality	1	43
Tetrahymena thermophila	ciliate protozoa	NR	Roundup	57	Mortality	1	43
Tetrahymena thermophila	ciliate protozoa	NR	Roundup	117	Mortality	1	43

Median LOEC for ROUNDUP/VISION: 29 mg/L
Median LOEC for GLYPHOSATE: 3,800 mg/L

1.4 Appendix E: Toxicity of Triclopyr to Animals and Other Organisms

Table E-2: Triclopyr Toxicity to Birds: Mortality

Scientific Name	Common Name	Age (days)	Formulation	Concentration[a] or dose (mg/kg)	Study Duration (days)	Endpoint	Type of Exposure[b]	Ref
Anas platyrhynchos	mallard duck	14	triclopyr acid	1,480	14	LD_{50}	oral	44
Anas platyrhynchos	mallard duck	14	triclopyr TEA	> 4,660	8	LC_{50}	oral	44
Anas platyrhynchos[c]	mallard duck	NR	triclopyr acid	1,700	14	LD_{50}	diet	44
Anas platyrhynchos[c]	mallard duck	NR	triclopyr acid	5,620	8	LC_{50}	diet	44
Anas platyrhynchos[c]	mallard duck	NR	triclopyr BEE	>6,700	8	LC_{50}	diet	44
Poephila guttata	Zebra finch	NR	Garlon 4	1,920	5	LD_{50}	diet	44
Cortunix japonica	Japanese quail	NR	triclopyr acid	3,270	8	LC_{50}	diet	44
Colinus virginianus	northern bobwhite[c]	NR	triclopyr BEE	3,740	8	LC_{50}	diet	44
Colinus virginianus	northern bobwhite	14	triclopyr acid	2,930	8	LC_{50}	diet	44
Colinus virginianus	northern bobwhite	NR	triclopyr BEE	6,040	8	LC_{50}	diet	44
Colinus virginianus	northern bobwhite	14	triclopyr TEA	>5,380	8	LC_{50}	diet	44
Colinus virginianus	northern bobwhite	210	triclopyr BEE	610	14	LD_{50}	oral	44
Colinus virginianus	northern bobwhite	210	triclopyr BEE	510	21	LD_{50}	oral	47
Colinus virginianus[c]	northern bobwhite	NR	triclopyr BEE	>3,880	8	LC_{50}	diet	44
Median LD_{50} for birds: 1,698 mg/kg								
Median LC_{50} for birds: >5,401 mg/kg								

NR = Not Reported ; TEA = Triethylamine sal; BEE = Butoxyethyl ester
Statistical significance was not reported.
[a] LC_{50} = concentration in mg chemical per kg food; LD_{50} = dose in mg chemical per kg organism body weight. An attempt was made to convert all concentrations to units of "acid equivalents", however, some studies were not diligent in reporting units.
[b] Dose frequency is not reported.
[c] There are two studies that yield this result.

Table E-3: Triclopyr Toxicity to Birds: Sub-lethal Effects

Scientific Name	Common Name	Age (days)	Formulation	Concentration (mg/kg food)	Study Duration	End-point	Effect	Exposure[a]	Ref
Poephila guttata	zebra finch	NR	Garlon 4	500 mg/kg	29 days	LOEC	weight loss	diet	44
Anas platyrhynchos	mallard duck	NR	triclopyr acid	100 mg/kg	29 days	NOEC	offspring survivorship	diet	47
Anas platyrhynchos[b]	mallard duck	NR	triclopyr acid	200 mg/kg	29 days	LOEC	offspring survivorship	diet	47
Colinus virginianus	northern bobwhite	NR	triclopyr acid	500 mg/kg	29 days	LOEC	egg thickness	diet	47
Poephila guttata	zebra finch	NR	Garlon 4	150 mg/kg	29 days	NOEC	weight loss	diet	44
Colinus virginianus	northern bobwhite	NR	triclopyr acid	500 mg/kg	29 days	NOEC	egg thickness	diet	47

NR = Not Reported. Statistical significance was not reported.
[a] Dose frequency is not reported.
[b] There are two studies by different authors that yield this result.

Table E-4. Toxicity of Triclopyr to Honey Bees: Mortality Using an LD_{50} Endpoint

Scientific Name	Common Name	Age (days)	Formulation	Dose (µg/bee)	Study Duration (days)	Exposure Type	Ref
Apis mellifera	honeybee	1-7 days	NR	>100	2	once, topically	47
Apis mellifera	honeybee	NR	NR	> 25	2	once, topically	4
Apis mellifera[a]	honeybee	NR	NR	> 100	2	once, topically	47

NR = Not Reported. Statistical significance was not reported.
[a] There are two studies that yield this result.

Table E-5. Triclopyr Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Formulation	Water Flow	Conc. [mg/L]	Duration (days)	Dose Frequency	Ref
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 4	static	1.56	1	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 4	static	1.56	2	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 4	static	1.56	3	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 4	static	1.56	4	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 4	static	1.56	1	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 4	static	1.34	2	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 4	static	1.26	3	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 4	static	1.26	4	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 4	static	1.85	1	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 4	static	1.11	2	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 4	static	1.04	3	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 4	static	1.04	4	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 4	static	3.04	1	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 4	static	2.15	2	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 4	static	2.00	3	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 4	static	2.00	4	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 4	static	3.12	1	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 4	static	2.00	2	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 4	static	2.00	3	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 4	static	2.00	4	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	Garlon 4	static	1.41	1	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	Garlon 4	static	0.96	2	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	Garlon 4	static	0.89	3	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	Garlon 4	static	0.89	4	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr BEE	static	0.74	1	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr BEE	static	0.74	2	once	48

Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr BEE	static	0.74	3	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr BEE	static	0.74	4	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr BEE	static	0.30	1	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr BEE	static	0.22	2	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr BEE	static	0.22	3	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr BEE	static	0.22	4	once	48

NR = Not Reported : TEA = Triethylamine salt: BEE = Butoxyethyl ester; Statistical significance not reported.

Table E-5 (Cont.): Triclopyr Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Chemical Formulation	Water Flow	Conc. (mg/L)	Duration (days)	Dose Frequency	Ref
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr BEE	static	0.37	1	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr BEE	static	0.30	2	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr BEE	static	0.30	3	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr BEE	static	0.30	4	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr BEE	static	0.82	1	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr BEE	static	0.82	2	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr BEE	static	0.82	3	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr BEE	static	0.82	4	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr BEE	static	1.2	1	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr BEE	static	0.82	2	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr BEE	static	0.82	3	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr BEE	static	0.82	4	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr BEE	static	0.45	1	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr BEE	static	0.37	2	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr BEE	static	0.37	3	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr BEE	static	0.37	4	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 3	static	351	1	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 3	static	336	2	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 3	static	336	3	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	Garlon 3	static	327	4	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 3	static	223	1	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 3	static	205	2	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 3	static	194	3	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	Garlon 3	static	188	4	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 3	static	249	1	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 3	static	219	2	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 3	static	219	3	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	Garlon 3	static	219	4	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 3	static	322	1	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 3	static	307	2	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 3	static	296	3	once	48

Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	Garlon 3	static	296	4	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr	static	9.9	1	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr	static	9.6	2	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr	static	9.6	3	once	48
Oncorhynchus kisutch	coho or silver salmon	4.0, 0.5, 30	triclopyr	static	9.6	4	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr	static	7.9	1	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr	static	7.5	2	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr	static	7.5	3	once	48
Oncorhynchus keta	chum salmon	4.5, 0.5, 30	triclopyr	static	7.5	4	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr	static	7.8	1	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr	static	7.5	2	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr	static	7.5	3	once	48
Oncorhynchus nerka	sockeye salmon	3.9, 0.5, 45	triclopyr	static	7.5	4	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr	static	8.4	1	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr	static	7.8	2	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr	static	7.6	3	once	48
Oncorhynchus mykiss	rainbow trout	4.1, 0.7, 30	triclopyr	static	7.5	4	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr	static	9.7	1	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr	static	9.7	2	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr	static	9.7	3	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	triclopyr	static	9.7	4	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr	static	13.3	1	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr	static	8.8	2	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr	static	6.1	3	once	48
Oncorhynchus gorbuscha	pink salmon	3.5, 0.2, 38	triclopyr	static	5.3	4	once	48

NR = Not Reported ; TEA = Triethylamine salt; BEE = Butoxyethyl ester; Statistical significance not reported.

Table E-5 (Cont.): Triclopyr Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Chemical Formulation	Water Flow[b]	Conc. [mg/L]	Duration (days)	Dose Frequency	Ref
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 3	static	333	1	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 3	static	220	2	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 3	static	200	3	once	48
Oncorhynchus tshawytscha	chinook salmon	6.8, 2.7, 105	Garlon 3	static	194	4	once	48
Oncorhynchus mykiss	rainbow trout	NR	triclopyr	static	117	4	once	47
Lepomi smacrochirus	bluegill sunfish	NR	triclopyr	static	148	4	once	47
Oncorhynchus kisutch	coho salmon	8.4, 6.1, juv.	triclopyr BEE	static	1.6	4	once	49
Oncorhynchus mykiss	rainbow trout	3.4, 0.29, fry	triclopyr BEE	static	1.6	4	once	49
Oncorhynchus mykiss	rainbow trout	NR, NR, NR	triclopyr TEA	flow through	286	4	once	47
Oncorhynchus mykiss	rainbow trout	NR, NR, NR	triclopyr TEA	flow through	83	4	once	47
Lepomi smacrochirus	bluegill sunfish	NR, NR, NR	triclopyr TEA	flow through	416	4	once	47
Lepomi smacrochirus	bluegill sunfish	NR, NR, NR	triclopyr TEA	flow through	162	4	once	47
Pimephales promelas	fathead minnow	NR, NR, NR	triclopyr TEA	flow through	441	4	once	47
Pimephales promelas	fathead minnow	NR, NR, NR	triclopyr TEA	flow through	176	4	once	47
Pimephales promelas	fathead minnow	NR, NR, NR	triclopyr TEA	flow through	90	4	once	47
Oncorhynchus mykiss	rainbow trout	NR, NR, NR	triclopyr BEE	flow through	0.45	4	once	47
Oncorhynchus mykiss	rainbow trout	NR, NR, NR	triclopyr BEE	flow through	0.93	4	once	47
Oncorhynchus mykiss	rainbow trout	NR, NR, NR	triclopyr BEE	flow through	0.35-1.22	4	once	47
Lepomi smacrochirus	bluegill sunfish	NR, NR, NR	triclopyr BEE	flow through	1.1	4	once	47
Lepomi smacrochirus	bluegill sunfish	NR, NR, NR	triclopyr BEE	flow through	0.25	4	once	47
Lepomi smacrochirus	bluegill sunfish	NR, NR, NR	triclopyr BEE	flow through	0.60	4	once	47
Pimephales promelas	fathead minnow	NR, NR, NR	triclopyr BEE	flow through	1.67	4	once	47
Pimephales promelas	fathead minnow	NR, NR, NR	triclopyr BEE	flow through	1.6	4	once	47
Oncorhynchus kisutch	coho salmon	NR, NR, yolk fry	triclopyr BEE	flow through	0.33-0.34	4	once	47
Oncorhynchus mykiss	rainbow trout	3.4, 0.33, fry	Garlon 3	static	282	4	once	50
Oncorhynchus mykiss	rainbow trout	4.0, NR, fry	Garlon 4	static	1.8	4	once	50
Oncorhynchus mykiss	rainbow trout	3-5, NR, NR	Garlon 4	flow through	16.7	0.042	constant	50
Oncorhynchus mykiss	rainbow trout	3-5, NR, NR	Garlon 4	flow through	1.4	0.25	constant	50
Oncorhynchus mykiss	rainbow trout	3-5, NR, NR	Garlon 4	flow through	0.59	1	constant	50
Oncorhynchus nerka	sockeye salmon	7.1, 4.5, juv	triclopyr BEE	static	1.04	4	once	49
Oncorhynchus nerka	sockeye salmon	2.9, 0.22, fry	triclopyr BEE	static	0.89	4	once	49
Oncorhynchus tshawytscha	chinook salmon	3-5, NR, NR	Garlon 4	flow through	26	0.042	constant	50
Oncorhynchus tshawytscha	chinook salmon	3-5, NR, NR	Garlon 4	flow through	3.5	0.25	constant	50
Oncorhynchus tshawytscha	chinook salmon	3-5, NR, NR	Garlon 4	flow through	1.3	1	constant	50
Pimephales promelas	fathead minnow	1.6-3.1,0.22, NR	NR	static	173	4	once	50
Pimephales promelas	fathead minnow	1.6-3.1,0.22, NR	NR	flow through	85	4	constant	50
Pimephales promelas	fathead minnow	1.6-3.1,0.22, NR	NR	flow through	71	8	constant	50
Median concentration dose that caused 50% mortality in fish for triclopyr BEE and TEA respectively: 0.82 mg/L and 249 mg/L								

NR = Not Reported ; TEA = Triethylamine salt; BEE = Butoxyethyl ester; Statistical significance not reported.
[a] "Flow" means that a solution of the chemical at the specified concentration was flowing continuously through the chamber during the study time.

Table E-6: Chronic Triclopyr Toxicity to Fish

Scientific Name	Common Name	Age, Length (cm)	Formulation	Concentration (mg/L)	Study Duration (days)	End-point	Effect	Type of Exposure	Ref
Pimephales promelas	fathead minnow	NR	triclopyr TEA	<162	NR	LOEC	stunted length	NR	47
Oncorhynchus mykiss[a]	rainbow trout	NR	NR	0.24-0.32	4	LOEC	lethargy	NR	51
Oncorhynchus mykiss[a]	rainbow trout	NR	NR	0.074	4	LOEC	hypersensitive	NR	51
Oncorhynchus mykiss[a]	rainbow trout	juv. 4.8	Garlon 3A	141	1	LOEC	behavior	constant	4
Oncorhynchus mykiss[a]	rainbow trout	juv. 4.8	Garlon 3A	564	0.41	LOEC	avoidance	constant	4
Oncorhynchus mykiss[a]	rainbow trout	juv, 4.8	Garlon 4	0.45	1	LOEC	behavior	constant	4
Oncorhynchus mykiss[a]	rainbow trout	juv, 4.8	Garlon 4	14.2	0.41	LOEC	avoidance	constant	4
Pimephales promelas[a]	fathead minnow	fry	triclopyr TEA	178	28	LOEC	egg-fry survival	constant	52
Pimephales promelas[a]	fathead minnow	juv	triclopyr TEA	114	28	LOEC	reduced growth	constant	52
Pimephales promelas	fathead minnow	NR	triclopyr TEA	>104	NR	NOEC	stunted length	NR	47
Median LOEC for chronic fish toxicity: 14.2 mg/L									

NR = Not Reported ; TEA = Triethylamine salt; Statistical significance was not reported.
juv = juvenile organism
[a] Experiments were performed in "flow through" chambers.

Table E-7: Triclopyr Toxicity to Amphibians

Scientific Name	Common Name	Formulation	Age (days)	Concentration (mg/L)	Duration (days)	End-point	Effect	Ref
Xenopus laevis	African claw frog	Garlon 3A	embryo	162	4[a]	LC_{50}	mortality	53
Xenopus laevis	African claw frog	Garlon 4	embryo	9.3	4[a]	LC_{50}	mortality	53
Rana catesbeiana	bullfrog	triclopyr acid	0 dph	2.4	2[b]	LC_{100}	mortality	54
Rana clamitans	green frog	triclopyr acid	0 dph	2.4	2[b]	LC_{100}	mortality	54
Rana pipiens	leopard frog	triclopyr acid	0 dph	2.4	2[b]	LOEC	temporarily unresponsive to prodding	54
Rana catesbeiana	bullfrog	triclopyr acid	0 dph	1.2	2[b]	LOEC	temporarily unresponsive to prodding	54
Rana clamitans	green frog	triclopyr acid	0 dph	1.2	2[b]	LOEC	temporarily unresponsive to prodding	54

NR = not reported; dph = days post hatch.
[a] Constant exposure in Petri dish.
[b] Constant exposure in 1L beaker with aerated river water

Table E-8: Triclopyr Toxicity to Aquatic Invertebrates

Scientific Name	Common Name	Formulation	End-point	Concentration (mg/L)	Study Duration (days)	Type of Exposure	Effect	Ref
Daphnia magna	waterflea	triclopyr acid	LC_{50}	133	NR	NR		47
Daphnia magna	waterflea	triclopyr TEA	LC_{50}	1,055	NR	NR		47
Daphnia magna	waterflea	triclopyr BEE	LC_{50}	1.3	NR	NR		47
Daphnia magna	waterflea	triclopyr BEE	LC_{50}	8.9	NR	NR		47
Daphnia magna	waterflea	triclopyr TEA	NOEC	58	NR	NR	Brood size	55
Daphnia magna	waterflea	triclopyr TEA	LOEC	105	NR	NR	Brood size	55
Crassostrea virginica[a]	eastern oyster	triclopyr TEA	LC_{50}	58	NR	NR		47
Crassostrea virginica[a]	eastern oyster	triclopyr TEA	LC_{50}	>56	NR	NR		47
Uca pugilator[a]	fiddler crab	triclopyr TEA	LC_{50}	>1,000	NR	NR		47
Palaemontes pugio[a]	grass shrimp	triclopyr TEA	LC_{50}	326	NR	NR		47
Penaeus duorarum[a]	pink shrimp	triclopyr TEA	LC_{50}	895	NR	NR		47
Menidida beryllina[a]	tidewater silverside	triclopyr TEA	LC_{50}	130	NR	NR		47
Crassostrea virginica[a]	eastern oyster	triclopyr BEE	LC_{50}	0.32	NR	NR		47
Palaemontes pugio[a]	grass shrimp	triclopyr BEE	LC_{50}	2.5	NR	NR		47
Palaemontes pugio[a]	grass shrimp	triclopyr BEE	LC_{50}	1.7	NR	NR		47
Menidida beryllina[a]	tidewater silverside	triclopyr BEE	LC_{50}	0.45	NR	NR		47
Menidida beryllina[a]	tidewater silverside	triclopyr BEE	LC_{50}	0.76	NR	NR		47
Acroneuria abnormis	stonefly	form. triclopyr BEE[b]	LC_{50}	320	NR	NR		56
Dolophilodes distincta	caddisfly	form. triclopyr BEE[b]	LC_{50}	0.7-1.27	NR	NR		56
Epeorus vitrea	mayfly	form. triclopyr BEE[b]	LC_{50}	320	NR	NR		56
Heptagenia flavescens	mayfly	form. triclopyr BEE[b]	LC_{50}	320	NR	NR		56
Hydropsyches sp.	caddisfly	form. triclopyr BEE[b]	LC_{50}	310	NR	NR		56
Isogenoides sp.	stonefly	form. triclopyr BEE[b]	LC_{50}	21.8-126	NR	NR		56
Isonychia sp.	mayfly	form. triclopyr BEE[b]	LC_{50}	320	NR	NR		56
Ophiogomphus carolus	dragonfly	form. triclopyr BEE[b]	LC_{50}	320	NR	NR		56
Pteronarcys sp.	stonefly	form. triclopyr BEE[b]	LC_{50}	290	NR	NR		56
Pycnopsyche guttifer	caddisfly	form. triclopyr BEE[b]	LC_{50}	290	NR	NR		56
Simulium sp.	blackfly	form. triclopyr BEE[b]	LC_{50}	249-370	NR	NR		56
Median concentration that caused 50% mortality in aquatic invertebrates: >56 mg/L								

NR = Not Reported ; TEA = Triethylamine salt; BEE = Butoxyethyl ester; Statistical significance was not reported.
Age was not reported in any of the studies.
[a] Report did not say if the concentrations were in active ingredient or acid equivalent. It is likely that the numbers in the table are in units of active ingredient.
[b] The formulated product is not described so determining the acid equivalents is not possible. Most likely, the formulation was approximately 60% triclopyr BEE.

1.5 Appendix F: Toxicity of Clopyralid to Animals and Other Organisms

Table F-2. Clopyralid Toxicity to Birds: Mortality

Scientific Name	Common Name	Age (days)	Formulation	Concentration[a] or dose (mg/kg)	Study Duration (days)	Endpoint[b]	Type of Exposure[c]	Ref
Anas platyrhynchos	mallard duck	140	NR	> 2,000	14	LD_{50}	oral	4
Anas platyrhynchos[d]	mallard duck	10	clopyralid acid	> 4,640–5,620	8	LC_{50}	diet	4
Anas platyrhynchos	mallard duck	NR	clopyralid acid	1,465	14	LD_{50}	oral	4
Colinus virginianus[e]	northern bobwhite	NR	clopyralid acid	> 4,640–5,620	8	LC_{50}	diet	4
Median LD_{50} for birds: 1,698 mg/kg								
Median LC_{50} for birds: >5,401 mg/kg								

NR = Not Reported
[a] An attempt was made to put all concentrations in units of "acid equivalents;" however, units were not reported in some studies.
[b] LC_{50} values are the concentration in mg chemical per kg food. LD_{50} represent the dose in mg chemical per kg organism body weight.
[c] Dose frequency was not reported.
[d] There are two studies which bracket the extremes of the range.
[e] There are three studies included in this range.

Table F-3. Toxicity of Clopyralid to Honey Bees: Mortality Using an LD_{50} Endpoint.

Scientific Name	Common Name	Age (days)	Formulation	Dose (µg/bee)	Study Duration (days)	Exposure Type	Ref
Apis mellifera	honeybee	NR	NR	100	2	oral	4
Apis mellifera[a]	honeybee	NR	NR	100	2	topical	4

NR = Not Reported. The studies do not report how many applications were made. Statistical significance was not reported.
[a] There are two studies that yield this result.

Table F-4. Clopyralid Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Scientific Name	Common Name	Length, Weight, Age (cm, g, day)	Formulation	Water Flow	Conc. (mg/L)[a]	Duration (days)	Dose Freq.	Ref
Lepomis macrochirus	bluegill	NR, 0.1, NR	clopyralid MEA	static	1,645	4	once	4
Lepomis macrochirus	bluegill	NR, NR, NR	clopyralid acid	static	125	4	once	4
Oncorhynchus mykiss	rainbow trout	NR, 0.25, NR	clopyralid MEA	static	700	4	once	4
Oncorhynchus mykiss	rainbow trout	NR, NR, NR	clopyralid acid	static	104	4	once	4
Oncorhynchus mykiss	rainbow trout	NR, NR, ~7	clopyralid acid	flow[b]	700	4	once	57
Salvelinus confluentus	bull trout	NR, NR, NR	clopyralid acid	flow	802	4	once	57
Pimephales promelas	fathead minnow	NR, 0.2, NR	clopyralid MEA	static	>1,015	4	once	4

NR = Not Reported

[a] As discussed above, the USFS report stated that conversion of 2,000 mg a.i./L monoethanolamine salt of clopyralid (35% a.e.), gives 700 mg a.e./L. Presumably, the "35%" refers to the amount of clopyralid in the formulated product because the ratio of the molecular weight of clopyralid monoethanolamine to clopyralid acid is 0.756 and not 35%. This same record appears in the AQUIRE database, however no information on a.i. versus a.e. is given.

[b] Flow-chamber study.

Table F-5. Clopyralid Toxicity to Fish: Mortality Using an LC_x Endpoint

Scientific Name[a]	Common Name	Endpoint	Formulation	Water Flow	Conc. (mg/L)	Duration (days)	Dose Freq.	Ref
Oncorhynchus mykiss	rainbow trout	LC_5	clopyralid acid	NR	448	4	once	57
Oncorhynchus mykiss	rainbow trout	LC_{10}	clopyralid acid	NR	476	4	once	57
Oncorhynchus mykiss	rainbow trout	LC_{20}	clopyralid acid	NR	532	4	once	57
Oncorhynchus mykiss[c]	rainbow trout	model LC_1	clopyralid acid	NR	477	4	once	57
Salvelinus confluentus	bull trout	LC_5	clopyralid acid	NR	458	4	once	57
Salvelinus confluentus	bull trout	LC_{10}	clopyralid acid	NR	496	4	once	57
Salvelinus confluentus	bull trout	LC_{20}	clopyralid acid	NR	582	4	once	57
Salvelinus confluentus[c]	bull trout	model LC_1	clopyralid acid	NR	552	4	once	57

NR = Not Reported

[a] The age, weight and length of the fish were not recorded.

[b] Flow chamber study.

[c] The chronic LC_1 was estimated using a statistical model. Problems associated with this value are provided in the text.

Table F-6. Clopyralid Toxicity to Aquatic Invertebrates.

Scientific Name	Common Name	Age	Formulation	Concentration (mg/L)	Study Duration (days)	End-point	Effect	Application Frequency	Ref
Daphnia magna	waterflea	< 24 hr	NR	1,130[b]	2	EC_{50}	intoxication	once	4
Daphnia magna	waterflea	< 24 hr	clopyralid acid	225-232[a, b]	2	EC_{50}	intoxication	once	4
Daphnia magna	waterflea	NR	clopyralid MEA	350	NR	LC_{50}	intoxication	once	58
Daphnia magna	waterflea	NR	clopyralid MEA	23	NR	NOEC	intoxication	once	58
Chironomus sp.	midge	NR	fernanoxone	850	1	LC_{50}	mortality	once	4
Chironomus sp.	midge	NR		750	2	LC_{50}	mortality	once	4
Chironomus sp.	midge	NR		990	0.5	LC_{50}	mortality	once	4
Median LC_{50} for aquatic invertebrates: 750 mg/L									

NR = Not reported.

[a] Two studies represent this range.

[b] It is not clear whether this is in active ingredients or acid equivalents.

1.6 Appendix G: Toxicity of Clove Oil to Animals and Other Organisms

Table G-2: Clove Oil Toxicity to Insects: Mortality Using an LC_{50} Endpoint

Common and Scientific Name	Compound	Endpoint	Value	Reference
Sitophilus zeamais	eugenol	LD_{50}	30 µg/mg insect	59
Tribolium castaneum	eugenol	LD_{50}	31 µg/mg insect	59
Elateridae	eugenol	LD_{50}	517 µg/insect	60
Dermatophagoides farinae	eugenol	LD_{50}	0.52 kg/ha	61
Dermatophagoides pteronyssinus	eugenol	LD_{50}	0.37 kg/ha	61
Tyrophagus putrescentiae	eugenol	LD_{50}	1.2 kg/ha	62
Ochlerotatus caspius	eugenol	LC_{50}	7.5 mg/L	63
Ochlerotatus caspius	eugenol	LC_{50}	5.6 mg/L	63
Aedes aegypti	eugenol	LC_{50}	33 ppm	64
Trichoplusia ni	clove oil	LC_{50}	3700 ppm	65
Pseudoaletia unipuncta	clove oil	LC_{50}	4900 ppm	65
Pediculus capitis	eugenol	LC_{50}	25 kg/ha	66
Coptotermes formosanus	clove oil	LC_{100}	2 kg/ha	67
Median concentration that caused 50% mortality in insects: 0.52 kg/ha				

Table G-3: Clove Oil Toxicity to Microbes: Minimum Inhibitory Concentration Endpoint

Common and Scientific Name	Compound	Endpoint	Value	Reference
Candida albicans	eugenol	MIC	625 mg/L	68
Crytococcus neoformans	eugenol	MIC	293 mg/L	68
Median minimum inhibitory concentration: 293 mg/L				

Table G-4: Clove Oil Toxicity to Fish: LC_{50} and Sedation

Common and Scientific Name	Compound	Endpoint	Value	Reference
Rainbow trout, *Oncorhynchus mykiss*	clove oil	10min LC_{50}	81 mg/L	69
Rainbow trout, *Oncorhynchus mykiss*	clove oil	96 h LC_{50}	14 mg/L	69
Carp, *Cyprinus carpio*	clove oil	10min LC_{50}	74 mg/L	70
Carp, *Cyprinus carpio*	clove oil	96 h LC_{50}	18 mg/L	70
European catfish, *Silirus glanis*	clove oil	10min LC_{50}	77 mg/L	69
European catfish, *Silirus glanis*	clove oil	96 h LC_{50}	18 mg/L	69
Rainbow trout, *Oncorhynchus mykiss*	eugenol	30min LC_{50}	65 mg/L	71
Rainbow trout, *Oncorhynchus mykiss*	eugenol	12 h LC_{50}	9 mg/L	71
Tambaqui, *Colossoma macropomum*	eugenol	sedation	65 mg/L	72
Median concentration that caused 50% mortality in fish: 42[a] mg/L				

[a] Averaged from two LC_{50} values: 18 mg/L (96 hour) and 65 mg/L (30 minutes).

Table G-5: Clove Oil Toxicity to Aquatic Invertebrates: LC_{50} and Sedation

Common and Scientific Name	Compound	Endpoint	Value	Reference
Penaeus semisulcatus	clove oil	1 h LC_{50}	130 mg/L	73
Penaeus semisulcatus	clove oil	24 h LC_{50}	30 mg/L	73
Macrobrachium rosenbergii	clove oil	sedation	300 mg/L	74
Biomphalaria alexandria	eugenol	LC_{50}	28 mg/L	75
Bulinus truncatus	eugenol	LC_{50}	24 mg/L	75
Lymneae natalensis	eugenol	LC_{50}	22 mg/L	75
Median concentration that caused 50% mortality in aquatic invertebrates: 28 mg/L				

1.7 Appendix H: Toxicity of Pelargonic Acid to Animals and Other Organisms

Table H-2: Nonanoic Acid Toxicity to Birds: Mortality Using an LC_{50} Endpoint

Common Name	Scientific Name	Compound	Endpoint	Value (mg/kg)	Reference
Mallard duck	*Anas platyrhynchos*	soap salts	8 day LD_{50}	2,510	76
Mallard duck	*Anas platyrhynchos*	nonanoic acid	Sub-acute LC_{50}	5,620	4
Mallard duck	*Anas platyrhynchos*	soap salts	8 day LC_{50}	5,000	76
Bobwhite	*Colinus virginianus*	soap salts	8 day LC_{50}	5,000	76
Bobwhite	*Colinus virginianus*	nonanoic acid	LD_{50}	2,250	4
Bobwhite	*Colinus virginianus*	soap salts	8 day LD_{50}	2,000	76
Bobwhite	*Colinus virginianus*	soap salts	LD_{50}	2,150	76
Bobwhite	*Colinus virginianus*	nonanoic acid	Sub-acute LC_{50}	5,620	4
Median LC_{50} for concentration in food: 5,310[a] Median LD_{50} for dose to organism: 2,200[a]					

[a] The median LC_{50} and LD_{50} values are averages of two values: 5,000 and 5,620 mg/kg and .2,150 and 2,250 mg/kg respectively.

Table H-3: Nonanoic Acid Toxicity to Fish: Mortality Using an LC_{50} Endpoint

Common Name	Scientific Name	Compound	Endpoint	Value (mg/kg)	Reference
Red killifish	*Oryzias latipes*	capric acid	48 hr LC_{50}	20	77
Red killifish	*Oryzias latipes*	sodium caprate	LC_{50}	54	77
Fathead minnow	*Pimephales promelas*	soap salts	LC_{50}	21	76
Fathead minnow	*Pimephales promelas*	capric acid	96 hr LC_{50}	104	77
Bluegill sunfish	*Lepomis macrochirus*	soap salts	96 hr LC_{50}	9.2	76
Bluegill sunfish	*Lepomis macrochirus*	soap salts	96 hr LC_{50}	18.1	76
Bluegill sunfish	*Lepomis macrochirus*	soap salts	96 hr LC_{50}	91	4
Rainbow trout	*Oncorhynchus mykiss*	soap salts	96 hr LC_{50}	23	76
Rainbow trout	*Oncorhynchus mykiss*	soap salts	96 hr LC_{50}	35.4	76
Rainbow trout	*Oncorhynchus mykiss*	soap salts	96 hr LC_{50}	105	4
Median LC_{50}: 29.2 mg/L					

[a] The median LC_{50} value averages two values: 23 and 35.4 mg/L.

Table H-4: Nonanoic Acid Toxicity to Amphibians: Mortality Using an LC_{50} Endpoint

Common Name	Scientific Name	Compound	Endpoint	Value (mg/kg)	Reference
African claw frog	*Xenopus laevis*	decanoic acid	96 hr LC_{50}	24	4
African claw frog	*Xenopus laevis*	decanoic acid	96 hr EC_{50}	7.5	4
African claw frog	*Xenopus laevis*	nonanoic acid	96 hr LC_{50}	32.7	4
African claw frog	*Xenopus laevis*	nonanoic acid	96 hr EC_{50}	6.5	4
Median LC_{50}: 15.3 mg/L					

[a] The median values are averages of two values: 7.5 and 24 mg/L.

Table H-5: Nonanoic Acid Toxicity to Aquatic Invertebrates: Mortality Using an LC_{50} Endpoint

Common Name	Scientific Name	Compound	Endpoint	Value (mg/kg)	Reference
Waterflea	*Daphnia*	soap salts	48 hr LC_{50}	0.57	76
Gammarus	*Hyale plumulosa*	capric acid	48 hr LC_{50}	41	77
Waterflea	*Daphnia*	nonanoic acid	48 hr LC_{50}	96	4
Waterflea	*Daphnia*	soap salts	48 hr LC_{50}	102	76
Median LC_{50}: 68 mg/L					

[a] The median values are averages of two values: 41 and 96 mg/L.

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