Risks of Esfenvalerate Use to Federally Threatened California Red-Legged Frog

(*Rana aurora draytonii*)

Pesticide Effects Determination

Environmental Fate and Effects Division
Office of Pesticide Programs
Washington, D.C. 20460

February 19, 2008

Primary Authors
Shannon Borges, Biologist
Katrina White, Ph.D., Biologist
Nelson Thurman, Senior Fate Scientist
Environmental Risk Branch II
Environmental Fate and Effects Division (7507P)

Secondary Review
Donna Randall, Senior Effects Scientist
Environmental Risk Branch II
Environmental Fate and Effects Division (7507P)

Dana Spatz, Acting Branch Chief,
Environmental Risk Branch II
Environmental Fate and Effects Division (7507P)

Table of Contents

1.0 Executive Summary 1
2.0 Problem Formulation 7
2.1 Purpose 7
2.2 Scope 9
2.3 Previous Assessments 10
2.4 Stressor Source and Distribution 10
2.4.1 Environmental Fate Properties 10
2.4.2 Environmental Transport Mechanisms 20
2.4.3 Mechanism of Action 21
2.4.4 Use Characterization 21
2.5 Assessed Species 33
2.5.1 Distribution 33
2.5.2 Reproduction 39
2.5.3 Diet 39
2.5.4 Habitat 40
2.6 Designated Critical Habitat 41
2.7 Action Area 43
2.8 Assessment Endpoints and Measures of Ecological Effect 44
2.8.1 Assessment Endpoints for the CRLF 44
2.8.2 Assessment Endpoints for Designated Critical Habitat 46
2.9 Conceptual Model 49
2.9.1 Risk Hypotheses 49
2.9.2 Diagram 50
2.10 Analysis Plan 55
2.10.1 Measures to Evaluate the Risk Hypotheses and Conceptual Model 55
3.0 Exposure Assessment 60
3.1 Label Application Rates and Intervals 60
3.2 Aquatic Exposure Assessment 63
3.2.1 Modeling Approach 63
3.2.2 Model Inputs 65
3.2.3 Results 68
3.2.4 Existing Monitoring Data 68
3.3 Terrestrial Animal Exposure Assessment 74
3.4 Terrestrial Plant Exposure Assessment 76
4.0 Effects Assessment 77
4.1 Evaluation of Aquatic Ecotoxicity Studies 80
4.1.1 Toxicity to Amphibians 80
4.1.2 Toxicity to Freshwater Fish 81
4.1.3 Toxicity to Freshwater Invertebrates 83
4.1.4 Toxicity to Aquatic Plants 86
4.1.5 Freshwater Field Studies 86
4.2 Evaluation of Terrestrial Ecotoxicity Studies 88
4.2.1 Toxicity to Birds 88

4.2.2 Toxicity to Mammals 89
4.2.3 Toxicity to Non-Target Terrestrial Invertebrates 91
4.2.4 Toxicity to Terrestrial Plants 91
4.3 Use of Probit Slope Response Relationship to Provide Information on the Endangered Species Levels of Concern 92
4.4 Incident Database Review 93
5.0 Risk Characterization 96
5.1 Risk Estimation 96
5.1.1 Exposures in the Aquatic Habitat 96
5.1.2 Exposures in the Terrestrial Habitat 101
5.1.3 Primary Constituent Elements of Designated Critical Habitat 105
5.2 Risk Description 105
5.2.1 Direct Effects 108
5.2.2 Indirect Effects to the CRLF (via reductions in prey base) 110
5.2.3 Indirect Effects (via Habitat Effects) 112
5.2.4 Modification of Designated Critical Habitat 113
5.3 Risk Hypotheses Revisited 113
6.0 Uncertainties 116
6.1 Exposure Assessment Uncertainties 116
6.1.1 Maximum Use Scenario 116
6.1.2 Aquatic Exposure Modeling of Esfenvalerate 116
6.1.3 Action Area Uncertainties 118
6.1.4 Usage Uncertainties 118
6.1.5 Terrestrial Exposure Modeling of Esfenvalerate 118
6.1.6 Spray Drift Modeling 119
6.2 Effects Assessment Uncertainties 120
6.2.1 Age Class and Sensitivity of Effects Thresholds 120
6.2.2 Use of Surrogate Species Effects Data 120
6.2.3 Sublethal Effects 120
6.2.4 Location of Wildlife Species 121
7.0 Risk Conclusions 122
8.0 References 125

Appendices

APPENDIX A	Product Formulations Containing Multiple Active Ingredients
APPENDIX B	PRZM/EXAMS Modeling Results
APPENDIX C	Estimated Exposures and Risk Quotients for Terrestrial Environments (T-REX and T-HERPS)
APPENDIX D	Papers accepted for ECOTOX-OPP and Included
APPENDIX E	Papers accepted for ECOTOX-OPP but Not Included
APPENDIX F	Papers Excluded from ECOTOX (Without Abstracts)
APPENDIX G	Pounds Esfenvalerate Applied per Month in 2005 for Select Crops in California
APPENDIX H	Listing of Applicable Labels for Each Crop/Use Grouping
APPENDIX I	Total Pounds Applied in Each County for the Years 2002-2005
APPENDIX J	Summary of Esfenvalerate Half Lives in Soil
APPENDIX K	Post Processing of Residential and Rights-of-way Scenarios to Estimate Aquatic EECs
APPENDIX L	Toxicity Categories and Levels of Concern
APPENDIX M	Open Literature Review Summaries for Included ECOTOX Papers
Attachment 1	Status and Life History of the California Red Legged Frog

List of Tables

Table 1-1. Effects Determination Summary for Direct and Indirect Effects of Esfenvalerate on the CRLF and Effects to its Designated Critical Habitat. 4

Table 2-1. Summary of Physico-Chemical Properties of Esfenvalerate..................................... 12

Table 2-2. Summary of Esfenvalerate Environmental Fate Properties....................................... 18

Table 2-3. Labeled Agricultural Uses Assessed in this Document.[1] 22

Table 2-4. Labeled Non-agricultural Uses Assessed in this Document.[1,2] 25

Table 2-5. Labeled Non- agricultural Uses Qualitatively Assessed in this Document................ 26

Table 2-6. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 2002 to 2005 for Currently Registered Esfenvalerate Uses.[1] 29

Table 2-7. California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat... 35

Table 2-8. Summary of Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of Esfenvalerate on the CRLF. 45

Table 2-9. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat. 47

Table 3-1. Esfenvalerate Uses, Scenarios, and Application Information for Estimating Aquatic Environmental Concentrations. [1,2]... 61

Table 3-2. Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Esfenvalerate Endangered Species Assessment for the CRLF.[1,2].............. 65

Table 3-3. PRZM/EXAMS Scenarios Used to Estimate Concentrations of Esfenvalerate in the Aquatic Environment.[1]... 67

Table 3-4. Aquatic EECs (µg/L) for Esfenvalerate Uses in California.[1] 70

Table 3-5. Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Esfenvalerate with T-REX. 74

Table 3-6.Upper-Bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of the CRLF and its Small Mammalian Prey to Esfenvalerate. 75

Table 3-7. EECs (ppm) for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items. 76

Table 4-1. Summary of Esfenvalerate Toxicity Data Used to Assess Direct Effects, Indirect Effects, and Adverse Modification to Critical Habitat for the CRLF......................... 78

Table 4-2. Acute Toxicity of Esfenvalerate to Freshwater Fish. 82

Table 4-3. Chronic Toxicity of Esfenvalerate to Freshwater Fish... 82

Table 4-4. Acute Toxicity of Esfenvalerate to Freshwater Invertebrates. 84

Table 4-5. Chronic Toxicity of Esfenvalerate to Freshwater Invertebrates. 85
Table 4-6. Acute Oral and Subacute Dietary Toxicity of Esfenvalerate to Birds........................ 88
Table 4-7. Toxicity of Esfenvalerate to Mammals. 90
Table 4-8. Chronic Toxicity of Esfenvalerate to Mammals. 90
Table 4-9. Toxicity of Esfenvalerate to Non-Target Terrestrial Insects. 91
Table 5-1. RQs for Determination of Direct Effects to the Aquatic-Phase CRLF. 97
Table 5-2. RQs for Determination of Indirect Effects to the Aquatic-Phase CRLF Through Loss of Aquatic Invertebrate Food Base. 99
Table 5-3. Dietary- and Dose-Based Acute RQs for Determination of Direct Effects to the Terrestrial-Phase CRLF. 101
Table 5-4. RQs for Terrestrial Invertebrates for Determination of Indirect Effects to the Terrestrial-Phase CRLF. 103
Table 5-5. RQs for Terrestrial Mammals for Determination of Indirect Effects to the Terrestrial-Phase CRLF. 104
Table 5-6. Preliminary Effects Determination Summary for Esfenvalerate - Direct and Indirect Effects to the CRLF. 106
Table 5-7. Risk Hypothesis Revisited.. 113
Table 7-1. Effects Determination Summary for Direct and Indirect Effects of Esfenvalerate on the CRLF.. 122

List of Figures

Figure 2-1. Chemical Structures of Esfenvalerate and Related Compounds.............................. 11

Figure 2-2. Proposed Photodegradation Pathway of Esfenvalerate on Soil, Clay Mineral, and Humic Acid Surfaces based on Katagi 1991 and 1994. [1,2] 16

Figure 2-3. Average Total Pounds Applied in Each County for the Years 2002-2005. Counties applying on average more than 500 pounds per year were included in the figure. 28

Figure 2-4. Comparison of phases of the California Red-legged Frog (CRLF) life cycle to the average pounds esfenvalerate applied per month between 2003 and 2005. 31

Figure 2-5. Timing of Esfenvalerate Application: Average number of pounds of active ingredient applied in California for Almond and Peach, per month, between January 2002 through December 2005. Similar figures for other crops are available in........ 32

Figure 2-6. Pounds of Esfenvalerate Applied Each Year by Crop. 33

Figure 2-7. Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF 38

Figure 2-8. CRLF Reproductive Events by Month... 39

Figure 2-9. Conceptual Model for Pesticide Effects on Aquatic-Phase of the CRLF 51

Figure 2-10. Conceptual Model for Pesticide Effects on Terrestrial-Phase of the CRLF 52

Figure 2-11. Conceptual Model for Pesticide Effects on Aquatic Components of CRLF Critical Habitat 53

Figure 2-12. Conceptual Model for Pesticide Effects on Terrestrial Components of the CRLF Critical Habitat... 54

Figure 3-1. Total Pounds of Esfenvalerate Applied to Almonds by Month in 2005 based on CDPR PUR data.. 68

1.0 Executive Summary

The purpose of this assessment is to evaluate potential direct and indirect effects on the California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of esfenvalerate on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of the species' designated critical habitat. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

The CRLF was listed as a threatened species by USFWS in 1996. The species is endemic to California and Baja California (Mexico) and inhabits both coastal and interior mountain ranges. A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS, 1996) in California.

Esfenvalerate is an insecticide that has a variety of agricultural and non-agricultural uses, and is used both indoors and outdoors. Currently, there are over 150 labeled uses of esfenvalerate. An extensive list of these uses is provided in Section 2.4.4, as well as extensive lists of agricultural uses (see Table 2-3), non-agricultural uses (see Table 2-4), and uses qualitatively assessed in this document (see Table 2-6). A list of the uses that are considered as part of the federal action evaluated in this assessment includes: almonds, filberts, pecans, walnuts, broccoli, Chinese broccoli, cabbage, Chinese cabbage, cauliflower, collards, kohlrabi, mustard, corn (unspecified, pop, field, sweet), sunflower, apple, apricot, cherry, nectarine, peach, pear, plum, prune, cucumber, eggplant, melon (unspecified, cantaloupe, honeydew, musk, water), pumpkin, squash (unspecified, summer, winter), potato, turnip, artichoke, beans (dried, succulent), carrot, lentils, peas (unspecified, dried), pepper, sugar beet, cotton, kiwi, head lettuce, peanuts, radish, sugarcane, sorghum, tomato, Christmas trees, conifer plantations, seed orchards, forest tree nurseries, non-cropland, forest trees, softwoods, conifers, general outdoor surfaces, building perimeters, home and garden, lawn and grass, automobiles, kennels and animal housing areas, ant mounds and wasp and hornet nests, and mosquito breeding areas.

Available environmental fate data indicate that esfenvalerate is relatively stable to hydrolysis, with aerobic or anaerobic metabolism being the major pathways of degradation in soils and sediment. Under some conditions, photolysis may also be an important degradation pathway (Katagi11991; Katagi 1993; Castle *et al.* 1990, MRID 41728501). Esfenvalerate is relatively insoluble in water, isn't likely to volatilize, and, with a high K_{OC}, has a high tendency to sorb to soil and sediment. Major off site transport pathways for esfenvalerate will be spray drift during application and runoff, primarily sorbed to sediment. Esfenvalerate will persist in some environments, especially soils and sediments. A complete discussion of the environmental fate data is provided in Section 2.4.

Esfenvalerate consists of four stereoisomers (SS, RS, SR, RR); the active ingredient is enriched with the SS-isomer (75-90%) (Solomon *et al.* 2001; ATSDR 1993). In water, the SS-isomer may sterioisomerize into the RS and SR-isomers (Lee 1989, MRID 00146578). However, since the

SS-isomer is the most toxic to insects and data specific to the other individual isomers is limited, aquatic concentrations were estimated for the combined isomers and assumed toxicity equivalent to the more potent insecticidal SS-isomer (ATSDR 2003; Adelsbach *et al.* 2003; Eisler 1992).

No degradates are included in the exposure assessment as the only major aerobic and anaerobic degradate was carbon dioxide (Gaddamidi *et al*. 1992, MRID 42396801; Lee *et al*. 1985, MRID 00146578). Primary photolysis degradation products included carbon dioxide, 3-phenoxybenzyl alcohol, 3-phenoxybenzoic acid, and alpha-carbamoyl-3-phenoxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate (Katagi 1991; Katagi 1993; Castle *et al.* 1990, MRID 41728502). Degradation results in the breakage of the ester bond in the pyrethroid structure and the resulting degradates are not expected to add significantly to risk estimates based on esfenvalerate residues.

Monitoring data are available from the California Department of Pesticide Regulation (CDPR) for esfenvalerate in surface water and sediments. In surface water, esfenvalerate was detected in 0.8% of samples with concentrations ranging from 0.06 to 0.17 μg/L (CDPR, available at http://www.cdpr.ca.gov/docs/sw/surfdata.htm). CDPR also found esfenvalerate in 8% of sediment samples with concentrations ranging from 0.002 to 0.07 μg/g (ppm), or 20 to 70 ng/g (ppb). Weston *et al*. (2004) found esfenvalerate in 32% of sediment samples collected from the Central Valley of California with concentrations ranging from 10 to 30 ng/g (ppb). A complete discussion of the monitoring data is provided in Section 3.2.4.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey and its habitats to esfenvalerate are assessed separately for the two habitats. Tier-II aquatic exposure models are used to estimate high-end exposures of esfenvalerate in aquatic habitats resulting from runoff and spray drift from different uses. Peak model-estimated environmental concentrations resulting from different esfenvalerate uses range from 0.017 to 6.46 µg/L in the water column. These estimates are supplemented with analysis of available California surface water and sediment monitoring data from the CDPR. The maximum concentration of esfenvalerate reported by the CDPR surface water database from 2000-2005 (0.17 µg/L) is roughly 50 times lower than the highest peak model-estimated environmental concentration.

To estimate esfenvalerate exposures to the terrestrial-phase CRLF, and its potential prey resulting from uses involving esfenvalerate applications, the T-REX model is used mainly for aerial and ground spray applications. The AgDRIFT model is also used to estimate deposition of esfenvalerate on terrestrial and aquatic habitats from spray drift. The T-HERPS model is used to allow for further characterization of dose-based exposures of terrestrial-phase CRLFs relative to screening exposure estimates based on birds in T-REX.

The assessment endpoints for the CRLF include direct toxic effects on survival, reproduction, and growth, as well as indirect effects, such as reduction of the prey base or modification of its habitat. Direct effects to the CRLF in the aquatic habitat are based on toxicity information for freshwater fish, which are used as a surrogate for aquatic-phase amphibians when no amphibian data is available. In the terrestrial habitat, direct effects are based on toxicity information for birds, which are used here as a surrogate for terrestrial-phase amphibians. Given that the CRLF's prey items and primary constituent elements (PCEs) of designated critical habitat include or are dependent on the availability of freshwater aquatic invertebrates and aquatic plants, toxicity information for these taxonomic groups is also discussed. In the terrestrial habitat, indirect effects to the CRLF and effects to PCEs of designated critical habitat due to depletion of prey are assessed by considering effects to terrestrial insects, small terrestrial mammals, and frogs. Indirect effects and effects to PCEs of critical habitat due to modification of the terrestrial habitat are characterized by available data for terrestrial monocots and dicots; however, only information from the open literature is available by which to qualitatively discuss potential risks to plants. These are described.

Risk quotients (RQs), which are ratios of exposure estimates to appropriate toxicity measurement endpoints are used as estimates of potential risk in this assessment. Acute and chronic RQs are compared to the Agency's acute and chronic levels of concern (LOCs), respectively, to identify instances where esfenvalerate use within the action area has the potential to affect the CRLF and its designated critical habitat via direct toxicity or indirectly based on effects to its food supply (*i.e*., freshwater invertebrates, algae, fish, frogs, terrestrial invertebrates, and mammals) or habitat (*i.e*., aquatic plants and terrestrial upland and riparian vegetation) and the potential to affect PCEs of its designated critical habitat. When a RQ is below its respective LOC, the pesticide is determined to have "no effect" and where a RQ exceeds its respective LOC, a potential to cause effects is identified. One or more exceedances are used to draw a conclusion of "may affect." If a determination is made that use of esfenvalerate within the action area "may affect" the CRLF and its designated critical habitat, additional information is considered to refine the potential for exposure and effects, and the best available information is used to distinguish those actions that "may affect, but are not likely to adversely affect" (NLAA) from those actions that are "likely to adversely affect" (LAA) the CRLF and its designated critical habitat.

For indoor uses, a qualitative assessment rather than a quantitative approach with RQ calculations was performed. For indoor uses of esfenvalerate, exposure pathways to the CRLF or its designated critical habitat are incomplete and these uses of esfenvalerate were determined to have "No Effect" on the CRLF or its designated critical habitat. Indoor uses include:

- Interior vehicle uses (vehicles, boats, campers, railroad cars, truck trailers)
- Indoor uses: commercial, residential, and industrial buildings, grain storage facilities, cadavers and caskets, voids in equipment and structures, grain storage facilities

For the remainder of esfenvalerate uses, based on the best available information, the Agency makes a **Likely to Adversely Affect** determination for the CRLF. Additionally, the Agency has determined that there is the potential for modification of CRLF designated critical habitat from the use of the chemical. Direct effects are expected to the aquatic-phase CRLF as a result of acute risks for all uses, but also as a result of chronic risks for uses with high application rates. Indirect effects to the CRLF and effects to its designated critical habitat are also expected as a result of reduction in aquatic invertebrate, fish, and amphibian prey base. EFED does not have data to quantitatively assess risk to aquatic or terrestrial plants. However, based on indirect or supplemental evidence, adverse effects are not expected to occur as a result of losses of aquatic or terrestrial plants that provide food and/or habitat. Direct effects to the terrestrial-phase CRLF are expected due to acute risk to the CRLF as a result of uses with relatively high single application rates and/or high numbers of applications. Data are not available to reliably quantify chronic risk, but based on supplemental data for fenvalerate (made up of approximately equal amounts of the SS, SR, RS, and RR isomers), chronic risk is expected to occur for these uses as well. However, since these cannot be determined, our conservative conclusion is that direct effects may occur as a result of all uses. Indirect effects to the terrestrial-phase CRLF and its critical habitat are expected as a result of reductions in the terrestrial invertebrate, mammalian, and amphibian prey base. As with aquatic plants, data are not available to quantitatively assess effects to terrestrial plants; however, qualitative information in the open literature suggests that risk to terrestrial plants should not be expected at current label rates.

A summary of the risk conclusions and effects determinations for the CRLF and its designated critical habitat is presented in Table 1-1. Since data are not available to quantify plant risks and risk to plants is not expected; effects on critical habitat are expected to be the same as those identified for indirect effects to the CRLF. Use-specific determinations for direct and indirect effects to the CRLF are not provided, as our conclusions are applicable to each use. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2.

Table 1-1. Effects Determination Summary for Direct and Indirect Effects of Esfenvalerate on the CRLF and Effects to its Designated Critical Habitat.

Assessment Endpoint	Effects Determination[1]	Basis for Determination
Aquatic-Phase CRLF (Eggs, Larvae, and Adults)		
Direct Effects: Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	Likely to Adversely Affect	Acute LOCs for direct effects to the CRLF are exceeded for all uses and application rates. Uses that require high numbers of applications, regardless of their maximum single application rate, also result in direct chronic risk to the aquatic-phase CRLF. Probability of individual acute mortality was determined to be high based on RQs and the slope of dose-response. Incidents indicate potential for mortality with exposure to runoff following labeled uses. Exposure is expected in all areas occupied by CRLF.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants, fish, and frogs)	Freshwater invertebrates, fish, and other amphibians: Likely to Adversely Affect	Acute LOCs for aquatic invertebrates, fish, and other amphibians are exceeded for aquatic animals for all uses and application rates. The probability of mortality is high for aquatic invertebrates and fish. Uses that require high numbers of applications also result in chronic risk to these taxa.
	Non-vascular aquatic plants: Not Likely to Adversely Effect	Indirect effects resulting from losses of aquatic vascular and non-vascular plants as a food source or as a habitat component are not expected for current label rates based on supplemental information gathered in a mesocosm study submitted to OPP and from the field studies.

Assessment Endpoint	Effects Determination[1]	Basis for Determination
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	Vascular and Non-vascular aquatic plants: Not Likely to Adversely Affect	Indirect effects resulting from losses of aquatic vascular and non-vascular plants as a food source or as a habitat component are not expected for current label rates based on supplemental information gathered in a mesocosm study submitted to OPP and from field studies.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	Not Likely to Adversely Affect	EFED does not have aquatic plant toxicity data to estimate the risk to plants; however, based on studies available in the ECOTOX database, effects on terrestrial plants are expected to be unlikely.
Terrestrial-Phase CRLF (Juveniles and adults)		
Direct Effects: Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Likely to Adversely Affect	Acute risk to the CRLF has been identified for uses allowing numerous applications of 0.05 lbs ai/acre (*e.g.*, forestry uses – 25 apps/year), multiple applications at 0.075 lbs ai/acre and 0.1 lbs ai/acre, or single applications at higher rates. Estimated probability of acute mortality for an individual is high. A conservative conclusion is made that chronic effects may result from all uses based on supplemental information and the inability to quantitatively identify exposure levels that would not result in chronic effects. Overlap of esfenvalerate use is expected in all areas occupied by the CRLF.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	Terrestrial invertebrates: Likely to Adversely Affect	Acute LOCs for small and large insects are exceeded in all cases and the probability of an individual acute mortality is high. Overlap of use is expected for all areas occupied by the CRLF.
	Mammals: Likely to Adversely Affect	The acute and chronic LOCs are exceeded for all but one use and the probability of individual acute mortality is high. Overlap of use is expected for all areas occupied by the CRLF.
	Frogs: Likely to Adversely Affect	Since this conclusion was drawn for direct effects to the CRLF, risk is also presumed for other amphibians.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	Not Likely to Adversely Affect	EFED does not have aquatic plant toxicity data to estimate the risk to plants; however, based on supplemental information, effects on terrestrial plants are expected to be unlikely at the current use rates.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated to seek concurrence with the LAA determinations and to determine whether there are reasonable and prudent alternatives and/or measures to reduce and/or eliminate potential incidental take.

When evaluating the significance of this risk assessment's direct/indirect and habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (i.e., food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (i.e., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of CRLF life stages within specific recovery units and/or designated critical habitat within the action area. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the species.
- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual frogs and potential modification to critical habitat.

2.0 Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (U.S. EPA 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS 1998) and is consistent with procedures and methodology outlined in the Overview Document (U.S. EPA 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS 2004).

2.1 Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of esfenvalerate on a variety of agricultural (fruit and nut trees, corn, cole crops, melons, potatoes, and other vegetables) forestry, nursery, home and garden, and indoor/outdoor residential, commercial, and industrial uses (see Table 2-3, 2-4, and 2-5 for a detailed list of uses).

In addition, this assessment evaluates whether these actions can be expected to result in the modification of the species' designated critical habitat. Key biological information for the CRLF is included in Section 2.5, and designated critical habitat information for the species is provided in Section 2.6 of this assessment. This ecological risk assessment has been prepared consistent with a settlement agreement in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)) settlement entered in Federal District Court for the Northern District of California on October 20, 2006.

In this assessment, direct and indirect effects to the CRLF and potential modification to its designated critical habitat are evaluated in accordance with the methods described in the Agency's Overview Document (U.S. EPA 2004). Screening level methods include use of standard models such as PRZM-EXAMS, T-REX, and AgDRIFT, all of which are described at length in the Agency's Overview Document. An additional refinement includes an analysis of California use reporting data, use of the T-HERPS model to predict daily dietary intake specifically by the CRLF of esfenvalerate residues in terrestrial invertebrates and small mammal dietary items, and the probability of individual acute mortality based on dose-response slope data. Use of such information is consistent with the methodology described in the Agency's Overview Document, which specifies that "the assessment process may, on a case-by-case basis, incorporate additional methods, models, and lines of evidence that EPA finds technically appropriate for risk management objectives" (Section V, page 31 of U.S. EAP 2004).

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook*, the assessment of effects associated with registrations of esfenvalerate is based on an action area. The action area is considered to be the area directly or indirectly affected by the federal action, as indicated by the exceedance of the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level

FIFRA regulatory decision associated with a use of esfenvalerate may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the CRLF and its designated critical habitat within the state of California.

As part of the "effects determination," one of the following three conclusions will be reached regarding the potential use of esfenvalerate in accordance with current labels:

- "No effect";
- "May affect, but not likely to adversely affect"; or
- "May affect and likely to adversely affect".

Designated critical habitat identifies specific areas that have the physical and biological features, (known as primary constituent elements or PCEs) essential to the conservation of the listed species. The PCEs for CRLFs are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat (Section 2.6).

If the results of initial screening-level assessment methods show no direct or indirect effects (no LOC exceedances) upon individual CRLFs or upon the PCEs of the species' designated critical habitat, a "no effect" determination is made for use of esfenvalerate as it relates to this species and its designated critical habitat. If, however, potential direct or indirect effects to individual CRLFs are anticipated and/or effects may impact the PCEs of the CRLF's designated critical habitat, a preliminary "may affect" determination is made for the FIFRA regulatory action regarding esfenvalerate.

If a determination is made that use of esfenvalerate within the action area(s) associated with the CRLF "may affect" this species or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to the CRLF and other taxonomic groups upon which these species depend (e.g., aquatic and terrestrial vertebrates and invertebrates, aquatic plants, riparian vegetation, etc.). Additional information, including spatial analysis (to determine the geographical proximity of CRLF habitat and esfenvalerate use sites) and further evaluation of the potential impact of esfenvalerate on the PCEs is also used to determine whether modification of designated critical habitat may occur. Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the CRLF or the PCEs of its designated critical habitat. This information is presented as part of the Risk Characterization in Section 5.0 of this document.

The Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because esfenvalerate is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for esfenvalerate is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes (*i.e.*, the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of esfenvalerate that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the CRLF's designated critical habitat have been identified by the Services and are discussed further in Section 2.6.

2.2 Scope

The end result of the EPA pesticide registration process (*i.e*., the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (*e.g*., liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Thus, the use or potential use of esfenvalerate in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment.

Esfenvalerate is a synthetic pyrethroid that is registered for a variety of outdoor food/feed and non-food/non-feed uses in California. Uses for which esfenvalerate will be assessed using the risk quotient approach in this document are listed in Table 2-3 and 2-4. Formulations for the non-food/non-feed uses that will be assessed here include emulsifiable concentrate, microencapsulated, pressurized liquid, ready-to-use liquid, and wettable powder formulations. Products registered on food/feed uses that are included in this assessment include emulsifiable concentrate and ready-to-use liquid formulations. Application types for non-agricultural uses vary, including band spray, general surface spray, perimeter treatment, spot/crack/crevice treatment, fog, mount treatment, burrow treatment and others using a variety of equipment. Applications made in agricultural uses (including Christmas trees and nursery and forestry trees), include sprays made by aircraft, ground sprayer, hose-end sprayer, and sprinkler irrigation.

Esfenvalerate is also registered for many indoor food/feed and non-food/non-feed uses. Most of these are applied in spot and crack/crevice treatments, although some are also applied with a fogger. These uses are expected to be contained within the indoor environments intended for their use, and are not expected to result in exposure outside of the structure in which they are applied. **Therefore, these uses, which are listed in Table 2-5, will be considered to result in "no effect" to the CRLF and its designated critical habitat because the exposure pathways are considered incomplete.**

The uses considered in this risk assessment represent currently registered uses according to a review of all current labels. No other uses are relevant to this assessment. Any other reported use, such as may be seen in the CDPR Pesticide Use Reporting (PUR) database, represent either historic uses that have been canceled, mis-reported uses, or mis-use. Historical uses, mis-reported uses, and misuse are not considered part of the federal action and, therefore, are not considered in this assessment.

Although current registrations of esfenvalerate allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of esfenvalerate in portions of the action area that are reasonably assumed to be biologically relevant to the CRLF and its designated critical habitat. Further discussion of the action area for the CRLF and its critical habitat is provided in Section 2.7.

Transformation products and degradates

Estimated exposures are for all isomers (SS, SR, RS, and RR) of cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate. Esfenvalerate is comprised of 75-90% of the SS-isomer but under aqueous conditions it will also further transform into other isomers (Adelsbach *et al.* 2003; Solomon *et al.* 2001; ATSDR 1993). Degradates identified in environmental fate studies result from breakdown of the ester linkage (Figure 2-2) and are not of toxicological concern, relative to esfenvalerate, at the low level of exposures expected (Holmstead *et al.*1978; Kelley 2007).

Mixtures

The Agency does not routinely include, in its risk assessments, an evaluation of mixtures of active ingredients, either those mixtures of multiple active ingredients in product formulations or those in the applicator's tank. In the case of the product formulations of active ingredients (that is, a registered product containing more than one active ingredient), each active ingredient is subject to an individual risk assessment for regulatory decision regarding the active ingredient on a particular use site. If effects data are available for a formulated product containing more than one active ingredient, they may be used qualitatively or quantitatively in accordance with the Agency's Overview Document and the Services' Evaluation Memorandum (U.S., EPA 2004; USFWS/NMFS 2004).

Esfenvalerate has registered products that contain multiple active ingredients. Analysis of the available open literature and acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in APPENDIX A. The results of this analysis show that an assessment based on the toxicity of the single active ingredient of esfenvalerate is appropriate, as no discernable trends in potency that would suggest synergistic (*i.e*., more than additive) or antagonistic (*i.e*., less than additive) interactions were observed.

2.3 Previous Assessments

No assessment for a reregistration eligibility decision (RED) has been performed for esfenvalerate. Previous assessments for this chemical consist mainly of Section 24c Special Local Needs registrations and new use registrations. Data presented in these assessments were incorporated in this effects determination.

2.4 Stressor Source and Distribution

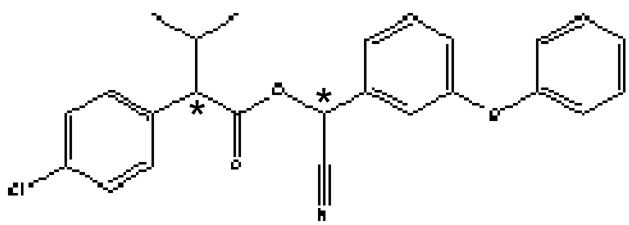
2.4.1 Environmental Fate Properties

The substance assessed is cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate. It has two chiral centers, one at the 2C position of the acid and one at the alpha C position of the alcohol (see Figure 2-1a), resulting in four possible isomers: RS, SR, SS, and RR. Fenvalerate is made up of approximately equal amounts of each isomer, while esfenvalerate is enriched with the SS-isomer (75 – 90%) (Adelsbach *et al.* 2003; Solomon *et al.* 2001; ATSDR 1993). The SS-alcohol (see Figure 2-1a), resulting in four possible isomers: RS, SR, SS, and RR. Fenvalerate is made up of approximately equal amounts of each isomer, while esfenvalerate is enriched with the SS-isomer (75 – 90%) (Adelsbach *et al.* 2003; Solomon *et al.* 2001; ATSDR 1993). The SS-isomer is a more effective insecticide than the other isomers (Solomon 2001; Katagi 1993). Sumitomo Chemical Company, Limited and Bayer Environmental Science canceled all products registered with fenvalerate as the active ingredient and esfenvalerate has replaced fenvalerate in most products (Kelley 2007).[1,2] Unless otherwise specified, all fate studies discussed were conducted using the SS-isomer.

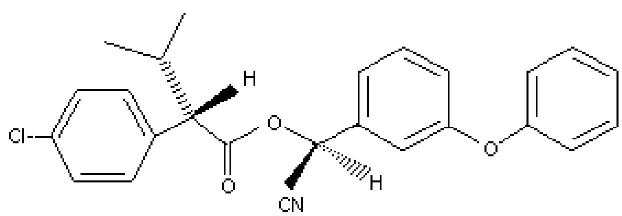
Figure 2-1 provides the chemical structure of esfenvalerate and related compounds and Table 2-1 lists the physico-chemical properties.

Figure 2-1. Chemical Structures of Esfenvalerate and Related Compounds

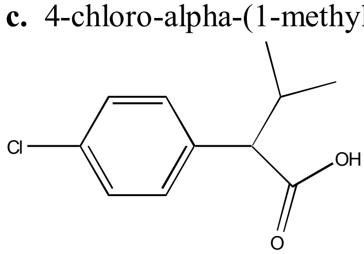
a. Cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate with chiral centers denoted with (*) at the 2C position of the acid and at the alpha C position of the alcohol (Eisler 1992).[1]



b. *(S)*-alpha-cyano-3-phenoxybenzyl *(S)*-2-(4-chlorophenyl)-3-methylbutyrate (esfenvalerate)[2]



c. 4-chloro-alpha-(1-methylethyl)-benzeneacetic acid (CPIA)



[1] Federal Register / Vol. 69, No. 150 / Thursday, August 5, 2004 / Notices / 47437 – 47439.

[2] Thirty-one products are still listed as active under the PC code for fenvalerate on the NPIRS database (http://ppis.ceris.purdue.edu/npublic.htm). For many of these products, the label lists the active ingredient as the SS-isomer (for examples see EPA Registration No. 498-186, 1021-1627, 11623-44). Other products do list fenvalerate as the active ingredient (for examples see EPA Registration No. 7056-169, 10806-61, 10806-73, 10806-87, 10806-93).

Property	Value (Method)	MRID #, Author[1]	Study Status, Date of Memorandum
	0.002 mg/L	Commission 2005 Open Lit., Kelley 2007	Screened
Log K_{OW}	>6 (OECD 117) 5.62 - >6 6.24 at 25°C	467253-04, Comb 2002 Open Lit., Laskowski 2002 Open Lit., European Commission 2005	Acceptable, 6/1/06 Screened Screened

[1] Open literature (lit.) indicates the study was obtained from the open literature and the study was not submitted to the EPA for review.
[2] Memorandum reviewing the product chemistry sent by Indira Gairola to George Larocca on June 1, 2006 indicated that the relative density was slightly lower (1.13) than that reported by Comb 2002.

Water and Sediment

The water solubility of esfenvalerate is low at 0.002 - <0.01 mg/L and it is hydrophobic (reported log K_{OW}s range from 5.62 to greater than 6.24) (Laskowski 2002; European Commission 2005; Comb 2002, MRID 467253-03). It is likely to sorb onto organic matter or suspended particles in the water column and in sediments (log K_{OC}s range from 4.93 to 5.8 mL/g) (Ohm 2001, MRID 45555102). In water, esfenvalerate sterioisomerizes into the RS and SR-isomers (Lee 1989, MRID 40999303; European Commission 2005). Hydrolysis rates in water are minimal and some photolysis may occur in shallow water where light is available (Stevenson 1987, MRID 40443801; Lee 1989, MRID 40999303).[2] The photolysis half-life was 6 days for the SS-isomer and 9 days for all isomers (Stevenson 1987, MRID 40443801).[3] Studies on microbial degradation of esfenvalerate in water and sediment were not submitted to the EPA for review. However, major degradates of esfenvalerate in water include carbon dioxide, 4-chloro-alpha-(1-methylethyl)benzeneacetic acid (CPIA), 2-(3-phenoxyphenyl)-3-(4-chlorophenyl)-4-methylpentane-nitrile (decarboxy-fenvalerate), and 3-phenoxybenzoic acid (Stevenson 1987, MRID 40443801; Lee 1989, MRID 40999303; European Commission 2005). No minor degradates were identified. As esfenvalerate has high sorption coefficients, it is not expected to remain in the water column, but most of it will sorb to organic materials or sediment. Samsoe-Petersen *et al*. (2001) measured degradation rates of [chlorophenyl-^{14}C]esfenvalerate and [phenoxyphenyl-^{14}C]esfenvalerate in pond sediment and 50 percent mineralization occurred between 73 and 350 days based on $^{14}CO_2$ evolution (Samsoe-Peterson *et al.* 2001). This indicates that esfenvalerate sorbed onto sediment is likely to persist. Stereoisomers were not accounted for in the study. However, the half-lives were based on measured $^{14}CO_2$ and it can be

[2] All isomers are stable to hydrolysis (Eisler 1992).
[3] The European Commission (2005) reported photolysis half-lives in water of 6 and 10 days and Laskowski (2002) reported a photolysis half-life in water of 17.2 days. Reviewed data indicate that 47 percent of the SS isomer is still present after seven days and 13 % is present in the SR and RS isomers (Dynamac Corp. 1988). Small amounts of 4-chloro-alpha–(1-methylethyl)-benzeneacetic acid (CPIA; up to 27.2 %) and 4-chloro-beta-(1-methylethyl)-alpha -(3-phenoxyphenyl)-benzenepropane-nitrile (decarboxy-fenvalerate; up to 12.4 percent) also formed (Dynamac Corp. 1988). The half-life for the sum of all isomers was calculated using data from Stevenson (1987) for this document. The analytical method used in the study could differentiate between the SR + RS and SS + RR isomers; it could not measure the individual isomers (Stevenson 1987; MRID 40443801).

assumed that conversion of the SS-isomer to other isomers was not considered mineralization or degradation (Samsoe-Peterson *et al.* 2001).

A field study examined the distribution of concentrations of esfenvalerate after application directly to a pond. Samsoe-Petersen *et al.* (2001) sprayed esfenvalerate directly onto a pond (25 g active ingredient (ai)/hectare, 0.022 lb ai/acre, near the highest recommended field dose in Denmark) and measured concentrations in the surface microlayer[4], water column[5], and sediment fractions[6]. Two weeks after application, the highest concentrations were found in sediment (9 μg/kg), with lower concentrations found on the surface microlayer (0.4 μg/L) and in the water column (0.05 μg/L) (Samsoe-Petersen *et al.* 2001). Percentages of the total amount applied in each compartment were not provided.

Soil

Overall data indicate that esfenvalerate is likely to bind to organic matter in soils and will degrade on the order of months to years via microbial degradation. When light does reach esfenvalerate in soil, photolysis can be an important degradation mechanism, especially when esfenvalerate is not bound to organic materials in soil (Katagi 1991; Katagi 1993). A field soil dissipation study measured a half-life of 7 to 14 days after a single surface application (0.5 lb/acre) to sandy loam to sandy clay loam soil from Madera, CA (Castle *et al*. 1990, MRID 41728502).[7] The European Commission (2005) estimated field dissipation half-lives of 62-126 days for a summer application and 68 – 87 days from an autumn application of esfenvalerate to bare sandy silt loam soil.

The main mechanisms of degradation in soil include anaerobic and aerobic degradation (Lee *et al.* 1985, MRID 00146578; Gaddamidi *et al*. 1992, MRID 42396801). Lee *et al.* (1985, MRID 00146578) measured an aerobic degradation half-life of 75 days in a silt loam soil and Gaddamidi *et al.* (1992, MRID 42396801) measured an anaerobic degradation half-life of 77 days in a Hanford loam soil.[8] The major degradation product was carbon dioxide and minor[9] degradation products included 4’’-chloro-(2’’’-isopropyl)phenylaceto-2-(3’-hydroxyphenoxy)phenylacetonitrile, alpha-carbamoyl-3-phenoxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate 3-phenoxybenzoic acid, and 4-(hydroxyphenoxy)benzoic acid (Dynamac Corp. 1986; Gaddamidi *et al.*1992, MRID 42396801). The soil aerobic and anaerobic degradation half-lives are much higher than the field dissipation half-life measured by Castle *et al.* (1990,

---

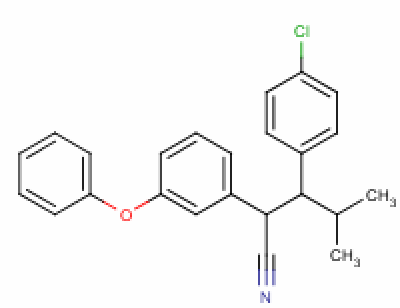
[4] The surface microlayer was sampled using a Garrett screen and the amount sampled corresponded to a thickness of 0.34 mm of water on the surface of the pond (Samsoe-Petersen *et al.* 2001).
[5] Water samples were collected at depths of 10 and 30 cm below the surface and 30 cm above the bottom (Samsoe-Petersen *et al.* 2001).
[6] Sediments samples were collected from the top 2 cm of the sediment column (Samsoe-Petersen *et al.* 2001).
[7] The plot was irrigated for 3-8 hours six times during the sampling period.
[8] Gaddamidi et al. (1992, MRID No. 423968-01) reported concentrations of $^{14}CO_2$, esfenvalerate, and bound residues. The material balance ranged from 90.9 – 100.3 % of total radioactivity and on day 60 up to 18.3 % of the total radioactivity was in bound residues, 49.7% was $^{14}CO_2$, and 27.9% was reported as esfenvalerate. No data was reported for other degradates or for other isomers as $^{14}CO_2$ was reported as the only major degradate. Not enough information was available to determine whether the results were specific to the SS isomer or to total isomers. As data was reported for esfenvalerate, the data is assumed to be specific to the SS-isomer.
[9] Minor degradates made up less than five percent of the amount applied.

MRID 41728501) (7-14 days) and in the same range as those reported by the European Commission 2005 (62-126 days). Field dissipation studies measure degradation in the field and allow for many types of degradation while anaerobic and aerobic degradation are specific to one type of degradation. Many variables could contribute to the different rates measured; however, we speculate that sunlight and irrigation contributed to the high rate of degradation in the Castle *et al.* (1990, MRID 41728502) study. It is also possible that esfenvalerate sorbed onto soil and organic particles and remained resistant to analytical extraction methods used.

The open literature also reported data on aerobic and anaerobic metabolism. Laskowski (2002) reported that aerobic soil half-lives ranged from 15 to 546 days with an average of 107 days and Kelley (2007) reported anaerobic soil half-lives ranged from 104 to 203 days with an average of 154 days (see APPENDIX J).

As illustrated in Figure 2-2**,** the photodegradation of esfenvalerate can involve the breakdown of the ester linkage (Katagi 1991, 1993). Hydration of the cyano group and ether cleavage in the alcohol moiety can also be enhanced with sunlight (Katagi 1991). Minimal photolysis occurred in a sandy loam soil, possibly due to binding of esfenvalerate to materials in the sandy loam soil (Castle 1990, MRID 41728502). However, other research shows that esfenvalerate may undergo photolysis in some soil types. Laskowski (2002) reported photolysis half-lives in soil of 14.4 to 17.2 days in dry soils of unspecified type and Katagi (1991, 1993) reported photolysis half-lives in soil ranging from < 1 day in kaolinite and montmorillonite to 100 days in a Noichi upland soil. Graebing (2004) reported a photolysis half-life in sandy loam soil of 30 days. Primary photolysis degradation products included carbon dioxide, 2-(3-phenoxyphenyl)-3-(4-chlorophenyl)-4-methylpentanenitrile, 3-phenoxybenzyl alcohol, 3-phenoxybenzoic acid, and alpha-carbamoyl-3-phenoxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate (Katagi 1991; Katagi 1993; Castle *et al.* 1990, MRID 41728501).

d. 4-chloro-beta-(1-methylethyl)-alpha -(3-phenoxyphenyl)-benzenepropane-nitrile (decarboxyfenvalerate)[3]



[1] Structure obtained from Chemfinder available at http://chemfinder.cambridgesoft.com/ (accessed 1/11/2008)
[2] Structure obtained from IPCSINTOX Databank from the UK National Poisons Information Service Monograph for esfenvalerate available at http://www.intox.org/databank/documents/chemical/esfenval/ukpid63.htm (accessed 1/11/2008).
[3] Structure obtained from Toxnet available at http://toxnet.nlm.nih.gov/index.html (accessed 1/14/2008).

Air

Esfenvalerate has a vapor pressure of approximately 0.063 mPa and an estimated Henry's Law constant of greater than 1.87 Pa-m^3/mol, indicating it is not likely to volatize at environmental temperatures (Comb 2002, MRID 467253-04). The European Commission (2005) reported a photochemical oxidative degradation half-life of 1.2 days based on the Atkinson method and Comb (2002, MRID 467253-04) estimated a half-life of 5.8 hours using the Simplified Molecular Input Line Entry System (SMILES), indicating that esfenvalerate is not persistent in air. Based on the short half-life, it is not expected to undergo long range transport. As these photolysis rates are both estimates, the degradates were not measured or identified. Major and minor degradates are expected to be similar to those discussed for photolysis in other media.

Table 2-1. Summary of Physico-Chemical Properties of Esfenvalerate.

Property	**Value (Method)**	**MRID #, Author[1]**	**Study Status, Date of Memorandum**
Empirical Formula	$C_{25}H_{22}ClNO_3$		
Molecular Weight	419.9 g/mol		
Melting Point	59.5 – 61.5 ^{o}C (OECD 102)	467253-05, Comb 2002	Acceptable, 6/1/06
Boiling Point	Not determinable (OECD 103)	467253-03, Comb 2002	Acceptable, 6/1/06
Relative Density	1.13 g/cm^3 at 23^{o}C(OECD 109)[2]	467253-03, Comb 2002	Acceptable, 6/1/06
Vapor Pressure	6.3 x 10^{-5} Pa at 25^{o}C (OECD 109) 6.7 x 10^{-5} Pa	467253-04, Comb 2002 Open Lit., Jones 2002, Laskowski 2002	Acceptable, 6/1/06 Screened
Henry's Law Constant	>1.87 Pa-m^3/mol at 25^{o}C (estimated) 1.4 x 10^{-7} Pa-m^3/mol	467253-04, Comb 2002 Open Lit., Laskowski 2002	Not Reviewed Screened
Water Solubility	< 0.01 mg/L at 20^{o}C (OECD 105) 0.006 mg/L	467253-03, Comb 2002 Open Lit., Laskowski 2002, European	Acceptable, 6/1/06 Screened

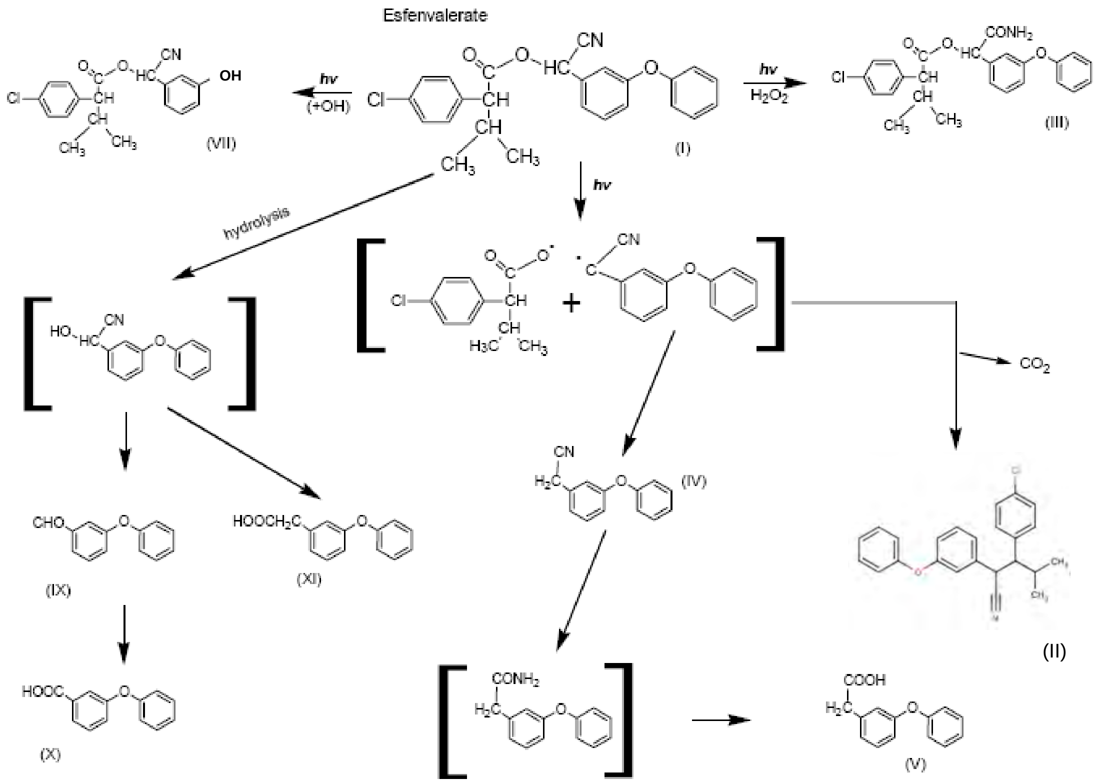


Figure 2-2. Proposed Photodegradation Pathway of Esfenvalerate on Soil, Clay Mineral, and Humic Acid Surfaces based on Katagi 1991 and 1994. [1,2]

[1] This figure was copied from Kelley 2007 with degradates (II) and (VII) corrected based on Katagi 1991.
[2] Below is a list of degradation products of esfenvalerate shown in Figure 2-2. Major degradates are denoted by an asterisk (*) after the name.

2-(3-phenoxyphenyl)-3-(4-chlorophenyl)-4-methylpentanenitrile (II)*
alpha-carbamoyl-3-phenoxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate (III)*
3-phenoxybenzyl cyanide (IV)
3-phenoxyphenylacetic acid (V)
alpha-cyano-3-(4-hydroxyphenoxy)benzyl 2-(4-chlorophenyl)-3-methylbutyrate (VI)
alpha-cyano-3-hydroxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate (VII)
alpha-cyano-3-cyanobenzyl 2-(4-chlorophenyl)-3-methylbutyrate (VIII)
3-phenoxybenaldehyde (IX)
3-phenoxybenzoic acid (X)*

Groundwater

Based on a leaching study and high K_{OW}s, K_ds, and K_{OM}s, esfenvalerate is unlikely to leach into ground water (Merritt 1992, MRID 42350201; Ohm 2001, MRID 45555102; Houston 1978).

Bioaccumulation

Carp (*Cyprinus carpio*) were exposed to 0.046 – 0.061 parts per billion ^{14}C-esfenvalerate labeled at the phenoxyphenyl group or ^{14}C-esfenvalerate labeled at the chlorophenyl group for 28 days followed by a 14 day depuration phase. Total radioactivity, SS-isomer, SR-isomer, and metabolites were measured in carp. Daily bioconcentration factors (BCF) for total isomer residues ranged from 334-3650 (Oshima *et al*. 1991, MRID 42922401; Oshima *et al*. 1993, MRID 42922401).[10] Approximately 70% of accumulated radioactivity and residues were eliminated during the 14-day depuration period, resulting in an estimated half-life of 7-8 days. This indicates that after exposure to the esfenvalerate stops, approximately half of the esfenvalerate and its metabolites in the carp will be removed from the fish in 7 to 8 days. The metabolic pathways were oxidation of the 4' position of the alcohol moiety and the 3 position of the acid moiety, cleavage of the ester linkage, and conjugation of the resultant phenol and acid with glucuronic acid or sulfuric acid (Oshima et al. 1993, MRID 42922401). The major metabolites were the glucuronide of 4'-OH-fenvalerate (contributing to up to 6-34% of ^{14}C in fish), 4'-OH-fenvalerate (contributing to up to 1-5% of ^{14}C in fish), sulfate of 4'-OH-PB acid (contributing to up to 2-6% of ^{14}C in fish), and CPIA (contributing to up to 6-15% of ^{14}C in fish) (Oshima *et al.* 1991, MRID 42170501).

When metabolism, growth dilution, and other confounding factors are ignored, bioconcentration factors are expected to increase with increasing log K_{OW}s (for log K_{OW} up to ~ 6) (Gobas *et al.* 2000; Bintein *et al.* 1993). Using the relationship published by Mackay between K_{OW} and BCF, results in a predicted BCF of 48000 or log BCF of 4.68 for esfenvalerate (Gobas *et al*. 2000).[11] This indicates that esfenvalerate has a high potential to bioconcentrate in organisms. However, measured BCFs for carp are much lower than predicted and significant bioconcentration is not expected to occur in organisms that readily metabolize pyrethroids such as mammals and birds. Mammals and birds tend to metabolize pyrethroids while insects are more susceptible to toxicity and bioconcentration because of less developed metabolic systems (Eisler 1992). The ability of fish to metabolize pyrethroids varies. For example, carp are known to have a well developed esterase metabolism that will metabolize esfenvalerate, thus reducing its bioconcentration and toxicity (Adelsbach *et al.* 2003). On the other hand, rainbow trout are known to have decreased rates of metabolism and low rates of esterase activity for pyrethroids; they are more susceptible to toxicity and bioconcentration of esfenvalerate (Adelsbach *et al.* 2003). Amphibians in later developmental stages may have a more developed metabolic system than their younger counterparts and amphibians in developmental stages can be more susceptible to xenobiotic toxicity (Greulich *et al.* 2003).

---

[10] The registrant submitted results comparing bioconcentration of d-trans-Phenothrin in carp and bluegill. The study showed similar bioconcentration and metabolism and a study on esfenvalerate with carp was accepted to fulfill the bioaccumulation study requirements (Review memo dated 11/29/1994).

[11] The BCF was estimated using the equation BCF = 0.048 Kow and a log Kow of 6. This value was estimated to qualitatively show the bioconcentration potential of esfenvalerate (Gobas *et al.* 2000). It should be used with caution for other purposes as the log Kow approaches the limit of the relationship and significant metabolism is expected in many organisms (Gobas *et al.* 2000; Eisler 1992).

Degradates

The major pathway of degradation in soils and sediments is expected to be aerobic or anaerobic metabolism. The only major aerobic and anaerobic degradate was carbon dioxide (Gaddamidi *et al*. 1992, MRID 42396801; Lee *et al*. 1985, MRID 00146578). When sunlight is available, photolysis may occur and photolysis degradates include up to 27.2 % CPIA and 12.4 % decarboxy-fenvalerate (Dynamac 1988). Based on the data available, decarboxy fenvalerate is less toxic (rat oral LD50 was 67-87 mg/kg for esfenvalerate and >500 mg/kg for decarboxyfenvalerate) and concentrations of decarboxyfenvalerate will be much lower, approximately 87% lower, than the parent compound (Kelley 2007; Holmstead *et al.* 1987). No toxicity data were available for CPIA; however, breaking the ester bond is expected to significantly decrease the toxicity of the substance as compared to the parent compound. As the expected toxicity and exposure of the degradates do not exceed that of esfenvalerate, they were not considered to contribute substantially to the toxicity exposure. The SS-isomer may sterioisomerize into the RS and SR-isomers in water. However, application rates are based on the SS-isomer and half-lives used in the exposure estimates are based on breakdown of the combined isomers. Thus, in the aquatic environment, the estimated concentration of the SS-isomer represents the sum of all isomers present or the maximum concentration of the SS-isomer. As the SS-isomer is the most toxic isomer for insects and only limited toxicity data is available for other individual isomers, this may be assumed to be the most protective assumption (ATSDR 2003; Adelsbach *et al.* 2003; Eisler 1992).[12]

Summary of Environmental Fate Properties

Table 2-2 lists the environmental fate properties of esfenvalerate, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

Table 2-2. Summary of Esfenvalerate Environmental Fate Properties.

Study	**Value, SS-isomer/All Isomers[1] (units)**	**Major Degradates** ***Minor Degradates***	**MRID #, Author[2]**	**Study Status (Date of Memorandum Referenced)**
Hydrolysis	Minimal degradation in 30 days at pH 5, 7, 9, All isomers	Not Applicable	40999303, Lee 1989	Acceptable (3/14/1991)
Direct Aqueous Photolysis	$T^{1/2}$ = 6 days at pH 5, SS-isomer $T^{1/2}$ = 9 days, All isomers	CO_2, CPIA, decarboxyfenvalerate	40443801, Stevenson 1987 40443801, Stevenson 1987	Acceptable (1/5/1988 ,7/27/1992) Calculated for this review
Soil Photolysis	Minimal in 30 days, SS-isomer[3]	*CO_2, CPIA, decarboxy-fenvalerate*	41728501 Castle *et al.*	Acceptable (3/6/1991)

[12] When the SS-isomer is used in aquatic toxicology studies it will also undergo isomerization when placed in water. The only way to ensure exposure to one isomer to be able to compare the toxicity of the different isomers to aquatic organisms would be to inject the organism.

Study	Value, SS-isomer/All Isomers[1] (units)	Major Degradates *Minor Degradates*	MRID #, Author[2]	Study Status (Date of Memorandum Referenced)
			1990	
	Range from < 1 day in kaolinite to 100 days in a Noichi upland soil, SS-isomer	3-phenoxybenzyl alcohol, 3-phenoxybenzoic acid, and decarboxy fenvalerate	Open Lit., Katagi 1991, Katagi 1993	Screened
Aerobic Soil Metabolism	$T^{1/2}$= 75 days in silt loam soil, SS-isomer[3]	CO_2, *4''-chloro-(2'''-isopropyl)phenylaceto-2-(3'-hydroxyphenoxy)phenylacetonitrile, alpha-carbamoyl-3-phenoxybenzyl 2-(4-chlorophenyl)-3-methylbutyrate 3-phenoxybenzoic acid, and 4-(hydroxyphenoxy)benzoic acid*	00146578, Lee *et al*. 1985	Acceptable (11/29/1994)
	Reported range of 15 – 546 days in literature with an average of 107 days		Open Lit., Laskowski 2002	Screened
Anaerobic Soil Metabolism	$T^{1/2}$ = 77 days in sandy loam, SS-isomer[3]	CO_2, *4''-Chloro-(2'''-isopropyl)phenylaceto-2-(3'-hydroxyphenoxy)phenylacetonitrile, 4''-chloro-(2'''-isopropyl)phenylaceto-2-(3'-phenoxy)phenylacetamide, 3-phenoxybenzoic acid, and 4-(hydroxyphenoxy)benzoic acid*	42396801 Gaddamidi *et al*. 1992	Acceptable (3/30/1993)
	Reported range of 104 - 203 days with an average of 154 days		Open Lit., Kelley 2007	Screened
Anaerobic Aquatic Metabolism	Not available	Not available		
Aerobic Aquatic Metabolism	Not available	Not available		

Study	Value, SS-isomer/All Isomers[1] (units)	Major Degradates *Minor Degradates*	MRID #, Author[2]	Study Status (Date of Memorandum Referenced)
$K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g) $K_{oc\text{-}ads}$ / $K_{oc\text{-}des}$ (mL/g) K_{OM} (mL/g)	600, 700, 750, 1,700, 5,200, 15,500 (sandy loam, sandy clay loam, silt loam, loam, loamy sand, silt clay loam) 85,700, 140,000, 141,700, 171,700, 375,000, 596,200 (sandy loam, sandy clay loam, loam, loamy sand, silt loam, silt clay loam) 50,000, 77,800, 85,000, 101,000, 187,500, 352,300 (sandy loam, sandy clay loam, loam, loamy sand, silt loam, silt clay loam)	Not applicable Not applicable Not applicable	45555102 Ohm 2001	Not Reviewed
Terrestrial Field Dissipation	$T^{1/2}$ = 14 days in sandy loam/sandy clay loam, Isomer information was not specified	Not reported	41728502 Castle *et al.* 1990 and supplement	Acceptable (7/27/1992)
Aquatic Field Dissipation	Not available	Not available		
Bioconcentration Factor	334-3650 Carp, All isomers	Metabolites included glucuronide of 4'-OH-fenvalerate, CPIA, *4'-OH-fenvalerate, and sulfate of 4'-OH-PB acid*	42922401 Oshima *et al.* 1993 42170501 Oshima *et al.* 1991	Acceptable (11/29/1994)

[1] Cyano-3-phenoxybenzyl-2-(4-chlorophyl)-3-methylbutyrate has four different isomers. All fate studies were conducted using the SS-isomer but the rate data may apply to the SS-isomer or total isomers as the SS-isomer may undergo isomerization. If the SS-isomer is listed the data was specific to the SS-isomer. If all isomers is listed, then the rate data is specific to total isomers.

[2] Open literature (lit.) indicates the study was obtained from the open literature and the study was not submitted to the EPA for review.

[3] Limited information was available on the various isomers in the study. However, the value was reported as specific to esfenvalerate or the SS-isomer.

2.4.2 Environmental Transport Mechanisms

Potential transport mechanisms include pesticide surface water runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. Surface water runoff and spray drift are expected to be the major routes of exposure for esfenvalerate. Because of its high tendency to sorb to soil (as evidenced by high K_d/K_{OC} values), esfenvalerate is expected to reach water bodies primarily sorbed to sediment. With its persistence, esfenvalerate may accumulate in sediment, where it may be a reservoir for exposure for benthic organisms Esfenvalerate is not persistent in the atmosphere and is not expected to migrate via long range transport.

In general, deposition of drifting or volatilized pesticides is expected to be greatest close to the site of application. Computer models of spray drift (AgDRIFT) are used to determine potential exposures to aquatic and terrestrial organisms via spray drift. Since esfenvalerate is expected to be used in all areas occupied by the CRLF, use of spray drift modeling was done to examine the potential for spray drift buffers to mitigate effects by using the estimated fraction spray drift with the buffer to estimate exposure.

2.4.3 Mechanism of Action

Esfenvalerate is a type two synthetic pyrethroid. The primary mechanism of action of pyrethroids is interference with the closing of voltage-dependent sodium channels, resulting in repetitive firing of neurons (ATSDR 2003). After exposure the organism may exhibit hyperexcitation, tremors, convulsions, and/or salivation, followed by lethargy, paralysis, and death (Kelley 2007). Type two pyrethroids, those that contain a cyano group in the alcohol and halogen in the acid, are also reported to have effects at the presynaptic membrane of voltage-dependent calcium channels and to interfere with ATPase enzymes involved with maintaining ionic concentration gradients across membranes (Solomon *et al*. 2001).

2.4.4 Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for esfenvalerate represents the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs. APPENDIX H lists the labels where esfenvalerate is an active ingredient (ai) and that are assessed in this document.

Esfenvalerate is a broad spectrum nonselective insecticide that is used to control a variety of insects in agriculture, commercial, residential, and industrial settings both indoors and outdoors. National uses are similar to those registered in California. Three labels[13] cover uses for agricultural crops, including the following general categories of food crops: almonds, filbert, pecan, walnut, broccoli, Chinese broccoli, cabbage, Chinese cabbage, cauliflower, collards

[13] Agricultural labels include Dupont Asana ® XL (EPA Registration Number 352-515, label date April 6, 2006), Esfenvalerate AG (EPA Registration Number 53883-135, label date September 17, 2004), and EsfenStar 8% EC (EPA Registration Number 71532-21, label date April 24, 2007). All information on the agricultural uses come from these three labels. In California, Dupont Asana ® XL may also be referred to as Adjourn Insecticide and is the only agricultural label listed as registered in California in the National Pesticide Information Retrieval System (NPIRS) available at http://ppis.ceris.purdue.edu/npublic.htm. However, the other labels do not state not to use the product in California.

kohlrabi mustard, corn (unspecified), field corn, pop corn, sweet corn, sunflower, apple, apricot, cherry, nectarine, peach, pear, plum, prune, lettuce, head, cucumber, eggplant, melons, cantaloupe, honeydew, musk melons, watermelons, pumpkin, squash, summer squash, winter squash, radish, turnip, white/Irish potato, artichoke, dried type beans, succulent (snap) beans, carrot, lentils, peas, dried-type peas, pepper, sugar beet, tomato, kiwi, peanuts, sugarcane, sorghum[14], and soybeans[15]. Agricultural nonfood crop uses include cotton, Christmas tree plantings, conifer plantations, conifer seed orchards, forest tree nurseries, and non-cropland (excluding public land such as forests, parks, or recreational areas). Dupont Asana® XL is also registered for a special local need, *e.g.*, a 24C label, for the control of grasshoppers and crickets on forest sites in California (EPA Registration Number CA-990022). The agricultural formulations are all sold as emulsifiable concentrates. In general, all crops may be treated via chemigation (via an irrigation system), aerial, and ground application methods. Esfenvalerate may not be applied by ground within 25 feet or by aerial methods within 150 feet of lakes, reservoirs, rivers, permanent streams, marshes, natural ponds, estuaries, or commercial fish ponds. The buffer zone must be increased to 450 feet when an ultralow volume (ULV) application is made. Esfenvalerate may be applied at plant as well for corn and sugarbeet. Table 2-3 specifies the maximum application rates for each agricultural use. Labels did not specify a maximum number of applications per year; however, this may be inferred from the maximum single application rate and the maximum seasonal application rates.

Table 2-3. Labeled Agricultural Uses Assessed in this Document.[1]

Crop Group	Crop/ Use	Maximum Single Application Rate (lbs ai/acre)	Maximum Seasonal Rate (lbs ai/acre)	Seasons per Year[2]	Application Interval (days)
Tree Nuts	Almonds	0.1	0.2	1[3]	NS[4]
	Filbert	0.1	0.2	1[5]	NS and 7
	Pecan	0.075	0.3	1[5]	7
	Walnut	0.1	0.2	1[6]	7
Cole Crops	Broccoli	0.05	0.4	1 to 2	NS and 7
	Broccoli, Chinese	0.05	0.4	1 to 2	NS
	Cabbage	0.05	NS	1 to 3	NS
	Cabbage, Chinese	0.05	0.4	1 to 3	NS
	Cauliflower	0.05	0.4	1 to 2	NS
	Collards	0.05	0.2	2 to 3	NS
	Kohlrabi	0.05	0.35	2 to 3[5]	NS
	Mustard	0.05	0.2	2 to 3[5]	NS
Corn	Corn	0.05	0.5	see below	NS
	Corn, field	0.05	0.25	1	NS
	Corn, field-at plant	0.0023 lbs ai per 1000 sq ft of row	0.05	1	
	Corn, pop	0.05	0.5	1	NS
	Corn, sweet	0.05	0.5	1 to 2	NS

[14] Use on sorghum is restricted in California on two agricultural labels but is not restricted for Esfenvalerate AG.
[15] Soybeans are not commonly grown in California and were not assessed in this document.

Crop Group	Crop/ Use	Maximum Single Application Rate (lbs ai/acre)	Maximum Seasonal Rate (lbs ai/acre)	Seasons per Year[2]	Application Interval (days)
	Sunflower	0.05	0.2	1 to 2[5]	NS
Fruit	Apple	0.075	0.525 lbs	1	7
	Apricot	0.075	0.375 / 0.3 between bloom and harvest	1[5]	NS
	Cherry	0.075	0.375 / 0.3 between bloom and harvest	1[5]	NS
	Nectarine	0.075	0.375 / 0.3 between bloom and harvest	1	NS
	Peach	0.075	0.375 / 0.3 between bloom and harvest	1	NS
	Pear	0.075 season / 0.075 between bloom and harvest / 0.1 dormant	0.375 season / 0.225 between bloom and harvest / 0.2 dormant	1	NS
	Plum	0.075	0.375 / 0.3 between bloom and harvest	1[7]	NS
	Prune	0.075	0.375 / 0.3 between bloom and harvest	1[7]	NS
Cucumbers, Squash, and Melons	Cucumber	0.05	0.25	1	NS
	Eggplant	0.05	0.35	1	7-10
	Melons	0.05	0.25	1	NS
	Melons, cantaloupe	0.05	0.25	1	NS
	Melons, honeydew	0.05	0.25	1	NS
	Melons, musk	0.05	0.25	1[5]	NS
	Melons, water	0.05	0.25	1[5]	NS
	Pumpkin	0.05	0.25	1	NS
	Squash (unspecified)	0.05	0.25	1[5]	NS
	Squash (summer)	0.05	0.25	1	NS
	Squash (winter)	0.05	0.25	1[5]	NS
Potato	Potato, white/Irish	0.05	0.35	1	NS
	Turnip	0.05	0.5	1[5]	NS
Row Crops	Artichoke	0.05	0.15	1[7]	7
	Beans, dried type	0.05	0.2	1	NS and 7
	Beans, succulent (snap)	0.05	0.2	1	NS and 7
	Carrot	0.05	0.5	1	NS
	Lentils	0.05	0.2	1	NS
	Peas (unspecified)	2.892E-04 lb/gal	NS	1	NS and 7
	Peas, dried-type	0.05	0.2	1[5]	7
	Pepper	0.05	0.35	1	7
Sugar beet	Sugar beet	0.05	0.15	1	NS
	Sugar beet-at plant	0.0023 lbs ai per 1000 sq ft of row	0.05 at plant, 0.25 at plant and foliar	1	NS
Crops Not	Cotton (unspecified)	0.05	0.5	1	NS

Crop Group	Crop/ Use	Maximum Single Application Rate (lbs ai/acre)	Maximum Seasonal Rate (lbs ai/acre)	Seasons per Year[2]	Application Interval (days)
in Groups	Kiwi	0.05	0.35	1[7]	7
	Lettuce, head	0.05	0.35	1-2	NS
	Peanuts	0.05	0.15		NS
	Radish	0.05	0.1	3-5	NS
	Sugarcane	0.05	0.2		NS
	Sorghum	0.05	0.15	1 crop for grain, hay several times per year	NS
	Tomato	0.05	0.5	1	NS
Forest Tree Nursery and Tree Nursery	Christmas tree plantings, Conifer plantations seed orchards, Forest tree nurseries	0.05	1.6	1	NS, 7 for 2 sprays or every 28
Non-cropland	Prevent pests from getting to cropland	0.05	0.5	NS	NS

[1] Unless at plant application is specified in the Crop/Use column, esfenvalerate may be applied using aerial , ground, and chemigation methods
[2] Seasons per year were obtained from Memorandum from Monisha Kaul in BEAD to Melissa Panger in EFED dated 2/28/2007, unless stated otherwise.

[3] Mosz, N. Almond Timeline, 2002. Online: http://pestdata.ncsu.edu/croptimelines/pdf/CAalmond.pdf

[4] NS stands for not specified

[5] Seasons per year were assumed from similar crops in the crop grouping.

[6] Mosz, N. Walnut Timeline, 2002. Online: http://pestdata.ncsu.edu/croptimelines/pdf/CAwalnut.pdf
[7] USDA crop profiles, available online at http://cipm.ncsu.edu/cropprofiles/cropprofiles.cfm (accessed on December 1, 2007).

There are approximately 132 non-agricultural products registered nationally[16] and 81 products in registered in California[17]. Non-agricultural labels allow for use in commercial, industrial, and residential settings, including homes, office buildings, restaurants, schools, motels, barns, industrial buildings, poultry housing, feedlots, railroad cars, lawns, apartment buildings, warehouses, theatres, pet housing, kennels, dairy barns, truck trailers, milk rooms, livestock housing, garbage bins and receptacles, athletic facilities, trees, vehicles, boats, campers, ornamental trees and landscapes, along subterranean cables, poles, and post holes, alleys, general outdoor areas, and general indoor areas. Non-agricultural products may also be used in the home and garden and may be used on food crops such as fruits, tree nuts, vegetables, beans, melons, and nonfood crops such as ornamentals, shrubs, roses, shade trees, etc. Residential uses allow for use on blueberries and caneberries (blackberries, boysenberries, dewberries, loganberries, raspberries, youngberries, and varieties of these) while these uses are prohibited in California on

---

[16] Based on Office of Pesticides Information Network (OPPIN) search of pending and active registrations searched on November 14, 2007.
[17] Label numbers based on NPIRS state search by active ingredient on November 14, 2007. Some EPA registration numbers have more than one trade name and are listed multiple times on the list of products.

agricultural crops. Indoor uses include as a crack and crevice treatment, spot treatments, surface spray, foggers to treat insects such as ants, crickets, cockroaches, ticks, and various other insects. Outdoor uses include uses such as building perimeter, swarming termites, wood destroying pests, lawns, general outdoor surfaces, turf grass, automobiles, ant mounds, hornet and wasp nests, and mosquito breeding areas. Mosquito breeding areas are defined by the labels as sites where mosquitoes rest, harbor, or breed such as in tall grass, shrubbery, backyards, lawns, and around windows and doors (EPA Registration No. 1021-1815 and 1021-1794). Formulations are sold as emulsifiable concentrates, wettable powders, microencapsulation, ready-to-use liquids, and pressurized liquids. Application methods include spray, pressurized spray, hose-end spray, power sprayer, aerosol spray, tank top sprayer, compressed air sprayer, and fogger. Maximum single application rates for non-agricultural uses are provided in Table 2-4. Most of these labels did not give a maximum amount of esfenvalerate to apply per season or year. They usually supplied a maximum amount applied per specified area. Indoor uses listed in Table 2-5 were assumed to have incomplete exposure pathways to the CRLF and its designated critical habitat.

Table 2-4. Labeled Non-agricultural Uses Assessed in this Document.[1,2]

Use Group	Specific Uses	Maximum Single Application Rate (lbs ai / acre)	Maximum Seasonal Rate (lbs ai / acre)	Application Methods	Application Interval (days)
Forests	Forest Trees (all or unspecified), Softwoods, Conifers	0.05	1.6	ground, aerial	As needed
Residential, Commercial, and Industrial Areas: Agricultural/farm structures/buildings and equipment, Commercial Storage/warehouse premises, Non-agricultural Outdoor Buildings/structures, Non-agricultural Uncultivated Areas/soils, Recreation Areas	General Outdoor Surfaces: Unspecified, Paths and Patios, Refuse/Solid Waste Sites	0.51	NS	spray	NS
	Building Perimeter	0.2	NS	spray, microencapsulation	NS and 7
	Home and Garden: Ornamental Trees and Plants, Herbaceous Plants, Nonflowering Plants, Woody Shrubs and Vines, Fruits, Nuts, Berries and Vegetables, Shade Trees	NS	NS	spray	NS and 7 to 14
	Lawn and Grass	0.2	NS	spray, microencapsulation	NS
	Outside of Automobiles, Vehicles, Taxis, Limousines, Truck Trailers, Railroad Cars, Tires	NS	NS	spray, fogger	NS
	Kennels and Animal Housing Areas	0.1	NS	spray, fogger	NS

Use Group	Specific Uses	Maximum Single Application Rate (lbs ai / acre)	Maximum Seasonal Rate (lbs ai / acre)	Application Methods	Application Interval (days)
	Ant Mounds and Wasp and Hornet Nests	NS	NS	spray, fogger, microencapsulation	NS
	Mosquito breeding areas	0.2	NS	spray, microencapsulation	NS

[1] The Labeling and Use Information (LUIS) report lists Wide Area/General Outdoor Treatment (Public Health Use). This listing could easily be mistaken for a general wide area use that may involve significant use near aquatic environments. The labels referenced for this use includes EPA Registration Numbers 1021-1764, 1021-1635, 1021-1852, and 1021-1701. The outdoor uses allowed on these labels include treatment of wasp, hornet, yellow jacket nests, fire ant housing, and to kill fire ants, mud daubers, scorpions, spiders, crickets, carpenter ants, harvester ants, centipedes, earwigs, and sowbugs. These uses are covered by the general outdoor uses already listed in Table 2-4.
[2] NS=Not Specified.

Table 2-5. Labeled Non- agricultural Uses Qualitatively Assessed in this Document

Use Group	Specific Uses	Reason for Exclusion
Interior Vehicle Uses	Vehicles, Boats, Campers, Railroad Cars, and Truck Trailers	Minimal chance for exposure in terrestrial or aquatic environments
Indoor Uses: Commercial, Residential, and Industrial Buildings, Cadavers and Caskets, Voids in Equipment and Structures, Grain Storage Facilities	Surface Spray, Space Spray, Crack and Crevice Treatment, and Spot Treatment	Minimal chance for exposure in terrestrial or aquatic environments

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[18], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[19]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for esfenvalerate by county in this California-specific assessment were generated using CDPR PUR data. Four years (2002-2005) of usage data were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage

[18] United States Depart of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.usda.gov/nass/pubs/estindx1.htm#agchem.
[19] The California Department of Pesticide Regulation's Pesticide Use Reporting database provides a census of pesticide applications in the state. See http://www.cdpr.ca.gov/docs/pur/purmain.htm.

involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all five years. The units of area treated are also provided where available.

California PUR Usage Data

The state of California requires that all pesticide applications (excluding private homeowner uses) be reported. This data is collected in the PUR (pesticide use reporting) database. The Office of Pesticide Programs' (OPP) Biological and Economic Analysis Division (BEAD) performed an analysis (J. Carter and A. Grube , October 2, 2007) of the PUR data for years 2002 to 2005, including data for esfenvalerate. Use of esfenvalerate was reported in a total of 47 counties over that time. Esfenvalerate is registered for many non-agricultural uses and many products are manufactured for use by homeowners. This analysis does not include usage by homeowners because a reliable data source for this information is not available.

Some uses reported in the CDPR PUR database are different than those considered in the assessment (soil fumigation/preplant, vertebrate control, leek, research commodity, and barley). The uses considered in this risk assessment represent all currently registered uses according to a review of all current labels. No other uses are relevant to this assessment. Any other reported use, such as may be seen in the CDPR PUR database, represent either historic uses that have been canceled, mis-reported uses, or mis-use. Historical uses, mis-reported uses, and misuse are not considered part of the federal action and, therefore are not considered in this assessment.

According to the CDPR PUR database, a total of 29,918 lbs of esfenvalerate were used in California in 2002, 33,495 lbs in 2003, 30,817 lbs in 2004, and 32,566 lbs in 2005. The average annual number of pounds applied over that four-year period was 31,699. Figure 2-3 below shows the reported average annual number of pounds used in each county between 2002 and 2005 for those counties with >500 pounds per year. Seventy-seven percent of the average annual pounds applied were applied in eleven counties: Fresno, Monterey, San Joaquin, Stanislaus, Imperial, Kern, Sutter, Tulare, Merced, Butte, and Madera counties. Ninety-nine percent of the usage is accounted for by the counties applying more than 100 average pounds annually (counties above Contra Costa in APPENDIX I).

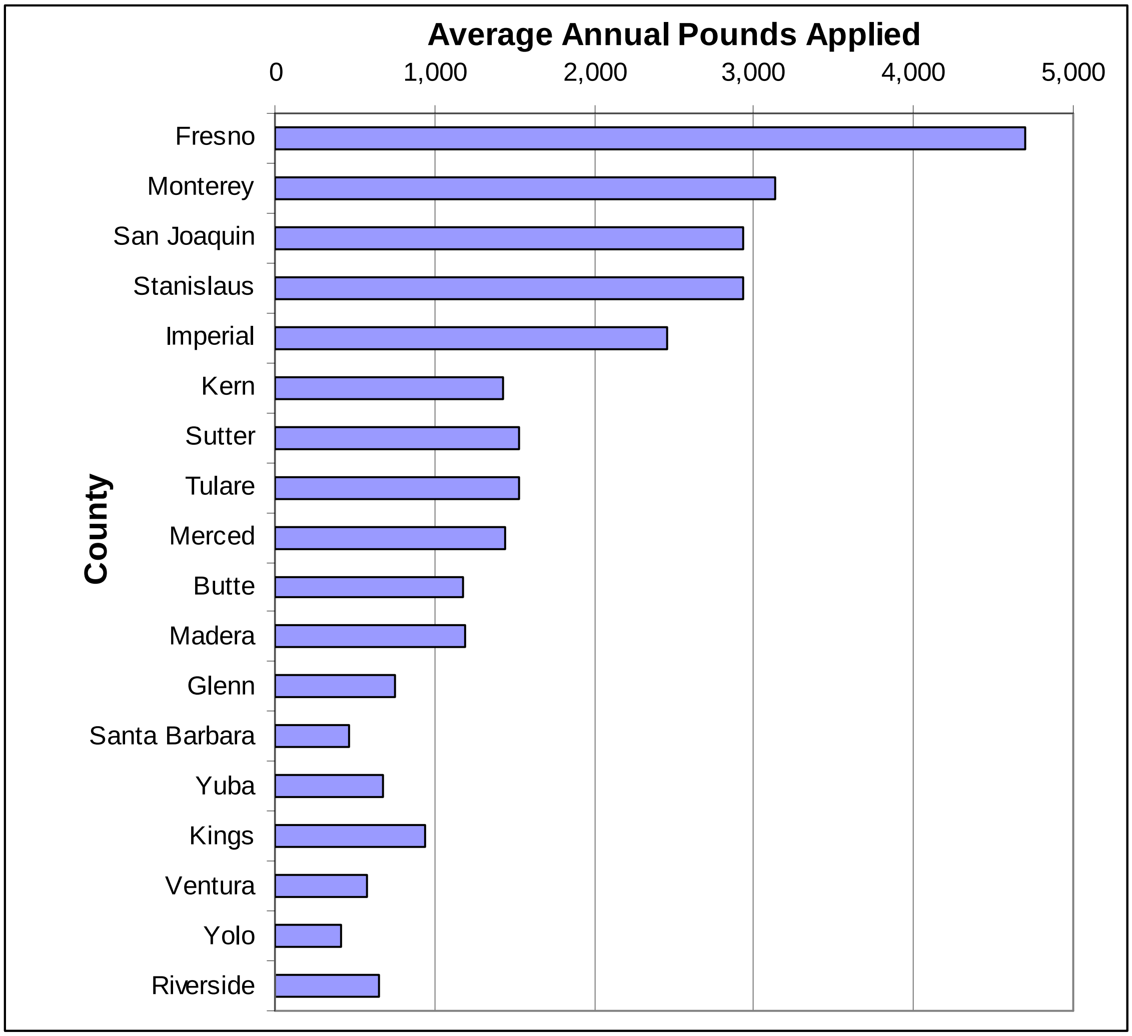


Figure 2-3. Average Total Pounds Applied in Each County for the Years 2002-2005. Counties applying on average more than 500 pounds per year were included in the figure.

Based on the average annual pounds applied between 2002 and 2005, greater than 1000 pounds of esfenvalerate is applied to nine crops annually: almond, peach, tomato, corn, artichoke, walnut, prune, lettuce, and nectarine. Approximately, 20 percent of esfenvalerate is applied to almonds, ten percent is applied to peach, tomato, and corn, and seven percent is applied to artichokes. All other uses accounted for less than five percent of the total esfenvalerate used in California. A summary of esfenvalerate usage for all California use sites is provided in Table 2-6**.**

Table 2-6. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 2002 to 2005 for Currently Registered Esfenvalerate Uses.[1]

Site Name	Average Annual Pounds Applied[2]	Average Application Rate	Average 95 Percentile Application Rate	Average 99 Percentile Application Rate	Average Maximum Application Rate
Almond	6778.9	0.05	0.07	0.09	0.20
Peach	3158.3	0.05	0.06	0.07	0.15
Tomato	3130.9	0.04	0.04	0.04	0.04
Corn	3006.0	0.05	0.05	0.06	0.07
Artichoke, Globe	2086.5	0.05	0.06	0.07	0.09
Walnut	1459.5	0.06	0.08	0.09	0.11
Prune	1307.6	0.04	0.06	0.07	0.11
Lettuce, Leaf	1193.0	0.04	0.05	0.05	0.07
Nectarine	1103.0	0.05	0.06	0.08	0.13
Cherry	867.2	0.04	0.06	0.06	0.09
Sugarbeet	860.6	0.04	0.04	0.04	0.08
Plum	805.1	0.04	0.06	0.08	0.13
Broccoli	768.0	0.04	0.04	0.06	0.10
Potato	671.8	0.05	0.09	0.12	0.14
Sunflower	578.9	0.05	0.07	0.07	0.10
Apricot	462.2	0.04	0.05	0.10	0.12
Bean, Dried	460.1	0.04	0.04	0.05	0.05
Carrot	447.5	0.05	0.05	0.08	0.08
Pear	435.0	0.05	0.07	0.14	0.20
Cauliflower	300.0	0.04	0.05	0.05	0.09
Pepper	294.9	0.04	0.06	0.07	0.08
Structural Pest Control	208.7	NS[3]	NS	NS	NS
Apple	200.8	0.05	0.10	0.15	0.15
Cotton	172.6	0.04	0.05	0.05	0.05
Cabbage	158.2	0.04	0.05	0.06	0.06
Bean, Succulent	104.5	0.04	0.05	0.07	0.07
Cantaloupe	100.8	0.04	0.05	0.06	0.06
N-Outdoor Trees	92.3	0.04	0.06	0.10	0.10
Bean, Unspecified	50.5	0.04	0.04	0.05	0.05
N-Greenhouse Flower	48.1	0.01	0.01	0.01	0.01
Peas	44.0	0.04	0.05	0.05	0.05
Watermelon	43.8	0.05	0.06	0.06	0.06
N-Outdoor Plants in Containers	43.2	0.07	0.10	0.11	0.11
Melon	40.2	0.05	0.10	0.10	0.10
Pumpkin	33.1	0.05	0.05	0.05	0.05
Squash	32.1	0.05	0.06	0.07	0.07
Radish	29.1	0.18	0.18	0.18	0.31
Eggplant	20.8	0.07	0.10	0.11	0.17
Cucumber	20.4	0.05	0.09	0.09	0.09

Site Name	Average Annual Pounds Applied[2]	Average Application Rate	Average 95 Percentile Application Rate	Average 99 Percentile Application Rate	Average Maximum Application Rate
Rights of Way	15.1	0.04	0.04	0.04	0.04
Uncultivated - Non Agricultural	11.0	0.05	0.06	0.06	0.06
Collard	9.4	0.05	0.05	0.07	0.07
Chinese Cabbage (Nappa)	8.9	0.04	0.05	0.06	0.06
Landscape Maintenance	5.7	0.04	0.04	0.04	0.04
Pecan	5.7	0.04	0.07	0.07	0.07
Mustard	4.9	0.04	0.05	0.05	0.05
Pistachio	4.2	0.03	0.03	0.03	0.03
Grape/Wine Grape	3.7	0.49	0.49	0.49	0.49
N-Greenhouse Plants in Containers	1.8	0.09	0.11	0.11	0.11
N-Greenhouse Transplants	1.8	0.03	0.04	0.13	0.13
Endive (Escarole)	1.6	0.05	0.05	0.05	0.05
Gai Lon	1.4	0.04	0.09	0.09	0.09
Pimento	1.2	0.03	0.03	0.03	0.03
Christmas Tree	1.2	0.04	0.05	0.05	0.05
Strawberry	1.0	0.34	0.43	0.43	0.43
N-Outdoor Flowers	0.9	0.05	0.09	0.09	0.09
Forest, Timberland	0.8	0.06	0.08	0.08	0.08
Fumigation (Other)	0.6	NS	NS	NS	NS
Bok Choy	0.6	0.04	0.04	0.04	0.04
Onion	0.4	0.02	0.02	0.02	0.02
Vegetable	0.2	0.07	0.07	0.07	0.07
Commodity Fumigation	0.2	NS	NS	NS	NS
Sugarcane	0.2	0.05	0.05	0.05	0.05
Chinese Greens	0.1	0.03	0.03	0.03	0.03
Public Health	0.1	NS	NS	NS	NS
Stone Fruit	0.1	0.03	0.03	0.03	0.03
Celery	0.1	0.04	0.04	0.04	0.04
Industrial Site	0.0	0.04	0.04	0.04	0.04
Avocado	0.0	0.03	0.03	0.03	0.03
Pome Fruit	0.0	0.04	0.04	0.04	0.04

[1] A zero represents a value less than 0.1 pounds.
[2] Average pounds applied is the sum of the average annual pounds applied for a specific use/site between 2002 and 2005 for all counties.
[3] NS stands for not specified.

Based on data reported in the CDPR PUR database, esfenvalerate application varies for different months and crops (Figure 2-4, Figure 2-5, and APPENDIX G) Months with highest pounds of esfenvalerate applied across California are January and July. These months coincide with all life cycles (young juveniles, tadpoles, and breeding/egg) of the CRLF and the high usage months for almonds (Figure 2-5).

In addition to considering the amount applied each month, Figure 2-6 shows that the amount applied for each use varies annually and may not follow a predictable trend. Over the four year time frame, usage on almonds increased while usage for peach, tomato, corn, and artichoke was relatively constant.

Figure 2-4. Comparison of phases of the California Red-legged Frog (CRLF) life cycle to the average pounds esfenvalerate applied per month between 2003 and 2005.

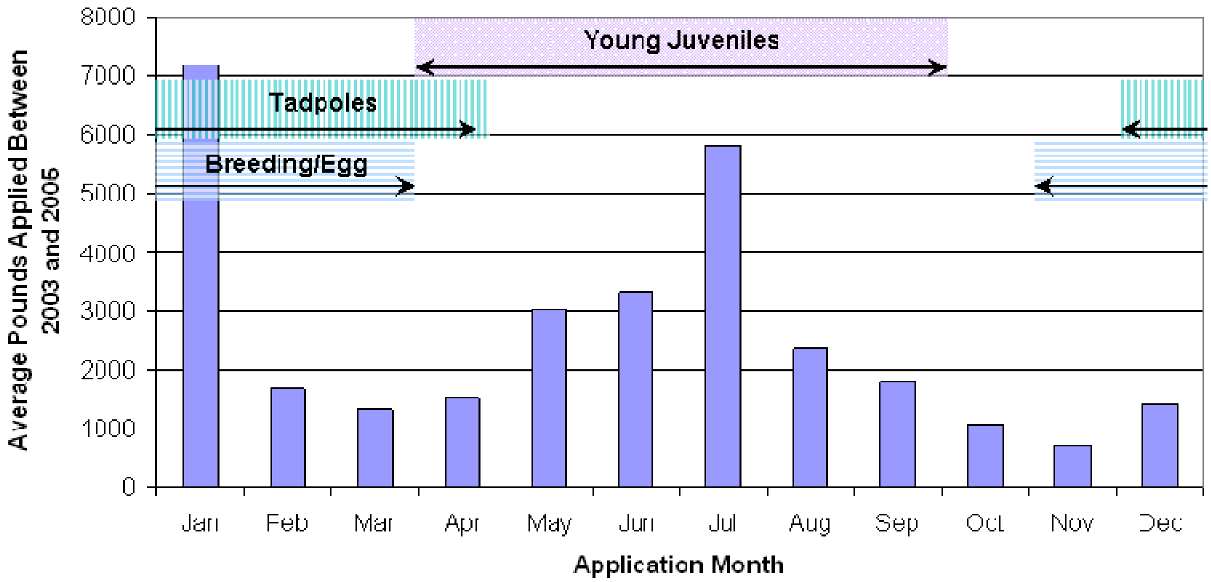


Figure 2-5. Timing of Esfenvalerate Application: Average number of pounds of active ingredient applied in California for Almond and Peach, per month, between January 2002 through December 2005. Similar figures for other crops are available in.

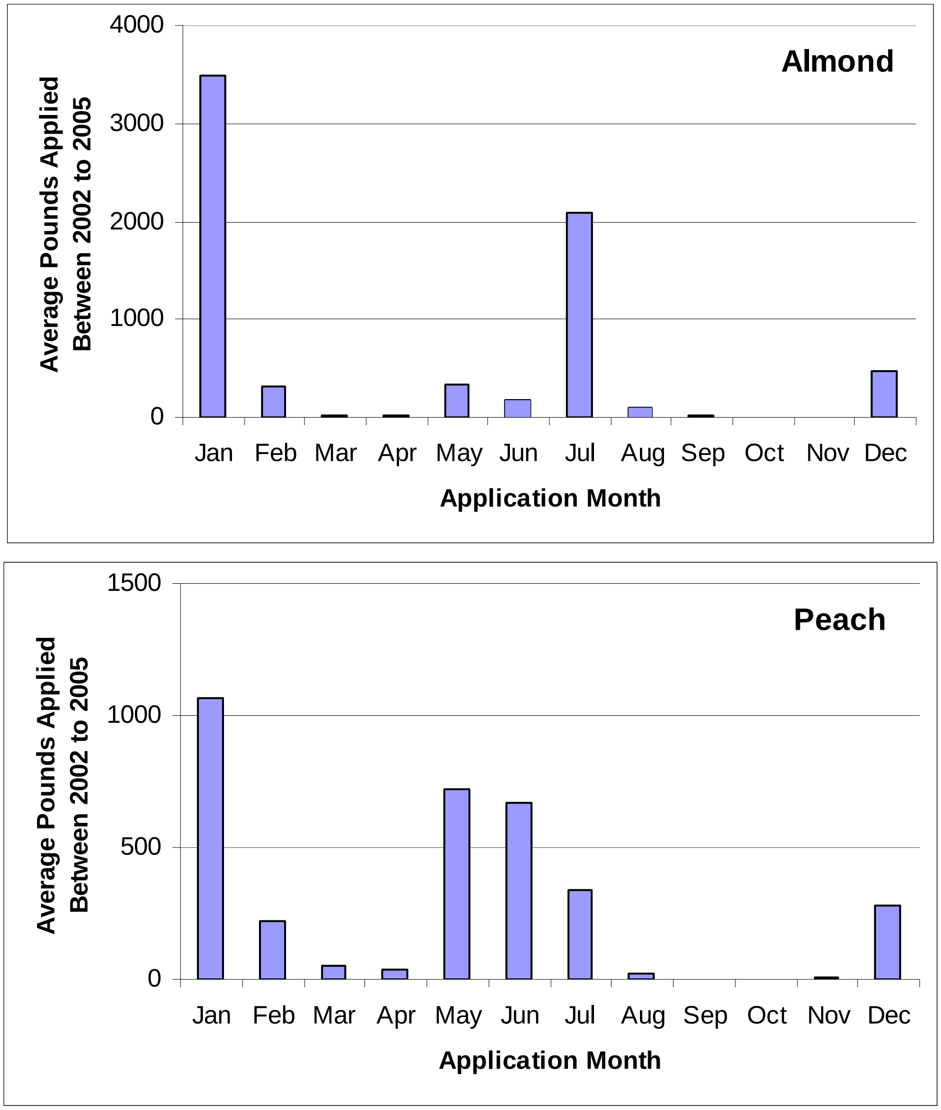
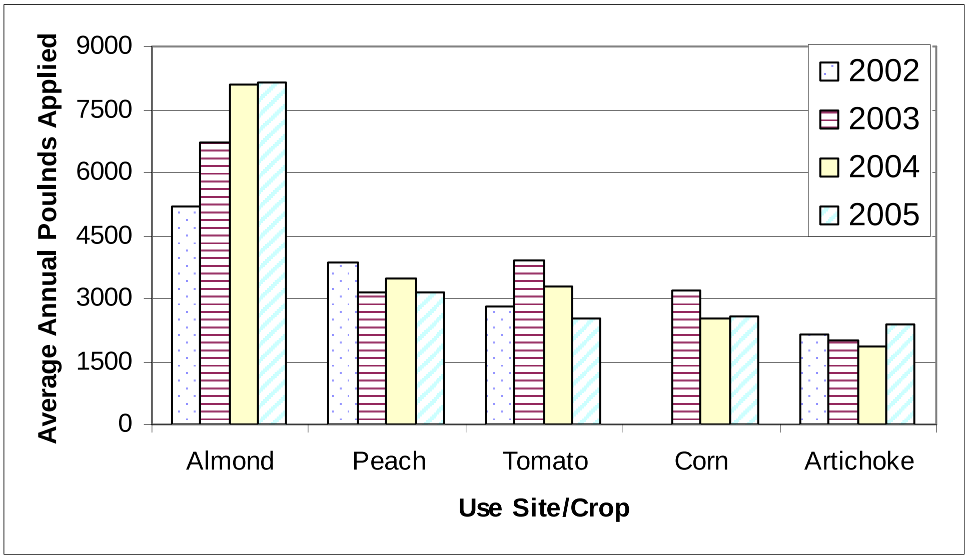


Figure 2-6. Pounds of Esfenvalerate Applied Each Year by Crop.



2.5 Assessed Species

The CRLF was federally listed as a threatened species by USFWS effective June 24, 1996 (USFWS 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (USFWS 2002). A brief summary of information regarding CRLF distribution, reproduction, diet, and habitat requirements is provided in Sections 2.5.1 through 2.5.4, respectively. Further information on the status, distribution, and life history of and specific threats to the CRLF is provided in Attachment 1.

Final critical habitat for the CRLF was designated by USFWS on April 13, 2006 (USFWS 2006; 71 FR 19244-19346). Further information on designated critical habitat for the CRLF is provided in Section 2.6.

2.5.1 Distribution

The CRLF is endemic to California and Baja California (Mexico) and historically inhabited 46 counties in California including the Central Valley and both coastal and interior mountain ranges (USFWS 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (USFWS 1996). The species has an elevational range of near sea level to 1,500 meters (5,200 feet) (Jennings and Hayes 1994); however, nearly all of the known CRLF populations have been documented below 1,050 meters (3,500 feet) (USFWS 2002).

Populations currently exist along the northern California coast, northern Transverse Ranges (USFWS 2002), foothills of the Sierra Nevada (5-6 populations), and in southern California south of Santa Barbara (two populations) (Fellers 2005a). Relatively larger numbers of CRLFs are located between Marin and Santa Barbara Counties (Jennings and Hayes 1994). A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS 1996). Occupied drainages or watersheds include all bodies of water that support CRLFs (i.e., streams, creeks, tributaries, associated natural and artificial ponds, and adjacent drainages), and habitats through which CRLFs can move (i.e., riparian vegetation, uplands) (USFWS 2002).

The distribution of CRLFs within California is addressed in this assessment using four categories of location including recovery units, core areas, designated critical habitat, and known occurrences of the CRLF reported in the California Natural Diversity Database (CNDDB) that are not included within core areas and/or designated critical habitat (see Figure 2-7). Recovery units, core areas, and other known occurrences of the CRLF from the CNDDB are described in further detail in this section, and designated critical habitat is addressed in Section 2.6. Recovery units are large areas defined at the watershed level that have similar conservation needs and management strategies. The recovery unit is primarily an administrative designation, and land area within the recovery unit boundary is not exclusively CRLF habitat. Core areas are smaller areas within the recovery units that comprise portions of the species' historic and current range and have been determined by USFWS to be important in the preservation of the species. Designated critical habitat is generally contained within the core areas, although a number of critical habitat units are outside the boundaries of core areas, but within the boundaries of the recovery units. Additional information on CRLF occurrences from the CNDDB is used to cover the current range of the species not included in core areas and/or designated critical habitat, but within the recovery units.

Recovery Units

Eight recovery units have been established by USFWS for the CRLF. These areas are considered essential to the recovery of the species, and the status of the CRLF "may be considered within the smaller scale of the recovery units, as opposed to the statewide range" (USFWS 2002). Recovery units reflect areas with similar conservation needs and population statuses, and therefore, similar recovery goals. The eight units described for the CRLF are delineated by watershed boundaries defined by US Geological Survey hydrologic units and are limited to the elevational maximum for the species of 1,500 m above sea level. The eight recovery units for the CRLF are listed in Table 2-7 and shown in Figure 2-7.

Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see Figure 2-7). Table 2-7 summarizes the geographical relationship among recovery units, core areas, and designated critical habitat. The core areas, which are distributed throughout portions of the historic and current range of the species, represent areas that allow for long-term viability of existing populations and reestablishment of populations within historic range. These areas were selected because they: 1) contain existing viable populations; or 2) they contribute to the connectivity of other habitat areas (USFWS 2002). Core area protection and enhancement are vital for maintenance and expansion of the CRLF's distribution and population throughout its range.

For purposes of this assessment, designated critical habitat, currently occupied (post-1985) core areas, and additional known occurrences of the CRLF from the CNDDB are considered. Each type of locational information is evaluated within the broader context of recovery units. For example, if no labeled uses of esfenvalerate occur (or if labeled uses occur at predicted exposures less than the Agency's LOCs) within an entire recovery unit, a "no effect" determination would be made for all designated critical habitat, currently occupied core areas, and other known CNDDB occurrences within that recovery unit. Historically occupied sections of the core areas are not evaluated as part of this assessment because the USFWS Recovery Plan (USFWS 2002) indicates that CRLFs are extirpated from these areas. A summary of currently and historically occupied core areas is provided in Table 2-7 (currently occupied core areas are bolded). While core areas are considered essential for recovery of the CRLF, core areas are not federally-designated critical habitat, although designated critical habitat is generally contained within these core recovery areas. It should be noted, however, that several critical habitat units are located outside of the core areas, but within the recovery units. The focus of this assessment is currently occupied core areas, designated critical habitat, and other known CNDDB CRLF occurrences within the recovery units. Federally-designated critical habitat for the CRLF is further explained in Section 2.6.

Table 2-7. California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat

Recovery Unit [1] (Figure 2-7)	**Core Areas [2,7] (Figure 2-7)**	**Critical Habitat Units [3]**	**Currently Occupied (post-1985) [4]**	**Historically Occupied [4]**
Sierra Nevada Foothills and Central Valley (1) (eastern boundary is the 1,500m elevation line)	**Cottonwood Creek (partial) (8)**	--	✓	
	Feather River (1)	BUT-1A-B	✓	
	Yuba River-S. Fork Feather River (2)	YUB-1	✓	
	--	NEV-1[6]		
	Traverse Creek/Middle Fork American River/Rubicon (3)	--	✓	
	Consumnes River (4)	ELD-1	✓	
	S. Fork Calaveras River (5)	--		✓
	Tuolumne River (6)	--		✓
	Piney Creek (7)	--		✓
	East San Francisco Bay (partial)(16)	--	✓	
North Coast Range Foothills and Western Sacramento River Valley (2)	**Cottonwood Creek (8)**	--	✓	
	Putah Creek-Cache Creek (9)	--		✓
	Jameson Canyon – Lower Napa Valley (partial) (15)	--	✓	
	Belvedere Lagoon (partial) (14)	--	✓	
	Pt. Reyes Peninsula (partial) (13)	--	✓	

Recovery Unit [1] (Figure 2-7)	Core Areas [2,7] (Figure 2-7)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
North Coast and North San Francisco Bay (3)	Putah Creek-Cache Creek (partial) (9)	--		✓
	Lake Berryessa Tributaries (10)	NAP-1	✓	
	Upper Sonoma Creek (11)	--	✓	
	Petaluma Creek-Sonoma Creek (12)	--	✓	
	Pt. Reyes Peninsula (13)	MRN-1, MRN-2	✓	
	Belvedere Lagoon (14)	--	✓	
	Jameson Canyon-Lower Napa River (15)	SOL-1	✓	
South and East San Francisco Bay (4)	--	CCS-1A[6]		
	East San Francisco Bay (partial) (16)	ALA-1A, ALA-1B, STC-1B	✓	
	--	STC-1A[6]		
	South San Francisco Bay (partial) (18)	SNM-1A	✓	
Central Coast (5)	**South San Francisco Bay (partial) (18)**	SNM-1A, SNM-2C, SCZ-1	✓	
	Watsonville Slough- Elkhorn Slough (partial) (19)	SCZ-2 [5]	✓	
	Carmel River-Santa Lucia (20)	MNT-2	✓	
	Estero Bay (22)	--	✓	
	--	SLO-8[6]		
	Arroyo Grande Creek (23)	--	✓	
	Santa Maria River-Santa Ynez River (24)	--	✓	
Diablo Range and Salinas Valley (6)	**East San Francisco Bay (partial) (16)**	MER-1A-B, STC-1B	✓	
	--	SNB-1[6], SNB-2[6]		
	Santa Clara Valley (17)	--	✓	
	Watsonville Slough- Elkhorn Slough (partial)(19)	MNT-1	✓	
	Carmel River-Santa Lucia (partial)(20)	--	✓	
	Gablan Range (21)	SNB-3	✓	
	Estrella River (28)	SLO-1A-B	✓	
Northern Transverse Ranges and Tehachapi Mountains (7)	--	SLO-8[6]		
	Santa Maria River-Santa Ynez River (24)	STB-4, STB-5, STB-7	✓	
	Sisquoc River (25)	STB-1, STB-3	✓	
	Ventura River-Santa Clara River (26)	VEN-1, VEN-2, VEN-3	✓	

Recovery Unit [1] (Figure 2-7)	Core Areas [2,7] (Figure 2-7)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
	--	LOS-1[6]		
Southern Transverse and Peninsular Ranges (8)	**Santa Monica Bay-Ventura Coastal Streams (27)**	--	✓	
	San Gabriel Mountain (29)	--		✓
	Forks of the Mojave (30)	--		✓
	Santa Ana Mountain (31)	--		✓
	Santa Rosa Plateau (32)	--	✓	
	San Luis Rey (33)	--		✓
	Sweetwater (34)	--		✓
	Laguna Mountain (35)	--		✓

[1] Recovery units designated by the USFWS (USFWS 2000, pg 49).
[2] Core areas designated by the USFWS (USFWS 2000, pg 51).
[3] Critical habitat units designated by the USFWS on April 13, 2006 (USFWS 2006, 71 FR 19244-19346).
[4] Currently occupied (post-1985) and historically occupied core areas as designated by the USFWS (USFWS 2002, pg 54).
[5] Critical habitat unit where identified threats specifically included pesticides or agricultural runoff (USFWS 2002).
[6] Critical habitat units that are outside of core areas, but within recovery units.
[7] Currently occupied core areas that are included in this effects determination are bolded.

Figure 2-7. Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

Recovery Units
1. Sierra Nevada Foothills and Central Valley
2. North Coast Range Foothills and Western Sacramento River Valley
3. North Coast and North San Francisco Bay
4. South and East San Francisco Bay
5. Central Coast
6. Diablo Range and Salinas Valley
7. Northern Transverse Ranges and Tehachapi Mountains
8. Southern Transverse and Peninsular Ranges

Core Areas

1. Feather River
2. Yuba River- S. Fork Feather River
3. Traverse Creek/ Middle Fork/ American R. Rubicon
4. Cosumnes River
5. South Fork Calaveras River*
6. Tuolumne River*
7. Piney Creek*
8. Cottonwood Creek
9. Putah Creek – Cache Creek*
10. Lake Berryessa Tributaries
11. Upper Sonoma Creek
12. Petaluma Creek – Sonoma Creek
13. Pt. Reyes Peninsula
14. Belvedere Lagoon
15. Jameson Canyon – Lower Napa River
16. East San Francisco Bay
17. Santa Clara Valley
18. South San Francisco Bay
19. Watsonville Slough-Elkhorn Slough
20. Carmel River – Santa Lucia
21. Gablan Range
22. Estero Bay
23. Arroyo Grange River
24. Santa Maria River – Santa Ynez River
25. Sisquoc River
26. Ventura River – Santa Clara River
27. Santa Monica Bay – Venura Coastal Streams
28. Estrella River
29. San Gabriel Mountain*
30. Forks of the Mojave*
31. Santa Ana Mountain*
32. Santa Rosa Plateau
33. San Luis Ray*
34. Sweetwater*
35. Laguna Mountain*

* Core areas that were historically occupied by the California red-legged frog are not included in the map

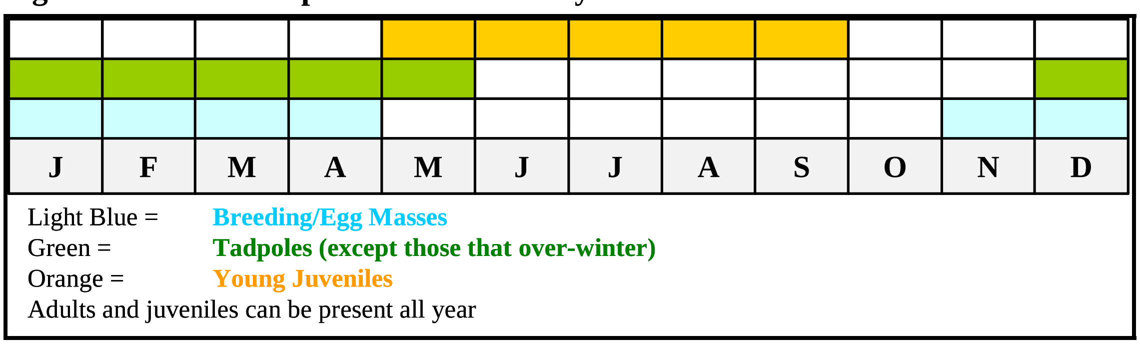
Other Known Occurrences from the CNDBB

The CNDDB provides location and natural history information on species found in California. The CNDDB serves as a repository for historical and current species location sightings. Information regarding known occurrences of CRLFs outside of the currently occupied core areas and designated critical habitat is considered in defining the current range of the CRLF. See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.

2.5.2 Reproduction

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers 2005a). According to the Recovery Plan (USFWS 2002), CRLFs breed from November through late April. Peaks in spawning activity vary geographically; Fellers (2005b) reports peak spawning as early as January in parts of coastal central California. Eggs are fertilized as they are being laid. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto 1984). Egg masses contain approximately 2000 to 6000 eggs ranging in size between 2 and 2.8 mm (Jennings and Hayes 1994). Embryos hatch 10 to 14 days after fertilization (Fellers 2005a) depending on water temperature. Egg predation is reported to be infrequent and most mortality is associated with the larval stage (particularly through predation by fish); however, predation on eggs by newts has also been reported (Rathburn 1998). Tadpoles require 11 to 28 weeks to metamorphose into juveniles (terrestrial-phase), typically between May and September (Jennings and Hayes 1994, USFWS 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers 2005b, USFWS 2002). Males reach sexual maturity at 2 years, and females reach sexual maturity at 3 years of age; adults have been reported to live 8 to 10 years (USFWS 2002). Figure 2-8 depicts CRLF annual reproductive timing.

Figure 2-8. CRLF Reproductive Events by Month



2.5.3 Diet

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus (USFWS 2002). Tadpoles filter and entrap suspended algae (Seale and Beckvar, 1980) via mouthparts designed for effective grazing of periphyton (Wassersug, 1984, Kupferberg *et al.*; 1994; Kupferberg, 1997; Altig and McDiarmid, 1999).

Juvenile and adult CRLFs forage in aquatic and terrestrial habitats, and their diet differs greatly from that of larvae. The main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic and terrestrial invertebrates found along the shoreline and on the water surface. Hayes and Tennant (1985) report, based on a study examining the gut content of 35 juvenile and adult CRLFs, that the species feeds on as many as 42 different invertebrate taxa, including Arachnida, Amphipoda, Isopoda, Insecta, and Mollusca. The most commonly observed prey species were larval alderflies (*Sialis* cf. *californica*), pillbugs (*Armadilliadrium vulgare*), and water striders (*Gerris* sp). The preferred prey species, however, was the sowbug (Hayes and Tennant, 1985). This study suggests that CRLFs forage primarily above water, although the authors note other data reporting that adults also feed under water, are cannibalistic, and consume fish. For larger CRLFs, over 50% of the prey mass may consists of vertebrates such as mice, frogs, and fish, although aquatic and terrestrial invertebrates were the most numerous food items (Hayes and Tennant 1985). For adults, feeding activity takes place primarily at night; for juveniles feeding occurs during the day and at night (Hayes and Tennant 1985).

2.5.4 Habitat

CRLFs require aquatic habitat for breeding, but also use other habitat types including riparian and upland areas throughout their life cycle. CRLF use of their environment varies; they may complete their entire life cycle in a particular habitat or they may utilize multiple habitat types. Overall, populations are most likely to exist where multiple breeding areas are embedded within varying habitats used for dispersal (USFWS 2002). Generally, CRLFs utilize habitat with perennial or near-perennial water (Jennings et al. 1997). Dense vegetation close to water, shading, and water of moderate depth are habitat features that appear especially important for CRLF (Hayes and Jennings 1988).

Breeding sites include streams, deep pools, backwaters within streams and creeks, ponds, marshes, sag ponds (land depressions between fault zones that have filled with water), dune ponds, and lagoons. Breeding adults have been found near deep (0.7 m) still or slow moving water surrounded by dense vegetation (USFWS 2002); however, the largest number of tadpoles have been found in shallower pools (0.26 – 0.5 m) (Reis, 1999). Data indicate that CRLFs do not frequently inhabit vernal pools, as conditions in these habitats generally are not suitable (Hayes and Jennings 1988).

CRLFs also frequently breed in artificial impoundments such as stock ponds, although additional research is needed to identify habitat requirements within artificial ponds (USFWS 2002). Adult CRLFs use dense, shrubby, or emergent vegetation closely associated with deep-water pools bordered with cattails and dense stands of overhanging vegetation (http://www.fws.gov/endangered/features/rl_frog/rlfrog.html#where).

In general, dispersal and habitat use depends on climatic conditions, habitat suitability, and life stage. Adults rely on riparian vegetation for resting, feeding, and dispersal. The foraging quality of the riparian habitat depends on moisture, composition of the plant community, and presence of pools and backwater aquatic areas for breeding. CRLFs can be found living within streams at distances up to 3 km (2 miles) from their breeding site and have been found up to 30 m (100 feet) from water in dense riparian vegetation for up to 77 days (USFWS 2002).

During dry periods, the CRLF is rarely found far from water, although it will sometimes disperse from its breeding habitat to forage and seek other suitable habitat under downed trees or logs, industrial debris, and agricultural features (UWFWS 2002). According to Jennings and Hayes (1994), CRLFs also use small mammal burrows and moist leaf litter as habitat. In addition, CRLFs may also use large cracks in the bottom of dried ponds as refugia; these cracks may provide moisture for individuals avoiding predation and solar exposure (Alvarez 2000).

2.6 Designated Critical Habitat

In a final rule published on April 13, 2006, 34 separate units of critical habitat were designated for the CRLF by USFWS (USFWS 2006; FR 51 19244-19346). A summary of the 34 critical habitat units relative to USFWS-designated recovery units and core areas (previously discussed in Section 2.5.1) is provided in Table 2-7.

'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species.' All designated critical habitat for the CRLF was occupied at the time of listing. Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be 'essential to the conservation of the species.' Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

- Breeding aquatic habitat;
- Non-breeding aquatic habitat;
- Upland habitat; and
- Dispersal habitat.

Further description of these habitat types is provided in Attachment 1.

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, USFWS does not include areas where existing management is sufficient to conserve the species. Critical habitat is designated outside the geographic area presently occupied by the species only when a designation limited to its present range would be inadequate to ensure the conservation of the species. For the CRLF, all designated critical habitat units contain all four of the PCEs, and were occupied by the CRLF at the time of FR listing notice in April 2006. The FR notice designating critical habitat for the CRLF includes a special rule exempting routine ranching activities associated with livestock ranching from incidental take prohibitions. The purpose of this exemption is to promote the conservation of rangelands, which could be beneficial to the CRLF, and to reduce the rate of conversion to other land uses that are incompatible with CRLF conservation. Please see Attachment 1 for a full explanation on this special rule.

USFWS has established adverse modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of esfenvalerate that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to USFWS (2006), activities that may affect critical habitat and therefore result in adverse effects to the CRLF include, but are not limited to the following:

(1) Significant alteration of water chemistry or temperature to levels beyond the tolerances of the CRLF that result in direct or cumulative adverse effects to individuals and their life-cycles.
(2) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat that could result in elimination or reduction of habitat necessary for the growth and reproduction of the CRLF by increasing the sediment deposition to levels that would adversely affect their ability to complete their life cycles.
(3) Significant alteration of channel/pond morphology or geometry that may lead to changes to the hydrologic functioning of the stream or pond and alter the timing, duration, water flows, and levels that would degrade or eliminate the CRLF and/or its habitat. Such an effect could also lead to increased sedimentation and degradation in water quality to levels that are beyond the CRLF's tolerances.
(4) Elimination of upland foraging and/or aestivating habitat or dispersal habitat.
(5) Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
(6) Alteration or elimination of the CRLF's food sources or prey base (also evaluated as indirect effects to the CRLF).

As previously noted in Section 2.1, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because esfenvalerate is expected to directly impact living organisms within the action area, critical habitat analysis for esfenvalerate is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7 Action Area

For listed species assessment purposes, the action area is considered to be the area affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). It is recognized that the overall action area for the national registration of esfenvalerate is likely to encompass considerable portions of the United States based on the large array of agricultural and non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the state of California. Deriving the geographical extent of this portion of the action area is based on consideration of the types of effects that esfenvalerate may be expected to have on the environment, the exposure levels to esfenvalerate that are associated with those effects, and the best available information concerning the use of esfenvalerate and its fate and transport within the state of California.

The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for esfenvalerate. An analysis of labeled uses and review of available product labels was completed. Several of the currently labeled uses are special local needs (SLN) or are restricted to specific states other than California and are excluded from this assessment. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the CRLF, the analysis indicates that, for esfenvalerate, the agricultural uses considered as part of the federal action evaluated in this assessment are listed in Table 2-3 and the non-food and non-agricultural uses are listed in Table 2-4. Table 2-4 lists indoor uses, which result in incomplete exposure pathways and/or, because of scale, are highly unlikely to result in meaningful measurable effects to the CRLF or its designated critical habitat. They were qualitatively assessed to have "No Effect" based on professional judgment and are therefore not evaluated further.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of esfenvalerate use patterns is determined. This "footprint" represents the initial area of concern based on an analysis of available land cover data for the state of California. The initial area of concern is typically defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. However, the overall conclusion of the analyses of esfenvalerate uses is that there is no area in California from which the possibility of the occurrence of esfenvalerate applications can be excluded. Therefore, the initial area of concern, defined as all land cover types that represent the labeled uses of esfenvalerate included in this assessment, is presumed to encompasses essentially the entire state of California.

Once the initial area of concern is defined, the next step is to compare the extent of that area with the results of the screening-level risk assessment. The screening-level risk assessment identifies which taxa, if any, are predicted to be exposed at concentrations above the Agency's Levels of Concern (LOC). The screening-level assessment includes an evaluation of the environmental fate properties of esfenvalerate to determine which routes of transport are likely to have an impact on the CRLF. An analysis of the environmental fate is presented above in Section 2.4.1; however, it is supposed that the uses of esfenvalerate will result in exposure across all CRLF habitat. Therefore, based on LOC exceedances, the action area encompasses both the aquatic and terrestrial portions of the CRLF habitat including designated critical habitat.

2.8 Assessment Endpoints and Measures of Ecological Effect

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected."[20] Selection of the assessment endpoints is based on valued entities (*e.g*., CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (*e.g*., waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of esfenvalerate (*e.g*., runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to esfenvalerate-related contamination (*e.g*., direct contact, etc.).

2.8.1 Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base or modification of its designated critical habitat. In addition, potential modification of critical habitat is assessed by evaluating potential effects to PCEs, which are components of the habitat areas that provide essential life cycle needs of the CRLF. Each assessment endpoint requires one or more "measures of ecological effect," defined as changes in the attributes of an assessment endpoint or changes in a surrogate entity or attribute in response to exposure to a pesticide. Specific measures of ecological effect are generally evaluated based on acute and chronic toxicity information from registrant-submitted guideline tests that are performed on a limited number of organisms. Additional ecological effects data from the open literature are also considered.

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in Section 4.0 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to esfenvalerate is provided in Table 2-8. Data were not available to quantitatively assess the risk of esfenvalerate to aquatic and terrestrial plants; however, qualitative information gathered from studies in ECOTOX provided some information that was used in making determinations for these taxa. Since fenvalerate is closely-related to esfenvalerate, studies on this chemical will be used if they provide more sensitive endpoints than esfenvalerate.

[20] From U.S. EPA (1992). *Framework for Ecological Risk Assessment.* EPA/630/R-92/001.

Table 2-8. Summary of Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of Esfenvalerate on the CRLF.

Assessment Endpoint	Measures of Ecological Effects[21]	
	Data Sought	**Final Selection**
Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)[a]		
1. Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	1a. Most sensitive fish acute LC_{50} if no suitable amphibian data are available	1a. Esfenvalerate, Rainbow trout 96-hr LC_{50} 0.07 ppb ai (source: -guideline study, no appropriate amphibian data were available)
	1b. Most sensitive fish early-life stage NOAEC if no suitable amphibian early life stage data are available	1b. Esfenvalerate, freshwater fish NOAEC 0.035 ppb-ai (source: estimated using an acute-to-chronic ratio (ACR); no appropriate amphibian data were available)
2. Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	2a. Most sensitive *(1)* fish LC_{50}; *(2)* aquatic invertebrate LC_{50} or EC_{50}; and *(3)* aquatic benthic invertebrate LC_{50} or EC_{50}	2a*(1)* Esfenvalerate, Rainbow trout 96-hr LC_{50} 0.07 ppb ai (source: guideline study)
		2a*(2)* Fenvalerate, waterflea 48-hr EC_{50} 0.05 ppb ai (source: guideline study)
		2a*(3)* No benthic invertebrate sediment data
	2b. Most sensitive *(1)* fish early-life stage NOAEC; and *(2)* aquatic invertebrate chronic NOAEC	2b*(1)* Esfenvalerate, freshwater fish early life stage NOAEC 0.035 ppb ai (source: estimated using an ACR derived from guideline studies)
		2b*(2)* Esfenvalerater, waterflea life cycle NOAEC 0.017 ppb ai (source: estimated using an ACR derived from guideline studies)
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	.3a. Vascular plant acute EC_{50} (duckweed guideline test or ECOTOX vascular plant)	3a and 3b. No quantitative data available for vascular or non-vascular aquatic plants
	3b. Non-vascular plant acute EC_{50} (freshwater algae or diatom, or ECOTOX non-vascular)	
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	4a. Distribution of EC_{25} values for monocots (seedling emergence, vegetative vigor, or ECOTOX)	4a and 4b. No quantitative data available for terrestrial plants[22]
	4b. Distribution of EC_{25} values for dicots (seedling emergence, vegetative vigor, or ECOTOX)[23]	

[21] All registrant-submitted and open literature toxicity data reviewed for this assessment are included in Section 4.0.
[22] The available information indicates that the California red-legged frog does not have any obligate relationships.
[23] The available information indicates that the California red-legged frog does not have any obligate relationships.

Assessment Endpoint	Measures of Ecological Effects[21]	
	Data Sought	Final Selection
Terrestrial Phase (Juveniles and adults)		
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Most sensitive bird[b] : *(1)* acute LC_{50} and *(2)* LD_{50} if terrestrial-phase amphibian data not available	5a*(1)*. Esfenvalerate, Northern bobwhite acute oral LD_{50} 381 mg ai/kg-bw (source: guideline study)
		5a*(2)* Esfenvalerate, Mallard 5-d dietary exposure LC_{50} 4894 ppm ai (source: guideline study)
	5b. Most sensitive bird[b] chronic NOAEC if terrestrial-phase amphibian data not available	5b. No studies available
6. Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,* terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	6a. Most sensitive *(1)* terrestrial invertebrate LD_{50} or ED_{50}; and *(2)* mammal acute LD_{50} or LC_{50}; and *(3)* bird[b] acute LC_{50} and LD_{50} [c]	6a*(1)*. Esfenvalerate, Honey bee acute contact LD_{50} 0.017 ug/bee (source: guideline study)
		6a*(2)* Esfenvalerate, laboratory rat acute oral LD_{50} 59.0 mg/kg-bw (source: guideline study)
		6a*(3)* Esfenvalerate, acute oral LD_{50} 381 mg ai/kg-bw and mallard 5-d dietary LC_{50} (source: guideline studies)
	6b. Most sensitive *(1)* mammal two-generation NOAEL or NOAEC; and *(2)* bird[b] chronic NOAEC	6b*(1)*. Esfenvalerate, laboratory rat reproductive NOAEL 4.21 mg/kg-bw/d (source: guideline study)
		6b*(2)* no study available
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	7a. Distribution of EC_{25} for monocots (seedling emergence, vegetative vigor, or ECOTOX 7b. Distribution of EC_{25} for dicots (seedling emergence, vegetative vigor, or ECOTOX)	7a and 7b No quantitative data available for terrestrial plants

[a] Adult frogs are no longer in the "aquatic phase" of the amphibian life cycle; however, submerged adult frogs are considered "aquatic" for the purposes of this assessment because exposure pathways in the water are considerably different than exposure pathways on land.

[b] Birds are used as surrogates for terrestrial-phase amphibians.

[c] Although the most sensitive toxicity value is initially used to evaluate potential indirect effects, sensitivity distribution is used (if sufficient data are available) to evaluate the potential impact to food items of the CRLF.

2.8.2 Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of esfenvalerate that may alter the PCEs of the CRLF's critical habitat. PCEs for the CRLF were previously described in Section 2.6. Actions that may modify critical habitat are those that alter the PCEs. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (*i.e.*, the biological resource requirements for the listed species associated with the critical habitat) and those for which esfenvalerate effects data are available.

Modification to the critical habitat of the CRLF includes the following, as specified by USFWS (2006) and previously discussed in Section 2.6:

1. Alteration of water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs.
2. Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.
3. Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat.
4. Significant alteration of channel/pond morphology or geometry.
5. Elimination of upland foraging and/or aestivating habitat, as well as dispersal habitat.
6. Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
7. Alteration or elimination of the CRLF's food sources or prey base.

Measures of such possible effects by labeled use of esfenvalerate on designated critical habitat of the CRLF are described in Table 2-9. Some components of these PCEs are associated with physical abiotic features (*e.g.*, presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 2-9. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat.

Assessment Endpoint	Measures of Ecological Effect[24]	
	Data Sought	**Selected Values**
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	a. Most sensitive aquatic plant EC_{50} (guideline or ECOTOX)	a, b, and c: No aquatic or terrestrial plant data were available; ancillary information
	b. Distribution of EC_{25} values for terrestrial monocots (seedling emergence, vegetative vigor, or ECOTOX)	
	c. Distribution of EC_{25} values for terrestrial dicots (seedling emergence, vegetative vigor, or ECOTOX)	

[24] All toxicity data reviewed for this assessment are included in Section 4.0.

Assessment Endpoint	Measures of Ecological Effect[24]	
	Data Sought	**Selected Values**
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[25]	a. Most sensitive EC_{50} values for aquatic plants (guideline or ECOTOX)	a, b, and c: No aquatic or terrestrial plant data were available; ancillary information is used
	b. Distribution of EC_{25} values for terrestrial monocots (seedling emergence or vegetative vigor, or ECOTOX)	
	c. Distribution of EC_{25} values for terrestrial dicots (seedling emergence, vegetative vigor, or ECOTOX)	
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[26]	a. Most sensitive EC_{50} value for aquatic plants (source; guideline or ECOTOX)	a, b, and c: No aquatic or terrestrial plant data were available; ancillary information is used
	b. Distribution of terrestrial monocot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)	
	c. Distribution of terrestrial dicot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)	
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	a. Most sensitive acute *(1)* LC_{50} values for fish; and *(2)* acute LC_{50} or EC_{50} values for aquatic invertebrates (including benthic invertebrates)	a*(1)* Esfenvalerate, Rainbow trout 96-hr LC_{50} 0.07 ppb ai (source: guideline study)
		a*(2)* Fenvalerate, waterflea 48-hr EC_{50} 0.05 ppb ai (source: guideline study)
	b. Most sensitive NOAEC values for *(1)* fish; and *(2)* aquatic invertebrates (source: guideline data)	b*(1)* Esfenvalerate, freshwater fish, early life stage NOAEC 0.035 ppb ai (source: estimated using an ACR derived from guideline studies)
		b*(2)* Esfenvalerate, waterflea, life cycle NOAEC 0.017 ppb ai (source: estimated using an ACR derived from guideline studies)
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	Most sensitive aquatic plant EC_{50} (source: guideline or ECOTOX)	No aquatic plant data were available; ancillary information used

[9] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.
[26] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

<table>
<tr><th rowspan="2">Assessment Endpoint</th><th colspan="2">Measures of Ecological Effect[24]</th></tr>
<tr><th>Data Sought</th><th>Selected Values</th></tr>
<tr><td colspan="3">Terrestrial Phase PCEs
(Upland Habitat and Dispersal Habitat)</td></tr>
<tr><td rowspan="2">Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance</td><td rowspan="6">a. Most sensitive terrestrial food source(1) acute LC_{50} or LD_{50} and chronic NOAEL values for mammals; (2) acute LC_{50} or LD_{50} and chronic NOAEL for birds; (3) acute LC_{50} or LD_{50} for terrestrial invertebrates; (4) acute LC_{50} and chronic NOAEC for freshwater fish; and (5) acute LC_{50} or EC_{50} and chronic NOAEC for aquatic invertebrates</td><td>a(1) Esfenvalerate, laboratory rat acute oral LD_{50} 59 mg/kg-bw (source: guideline study)</td></tr>
<tr><td>a(2) Esfenvalerate, Northern bobwhite acute oral LD_{50} 381 mg/kg-bw (source: guideline study)</td></tr>
<tr><td rowspan="2">Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal</td><td>a(3) Esfenvalerate, Honey bee acute contact LD50 0.017 ug/bee</td></tr>
<tr><td>a(4) Esfenvalerate, Rainbow trout 96-hr LC50 0.017 ppb ai (source: guideline study)

Esfenvalerate, freshwater fish, early life stage NOAEC 0.035 ppb ai (source: estimated using an ACR derived from guideline studies</td></tr>
<tr><td>Reduction and/or modification of food sources for terrestrial phase juveniles and adults</td><td rowspan="2">a(5) Esfenvalerate, waterflea 48-hr EC50 0.05 ppb ai (source: guideline study)

Esfenvalerate, waterflea life cycle NOAEC 0.017 ppb ai (source: estimated using an ACR derived from guideline studies)</td></tr>
<tr><td>Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.</td></tr>
</table>

2.9 Conceptual Model

2.9.1 Risk Hypotheses

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (U.S. EPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of esfenvalerate to the environment. The following risk hypotheses are presumed for this endangered species assessment:

- Labeled uses of esfenvalerate within the action area may directly affect the CRLF by causing mortality or by affecting growth or fecundity;

- Labeled uses of esfenvalerate within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;
- Labeled uses of esfenvalerate within the action area may indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity or cover;
- Labeled uses of esfenvalerate within the action area may indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (*i.e.*, riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- Labeled uses of esfenvalerate within the action area may modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, or sedimentation);
- Labeled uses of esfenvalerate within the action area may modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- Labeled uses of esfenvalerate within the action area may modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- Labeled uses of esfenvalerate within the action area may modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.
- Labeled uses of esfenvalerate within the action area may adversely modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor (esfenvalerate), release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial phases of the CRLF are shown in Figure 2-9 and Figure 2-10, respectively, and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in Figure 2-11and Figure 2-12, respectively. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure pathways to potential risk to the CRLF and modification to designated critical habitat is expected to be negligible.

Figure 2-9. Conceptual Model for Pesticide Effects on Aquatic-Phase of the CRLF

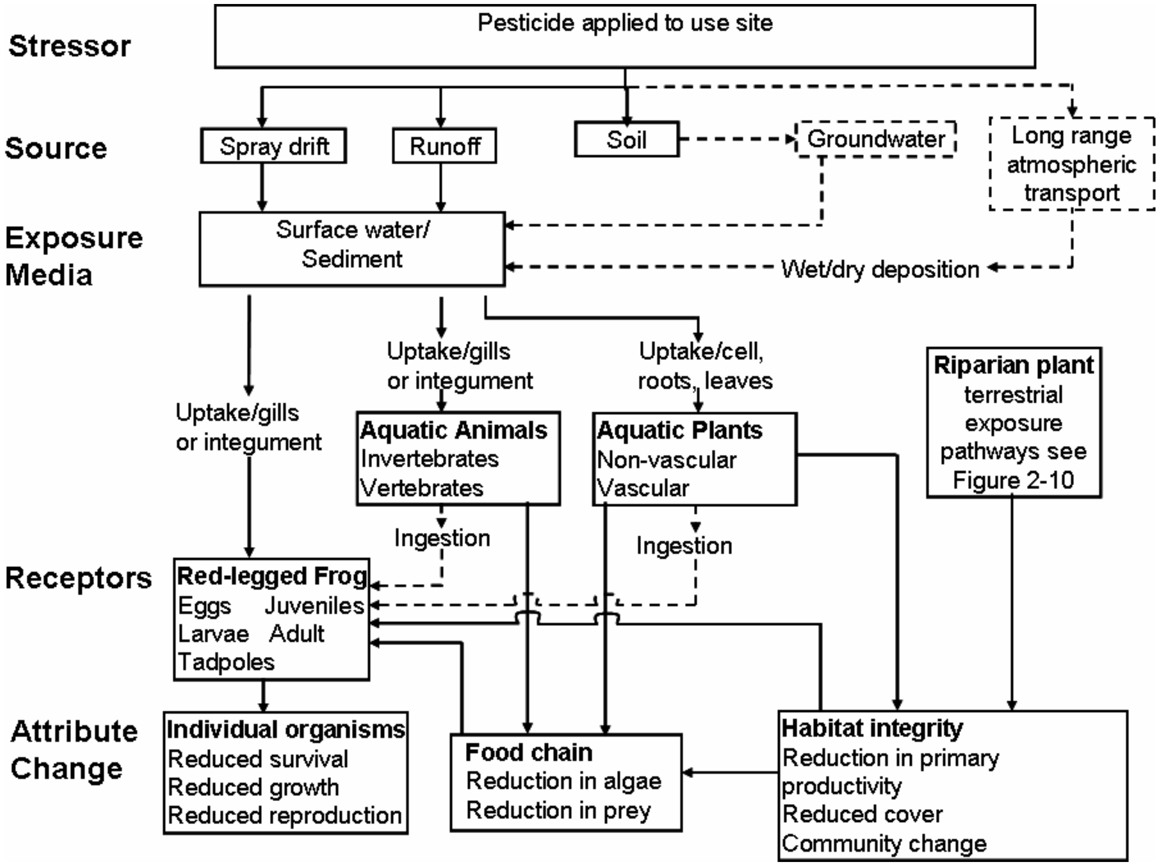


Figure 2-10. Conceptual Model for Pesticide Effects on Terrestrial-Phase of the CRLF

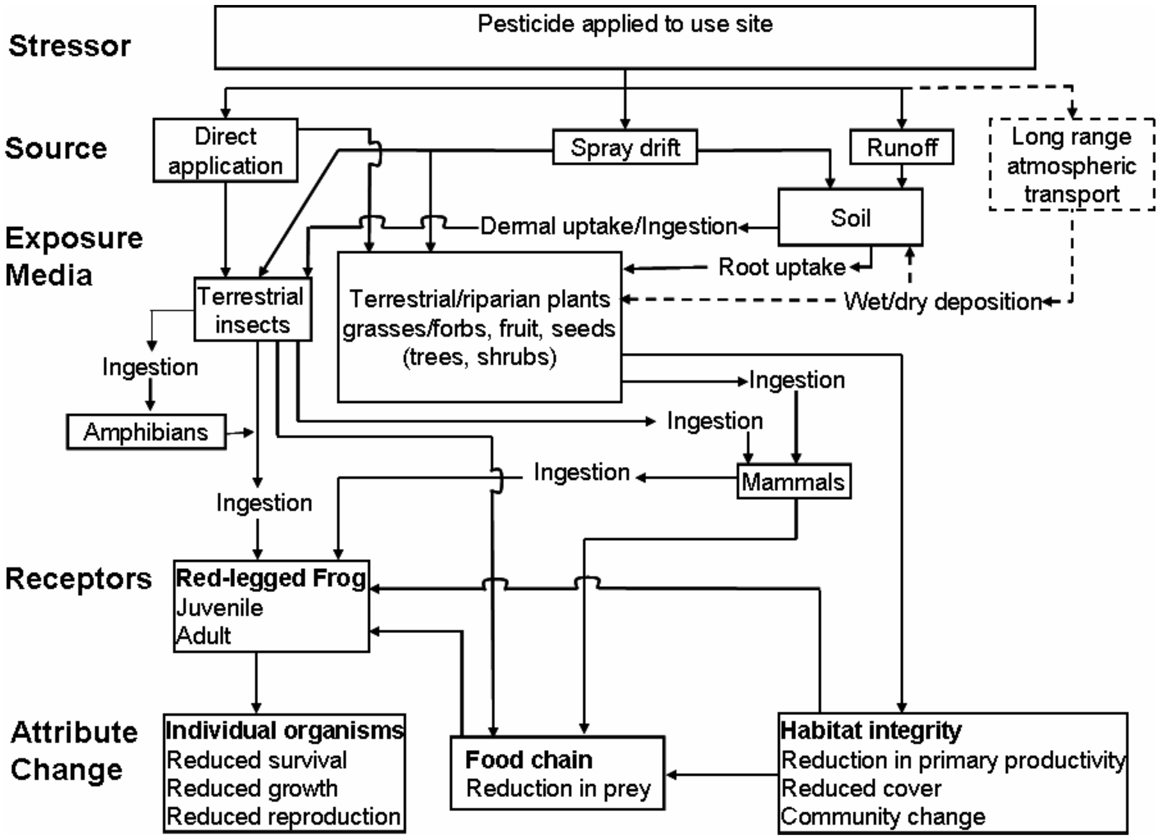


Figure 2-11. Conceptual Model for Pesticide Effects on Aquatic Components of CRLF Critical Habitat

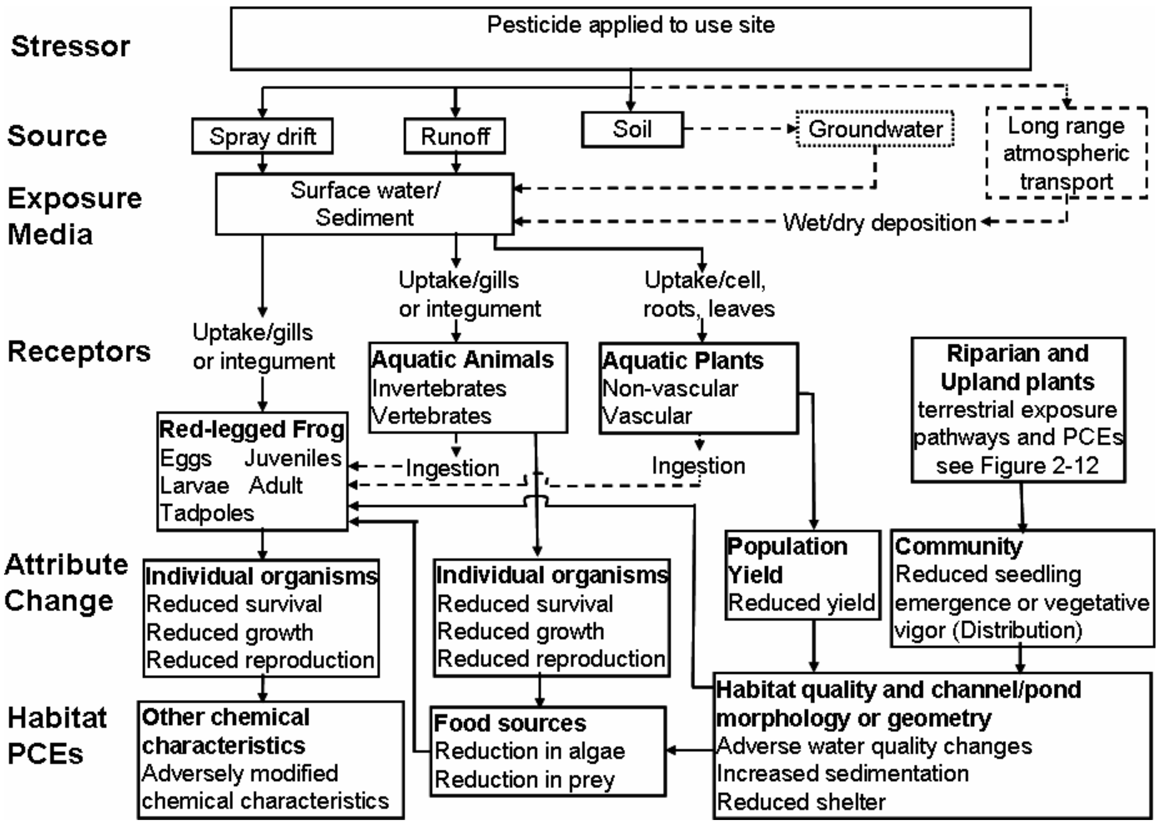
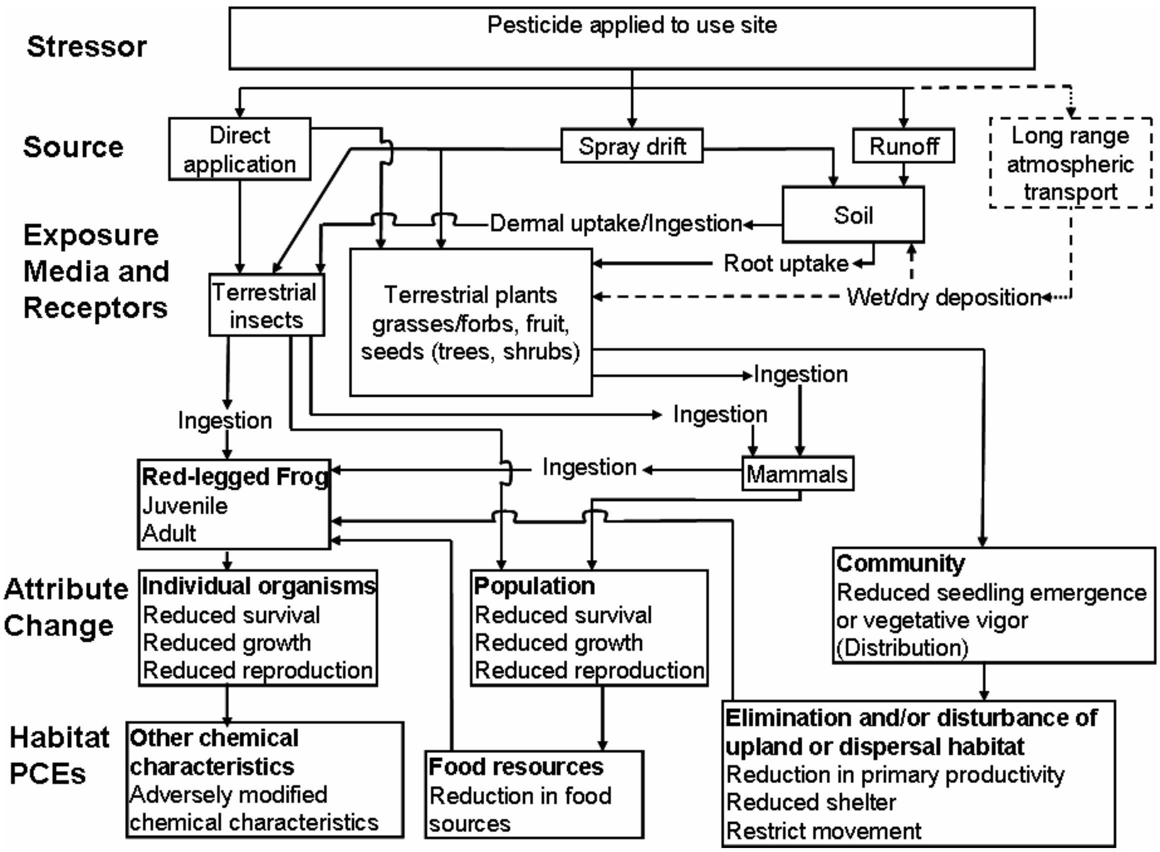


Figure 2-12. Conceptual Model for Pesticide Effects on Terrestrial Components of the CRLF Critical Habitat



2.10 Analysis Plan

In order to address the risk hypotheses, the potential for direct and indirect effects to the CRLF, its prey, and its habitat is estimated. In the following sections, the use, environmental fate, and ecological effects of esfenvalerate are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (U.S. EPA, 2004), the likelihood of effects to individual organisms from particular uses of esfenvalerate is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

2.10.1 Measures to Evaluate the Risk Hypotheses and Conceptual Model

*2.10.1.1 **Measures of Exposure***

The environmental fate properties of esfenvalerate along with available monitoring data indicate that runoff/erosion and spray drift are the principle potential transport mechanisms of esfenvalerate to the aquatic and terrestrial habitats of the CRLF. Because esfenvalerate has a strong tendency to sorb to soil (based on the Kd/Koc values), the transport of esfenvalerate from the field to water via runoff/erosion is most likely to occur with sediment. Esfenvalerate exposure in water is likely to occur both in the water column and in the pore water/ benthic sediment. In this assessment, transport of esfenvalerate through runoff/erosion and spray drift is considered in deriving quantitative estimates of esfenvalerate exposure to CRLF, its prey and its habitats.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of esfenvalerate using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to predict terrestrial EECs on food items is T-REX. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. A model is also available to estimate EECs relevant to terrestrial and wetland plants; however, toxicity values are not available for calculation of RQs, so a qualitative judgment will be made based on information presented in Section 4.0.

PRZM (v3.12.2, May 2005) and EXAMS (v2.98.4.6, April 2005) are screening simulation models coupled with the input shell pe5.pl (Aug 2007) to generate daily exposures and 1-in-10 year EECs of esfenvalerate that may occur in surface water bodies adjacent to application sites receiving esfenvalerate through runoff and spray drift. PRZM simulates pesticide application, movement and transformation on an agricultural field and the resultant pesticide loadings to a receiving water body via runoff, erosion and spray drift. EXAMS simulates the fate of the pesticide and resulting concentrations in the water body. The standard scenario used for ecological pesticide assessments assumes application to a 10-hectare agricultural field that drains into an adjacent 1-hectare surface water body, 2-meters deep (20,000 m^3 volume) with no outlet.

PRZM/EXAMS was used to estimate screening-level exposure of aquatic organisms to esfenvalerate. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10 year peak is used for estimating acute exposures of direct effects to the CRLF, as well as indirect effects to the CRLF through effects to potential prey items, including: algae, aquatic invertebrates, fish and frogs. The 1-in-10-year 60-day mean is used for assessing chronic exposure to the CRLF and fish and frogs serving as prey items; the 1-in-10-year 21-day mean is used for assessing chronic exposure for aquatic invertebrates, which are also potential prey items.

Given the aquatic toxicity of esfenvalerate and its likelihood of occurring in sediment, the Agency also considered the potential exposures resulting from benthic/sediment concentrations (EECs). Pore water concentrations are commonly used to predict toxicity of non-ionic substances in sediments and characterize exposure to organisms that spend time in or near sediments (Di Toro *et al.* 1991; US EPA 2003). PRZM/EXAMS also estimates 1-in-10-year peak, 21-day mean, and 60-day mean EECs for pore water. Total sediment concentrations may also be used to predict exposure to organisms. For example, total sediment concentrations may be used to predict exposure from ingested sediment. Total sediment concentrations were characterized based on monitoring data. These estimated EECs can be used to calculate risk quotients to determine possible risks.

Several label uses for esfenvalerate specify spray drift reduction buffers, which can affect peak aquatic EECs. The fraction spray drift used in PRZM/EXAMS was estimated based on the buffers and application methods specified on the labels using AgDRIFT. For aerial applications, very fine to fine drop size for ultra low volume applications and a buffer of 450 feet was assumed. For ground applications, a fine to medium drop size, high boom, and 25 foot buffer was assumed. These are the uses that predicted the highest fractions of spray drift for all of the use and buffer combinations specified on the labels.

Exposure estimates for the terrestrial-phase CRLF and terrestrial invertebrates and mammals (serving as potential prey) assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.3.1, 12/07/2006). This model incorporates the Kenega nomograph, as modified by Fletcher *et al*. (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represents the 95th percentile of residue values from actual field measurements (Hoerger and Kenega, 1972). For modeling purposes, direct exposures of the CRLF to esfenvalerate through residues on food are estimated using the EECs for the small bird (20 g), comparable to a young CRLF, which consumes small insects. Dietary-based and dose-based exposures of potential small mammalian prey of the CRLF are assessed using a 15 g small mammal which consumes short grass (dietary item with highest residue level). The small bird (20g) consuming small insects and the small mammal (15g) consuming short grass are used because these categories represent the largest RQs of the size and dietary categories in T-REX that are appropriate surrogates for the CRLF and one of its prey items. The estimated residues on small insects and large insects in T-REX are used as the estimated exposures for terrestrial insects to esfenvalerate.

Birds are currently used as surrogates for terrestrial-phase CRLF. However, amphibians are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds or mammals. As a consequence, birds are likely to consume more food than amphibians on a daily dietary intake basis, assuming similar caloric content of the food items. Therefore, the use of avian food intake allometric equation as a surrogate to amphibians is likely to result in an over-estimation of dose-based exposure and risk for reptiles and terrestrial-phase amphibians. Therefore, T-REX (version 1.3.1) has been refined to the T-HERPS model (v. 1.0), which allows for an estimation of food intake for poikilotherms using the same basic procedure as T-REX to estimate avian food intake.

*2.10.1.2 **Measures of Effect***

Data identified in Section 2.8 are used as measures of effect for direct and indirect effects to the CRLF. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. The ECOTOXicology database (ECOTOX) was searched in order to provide more ecological effects data and in an attempt to bridge existing data gaps. ECOTOX is a source for locating single chemical toxicity data for aquatic life, terrestrial plants, and wildlife. ECOTOX was created and is maintained by the USEPA, Office of Research and Development, and the National Health and Environmental Effects Research Laboratory's Mid-Continent Ecology Division.

The assessment of risk for direct effects to the terrestrial-phase CRLF makes the assumption that toxicity of esfenvalerate to birds is similar to or less than the toxicity to the terrestrial-phase CRLF. The same assumption is made for fish and aquatic-phase CRLF. Algae, aquatic invertebrates, fish, and amphibians represent potential prey of the CRLF in the aquatic habitat. Terrestrial invertebrates, small mammals, and terrestrial-phase amphibians represent potential prey of the CRLF in the terrestrial habitat. Aquatic, semi-aquatic, and terrestrial plants represent habitat of CRLF.

The acute measures of effect used for animals in this screening level assessment are the LD_{50}, LC_{50} and EC_{50}. LD stands for "Lethal Dose", and LD_{50} is the amount of a material, given all at once, that is estimated to cause the death of 50% of the test organisms. LC stands for "Lethal Concentration" and LC_{50} is the concentration of a chemical that is estimated to kill 50% of the test organisms. EC stands for "Effective Concentration" and the EC_{50} is the concentration of a chemical that is estimated to produce a specific effect in 50% of the test organisms. Endpoints for chronic measures of exposure for listed and non-listed animals are the NOAEL/NOAEC and NOEC. NOAEL stands for "No Observed-Adverse-Effect-Level" and refers to the highest tested dose of a substance that has been reported to have no harmful (adverse) effects on test organisms. The NOAEC (*i.e.*, "No-Observed-Adverse-Effect-Concentration") is the highest test concentration at which none of the observed effects were statistically different from the control. The NOEC is the No-Observed-Effects-Concentration. For non-listed plants, only acute exposures are assessed (*i.e.*, EC_{25} for terrestrial plants and EC_{50} for aquatic plants).

*2.10.1.3 **Integration of Exposure and Effects***

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from agricultural and non-agricultural uses of esfenvalerate, and the likelihood of direct and indirect effects to CRLF in aquatic and terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. For the assessment of esfenvalerate risks, the risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see APPENDIX L).

For this endangered species assessment, as discussed in Section 2.1, listed species LOCs are used for comparing RQ values for acute and chronic exposures of esfenvalerate directly to the CRLF. If estimated exposures directly to the CRLF of esfenvalerate resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is "may affect". When considering indirect effects to the CRLF due to effects to animal prey (aquatic and terrestrial invertebrates, fish, frogs, and mice), the listed species LOCs are also used. If estimated exposures to CRLF prey of esfenvalerate resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is a "may affect." If the RQ being considered also exceeds the non-listed species acute risk LOC, then the effects determination is a LAA. If the acute RQ is between the listed species LOC and the non-listed acute risk species LOC, then further lines of evidence (*i.e*. probability of individual effects, species sensitivity distributions) are considered in distinguishing between a determination of NLAA and a LAA. When considering indirect effects to the CRLF due to effects to algae as dietary items or plants as habitat, the non-listed species LOC for plants is used because the CRLF does not have an obligate relationship with any particular aquatic and/or terrestrial plant. If the RQ being considered for a particular use exceeds the non-listed species LOC for plants, the effects determination is "may affect." Further information on LOCs is provided in APPENDIX L.

2.10.1.4 ***Data Gaps***

Guideline studies are not available to provide estimates of esfenvalerate toxicity to aquatic plants or terrestrial plants. No studies are available for determining the chronic toxicity of esfenvalerate for birds (surrogate for terrestrial-phase amphibians). Although some information on plants is available from the ECOTOX open literature (see Section 4.0), no further information on esfenvalerate was found for birds.

Environmental fate data gaps exist for aerobic aquatic metabolism and anaerobic aquatic metabolism, resulting in uncertainty in the assessment of the stability of esfenvalerate in aquatic environments. In the absence of data, the Agency used results of soil metabolism studies to estimate aquatic metabolism rates for aquatic exposure modeling. The aerobic aquatic metabolism half-life, reflective of the persistence of esfenvalerate in the water column, was assumed to be twice that of the aerobic soil metabolism half life. The anaerobic aquatic metabolism half-life, reflective of persistence in the sediment, was assumed to be twice that of the anaerobic soil metabolism half-life.

While only a single guideline study existed for both aerobic and anaerobic soil metabolism, open literature (Laskowski, 2002; Kelley, 2007) provided a range of half-lives for these routes of degradation.

Only a single terrestrial field dissipation study, from 1990-1992, is available to assess the dissipation of esfenvalerate under field conditions. This limits the degree to which the Agency is able to characterize the combined interaction of multiple routes of dissipation in the field.

Limited information is available on the fate and transport of the four stereoisomers for esfenvalerate. In the absence of such information, the Agency assumed that all four isomers would behave similarly in the environment. All degradation half-lives were based on the breakdown of the molecule rather than any isomerization that might occur in the environment.

3.0 Exposure Assessment

Exposure is the contact or co-occurrence between a stressor (esfenvalerate) and a receptor (the CRLF and the habitat upon which it depends). The objective of exposure assessment is to describe exposure in terms of intensity, space, and time in units that can be combined with the effects assessment (USEPA 1998) presented in section 4.0.

3.1 Label Application Rates and Intervals

Esfenvalerate labels may be categorized into two types: labels for manufacturing uses (including technical grade esfenvalerate and its formulated products) and end-use products. While technical products, which contain esfenvalerate of high purity, are not used directly in the environment, they are used to make formulated products, which can be applied in specific areas to control insects. The formulated product labels legally limit esfenvalerate's potential use to only those sites that are specified on the labels. Each use will potentially provide a different exposure of CRLF to esfenvalerate in terms of intensity, space, and time.

EFED uses models to estimate the intensity and duration of exposure of organisms to chemical concentrations in the environment that are appropriate for locations at which the exposure of esfenvalerate and/or its degradates will co-occur with the CRLF. Uses that produce similar exposures (in terms of intensity, space, and time) are grouped together and evaluated as a single exposure scenario because it would be unwieldy and impractical to evaluate each individual esfenvalerate use. In this way, the large number of esfenvalerate uses that vary greatly in terms of potential exposure can be grouped into a more manageable number of exposure scenario groups that relatively accurately reflect the exposure expected from each of the label-permitted esfenvalerate uses.

The purpose of the exposure assessment is to determine if the currently permitted label uses will harm the CRLF, so scenarios for each use are developed using assumptions expected to result in the highest exposures. However, as shown in section 2.4.4, the paucity of information given on many esfenvalerate labels regarding the time of year when esfenvalerate can be applied, the number of applications per year or crop-cycle, and the minimum time until additional esfenvalerate treatments could be applied required that assumptions be made in the design of these scenarios.

Maximum application rates were used in each scenario in order to ensure that scenarios were conservative (protective of CRLF), at the same time they also represent the legal limit. For agricultural uses and the forest use, it was assumed the maximum application rate would be applied by ground or aerial application methods. When application intervals were not specified, an application interval of seven days was assumed because this was the lowest application interval provided on the labels. Application date was determined as described in Section 3.2.2.3 Application Information. When the CDPR PUR usage data indicated more than one start date, the application interval was also adjusted to model two start dates (see almond scenarios). Non-agricultural uses often have application rates when converted to lbs ai per acre that are much higher than the corresponding agricultural uses, but are applied to much smaller areas. The maximum home and garden rates from each crop/site were evaluated collectively, using scenarios developed for ground application to residential areas, right of ways, impervious surfaces, and lawns. Application dates for non-agricultural uses were assumed to begin on April 1st. As some labels allow for many repeated applications, some applications may occur outside the crop window of a particular scenario. AgDRIFT was used to estimate the spray drift fraction with the buffers specified on the label.

Currently registered agricultural and non-agricultural uses of esfenvalerate within California are discussed in Section 2.4. The uses being assessed using RQ methods are summarized in Table 3-1.

Table 3-1. Esfenvalerate Uses, Scenarios, and Application Information for Estimating Aquatic Environmental Concentrations. [1,2]

Scenario: Uses Represented By Scenario	Maximum Single Application Rate (kg ai/hectare)	Application Date (Day-Month)	Number of Applications Per Year[3]	Application Interval (Days)
CA almond WirrigSTD: Almond, Filbert, Pecan, Walnut	0.11	1-Jan	2	7
	0.11	1-Jan and 1-July	2	NA
	0.08	1-Jan and 1-July	4	7, 1 application after 1-Jan and 1-July
CAColeCropRLF: Broccoli, Chinese Broccoli, Cabbage, Chinese Cabbage, Cauliflower, Collards, Kohlrabi, Mustard	0.06	1-May	24	7
	0.06	1-May	12	7
CAcornOP: Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.06	1-Apr	20	7
	0.06	1-Apr	5	7
CAcornOP: At Plant[4,5] Applications to Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.11	1-Apr	1	NA[7]
CAcotton_WirrigSTD: Cotton	0.06	1-Sep	10	7
CAfruit_WirrigSTD: Apple, Apricot, Cherry, Kiwi, Nectarine, Peach, Pear, Plum, Prune	0.08	1-Jan	7	7
	0.08	1-Jan and 1-June	9	7, 5 applications after 1-Jan and 2 applications after 1-June
	0.08	1-Mar and 1-Nov	7	7, 4 applications after 1-Mar and 2 applications (0.11 application rate) after 1-Nov
CAlettuceSTD: Head Lettuce	0.06	1-Mar and 17-Aug	14	7, 7 applications after 1-Mar and 5 applications after 17-Aug
CAMelonsRLF: Cucumber, Eggplant, Melons, Cantaloupe,	0.06	1-Apr	7	7
	0.06	1-Apr	5	7

Scenario: Uses Represented By Scenario	Maximum Single Application Rate (kg ai/hectare)	Application Date (Day-Month)	Number of Applications Per Year[3]	Application Interval (Days)
Honeydew, Musk Melon, Watermelon, Pumpkin, Squash (all or unspecified), Summer Squash, Winter Squash				
CAonion_WirrigSTD: Radish	0.06	1-Apr	7	7
CAPotatoRLF: White/Irish Potato, Turnip	0.06	1-Mar	10	7
	0.06	1-Mar	7	7
CARowCropRLF: Artichoke, Dried Type Beans, Succulent (Snap) Beans, Carrot, Lentils, Peas (Unspecified), Dried-Type Peas, Pepper	0.06	1-Jun	3	7
CAsugarbeet_WirrigOP: At Plant[4,5] Application to Sugarbeet	0.11	1-Sep	1	NA
	0.11	1-Sep	1	NA
CAsugarbeet_WirrigOP: Sugarbeet	0.06	1-Sep	3	7
CAtomato_WirrigSTD: Tomato	0.06	1-Jul	10	7
CAresidentialRLF: Non Crop Land	0.06	1-Apr	10	7
CArightofwayRLF: Non Cropland	0.06	1-Apr	10	7
CAForestryRLF: Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries	0.06	1-Mar	25[8]	7
	0.06	1-Jul	25[8]	7
CAnurserySTD: Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries, and Forests	0.06	1-Mar	25[8]	7
	0.06	1-Jul	25[8]	7
CAresidentialRLF: Non-agricultural Uses[6]	0.22	1-Apr	1	NA
	0.22	1-Apr	2	7
	0.22	1-Apr	3	7
CAturfRLF: Lawns and Turf Grass	0.22	1-Apr	3	7
CArightofwayRLF: Non-agricultural Uses	0.22	1-Apr	3	7
	0.22	1-Apr	1	NA

Scenario: Uses Represented By Scenario	Maximum Single Application Rate (kg ai/hectare)	Application Date (Day-Month)	Number of Applications Per Year[3]	Application Interval (Days)
CAImperviousRLF: Non-agricultural Uses	0.22	1-Apr	1	NA

[1] Uses assessed based on memorandum from RD [September 7, 2007] confirming that the "list is accurate with respect to products and use patterns currently registered containing" esfenvalerate. As some labels allow for many repeated applications, some applications may occur outside the crop window of a particular scenario.
[2] Did not include sugarcane, sorghum, and peanuts in the table because the CDPR PUR usage data indicates that less than one pound of ai was applied to each of these sites and they do not fit within an already established scenario. Also, esfenvalerate is restricted from use on sorghum on the Dupont Asana Label XL (EPA Registration Number 352-515).
[3] Maximum applications per year were calculated by multiplying the maximum season rate by the maximum number of seasons and dividing by the maximum single application rate. The values used in calculations are reported in Table 2-3 and Table 2-4. When different maximum application rates were provided for a season and when dormant, each season rate was divided by the maximum single application rate and added to arrive at the maximum number of applications per year.
[4] Assumed that when applied at plant that esfenvalerate was only applied once per season. Page four of the Dupont Asana Label excludes CA for use of esfenvalerate at plant for corn to control black cutworm. However, page five also discusses at plant usage on corn and does not exclude use in CA.
[5] At plant applications and non-agricultural applications were assumed to be applied via ground application. In these PRZM scenarios input parameters for ground applications are set to CAM =1, application efficiency = 0.99, and fraction spray drift was determined using AgDRIFT. For aerial applications, input parameters were set to CAM=2, application efficiency=0.95, and fraction spray drift was determined using AgDRIFT.
[6] Assumed rate provided for lawns for all non-agricultural uses because many labels did not specify a maximum application rate per area and the lawn use rate was the highest for the non-agricultural uses. These PRZM scenarios are assumed to cover all non-agricultural uses. The use rate and use areas are similar for these uses.
[7] NA stands for not applicable.
[8] Thirty-two applications are actually possible with the maximum seasonal rate for tree and forest uses. However, PRZM would not run with the 32 applications input value.

3.2 Aquatic Exposure Assessment

3.2.1 Modeling Approach

The EECs (Environmental Effects Concentrations) were calculated using the EPA Tier II PRZM (Pesticide Root Zone Model) and EXAMS (Exposure Analysis Modeling System) with the EFED Standard Pond environment, PRZM and EXAMS. PRZM is used to simulate pesticide transport as a result of runoff and erosion from an agricultural field, and EXAMS estimates environmental fate and transport of pesticides in surface water.

The most recent PRZM/EXAMS linkage program (PE5, PE Version 5, dated Nov. 15, 2006) was used for all surface water simulations. Linked crop-specific scenarios and meteorological data were used to estimate exposure resulting from use on crops and turf.

Aquatic exposures are quantitatively estimated for all assessed uses using scenarios that represent high exposure sites for esfenvalerate use. Each of these sites represents a 10 hectare field that drains into a 1-hectare pond that is 2 meters deep and has no outlet. Exposure estimates generated using the standard pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that make these water bodies more or less vulnerable than the standard surrogate pond. Static water bodies that have larger ratios of drainage area to water body volume would be expected to have higher peak EECs than the standard pond. These water bodies will be either shallower or have large drainage areas (or both). Shallow water bodies tend to have limited additional storage capacity, and thus, tend to overflow and carry pesticide in the discharge whereas the standard pond has no discharge. As watershed size increases beyond 10 hectares, at some point, it becomes unlikely that the entire watershed is planted to a single crop, which is all treated with the pesticide. Headwater streams can also have peak concentrations higher than the standard pond, but they tend to persist for only short periods of time and are then carried downstream.

Esfenvalerate labels include a number of non-agricultural uses (Table 2-4), including applications around buildings, structures, and equipment in residential, commercial, and industrial areas; applications to lawns, grass, recreational areas, and uncultivated lands; and applications to forest trees. These uses are represented by the residential, turf, rights-of-way, impervious surface, and forestry scenarios listed in Table 3-1.

Residential and rights-of-way (ROW) scenarios were developed specifically for the San Francisco Bay region using the conceptual approach developed for the Barton Springs salamander atrazine endangered species risk assessment (U.S. EPA, 2006). The San Francisco area was selected to be representative of urbanized areas with CRLF habitat present in the general vicinity. The conceptual model for both scenarios integrates simultaneous modeling of the individual use scenario with an impervious scenario. This approach assumes that no watershed is completely covered by either the ¼ acre lot (the basis for the residential scenario) or undeveloped land (the basis for the ROW scenario) for residential and ROW use patterns; therefore, differential amounts of runoff will occur within the watershed. The impervious scenario was developed to represent the paved areas within a watershed not including roads, parking lots, sidewalks, and buildings outside the ¼ acre lot (the ¼ acre lot scenario accounts for impervious surfaces such as buildings within the represented area). By modeling a separate scenario for impervious surfaces, it is also possible to estimate that amount of exposure that could occur when the pesticide is over sprayed onto this surface. In previous endangered species risk assessments, the amount of modeled overspray was assumed to be 1% of the labeled application rate. Further details on how this value was derived and characterization of alternative assumptions are provided in the Barton Springs salamander endangered species risk assessment for atrazine (U.S. EPA, 2006).

In general, the majority of occupied areas (including core areas, designated critical habitat, and occurrence data from CNDDB, which are further defined in Section 2.5) are located in areas where the percentage of impervious surface is less than 20%. However, a few selected areas with higher percentages of impervious surface (*e.g.*, San Francisco Bay region) were evaluated to determine a representative value for residential settings. The conceptual model for the ROW scenario assumes that the watershed is represented by equal portions of impervious and pervious surface (50%). Based on geospatial data, it is evident that the occupied areas with the highest percentage of impervious cover are urban areas outside the occupied areas, and, in general, the occupied areas have impervious surface of less than 50%. Therefore, for purposes of modeling, it is assumed that a representative percentage of impervious cover is 50%. In general, as the percentage of impervious surface increases, the overall exposure resulting from applications to the pervious surface decreases because less mass is applied within the watershed. Additional information on the impact of this assumption has been previously characterized in the Barton Springs salamander endangered species risk assessment for atrazine (U.S. EPA, 2006).

3.2.2 Model Inputs

The appropriate PRZM and EXAMS input parameters for esfenvalerate were selected from the environmental fate data submitted by the registrant and in accordance with US EPA-OPP EFED water model parameter selection guidelines, Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version II, February 28, 2002. Input parameters can be grouped by physico-chemical properties and environmental fate data, application information, and scenarios.

3.2.2.1 Physico-chemical Properties and Environmental Fate

Esfenvalerate environmental fate data used for generating model parameters is listed in Table 2-1 and Table 2-2. The input parameters for PRZM and EXAMS are in Table 3-2.

Table 3-2. Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Esfenvalerate Endangered Species Assessment for the CRLF.[1,2]

Fate Property	Value	MRID, Author Year(or source)
Molecular Weight	419.9 g/mol	Kelley 2007
Henry's constant	1.4×10^{-12} atm-m^3/mol	Laskowski 2002
Vapor Pressure	4.5×10^{-7} torr	46725304, Comb 2002
Solubility in Water	0.006 mg/L[3]	Laskowski 2002
Photolysis in Water	9 days	40443801, Stevenson 1987
Aerobic Soil Metabolism	138 days[4]	EFED Guidance[2]
Hydrolysis	Stable	409999303, Lee 1989
Aerobic Aquatic Metabolism (water column)	276 days[5]	EFED Guidance[2]
Anaerobic Aquatic Metabolism (benthic)	462 days[6]	EFED Guidance[2]
K_{OC}	251,717 mL/g	EFED Guidance[2]
Application rate and frequency	See Table 3-1	EFED Guidance[2]

Fate Property	Value	MRID, Author Year(or source)
Application intervals	See Table 3-1	EFED Guidance[2]
Chemical Application Method (CAM)	1 for ground applications 2 for aerial applications	EFED Guidance[2]
Application Efficiency	0.99 for ground applications 0.95 for aerial applications	EFED Guidance[2]
Spray Drift Fraction[1]	0.0071 for ground applications 0.0625 for aerial applications	EFED Guidance[2]

[1] The spray drift fractions were estimated using AgDRIFT and the buffers specified on labels. For aerial applications, AgDRIFT values were set to very fine to fine drop size and a buffer of 450 feet. For ground applications, AgDRIFT values were set to fine to medium drop size, high boom, and a buffer of 25 feet.
[2] Inputs determined in accordance with EFED "*Guidance for Chemistry and Management Practice Input Parameters for Use in Modeling the Environmental Fate and Transport of Pesticides*" dated February 28, 2002.
[3] Three water solubility values were reported for esfenvalerate. The value for the guideline study submitted was not specific enough to use (<0.01 mg/L) and the other values were very similar (0.002 and 0.006 mg/L) (see Table 2-1). As the two values were very similar, the choice of the value would not have a significant affect on the modeling results.
[4] The aerobic soil metabolism half-life value is the 90th upper confidence bound on the mean metabolism half-life using the equation in EFED Guidance and the values in APPENDIX J.
[5] The aerobic aquatic metabolism half-life was estimated by multiplying the aerobic soil metabolism half-life by two.
[6] Assumed two times the aerobic soil metabolism half-life of 231days because the compound is hydrolytically stable and no aerobic or anaerobic aquatic metabolism data was available. As only one anaerobic soil metabolism value was available, the measured value (77 days) was multiplied by three.

*3.2.2.2 **PRZM Scenarios***

EPA used PRZM scenarios specific to California, representing a variety of crop and non-agricultural scenarios. Each scenario is intended to represent a high-end exposure setting for a particular crop. Each scenario location is selected based on various factors. Once a location is selected, a scenario is developed using locally specific soil, climatic, and agronomic data. Each PRZM scenario is assigned a specific climatic weather station providing 30 years of daily weather values, see APPENDIX B for the station chosen for each scenario. Table 3-3 summarizes the PRZM scenario name and location. Residential, right-of-ways, and impervious surface scenarios were processed further to estimate exposures when a percentage of a surface is impervious and a percentage is pervious. The method used is described in APPENDIX K. Treatment of 100% of an impervious surface is not expected to occur. However, these results were included, as the PRZM results are used to estimate EECs and they represent exposure that could occur when the pesticide is over sprayed onto an impervious surface.

Table 3-3. PRZM/EXAMS Scenarios Used to Estimate Concentrations of Esfenvalerate in the Aquatic Environment.[1]

Tier 2 Modeling Scenario	Location Modeled
CAalmond_WirrigSTD[2]	San Joaquin County
CAColeCropRLF	Monterey County
CAcornOP	Stanislaus and Jan Joaquin Counties
CAcotton_WirrigSTD[2]	Fresno County
CAfruit_WirrigSTD[2]	Fresno County
CAlettucesSTD	Monterey County
CAMelonsRLF	Fresno, Merced, Kern, and Kings Counties
CAonion_WirrigSTD[2]	Kern County
CAPotatoRLF	Kern County
CARowCropRLF	Kern, Monterey, San Luis Obispo, Santa Barbara, and Ventura Counties
CAsugarbeet_WirrigOP[2]	Central Valley
CAtomato_WirrigSTD[2]	San Joaquin County
CAresidentialRLF	San Francisco
CArightof wayRLF	Central/ coastal CA
CAForestryRLF	Trinity, Shasta, Modoc, and Humboldt Counties
CAnurserySTD	San Diego
CAturfRLF	Central / northern CA
CAImperviousRFL	San Francisco

[1] Counties for the different scenarios were taken from CA_PRZM_scenarios_surrogates.xls.
[2] Assumed the scenarios that included data on irrigation were located in the same area as the associated STD scenario, e.g., assumed that CAalomondSTD and CAalmond_WirrigSTD, used the same location assumptions.

3.2.2.3 Application Information

Crop-specific management practices for all of the assessed uses of esfenvalerate were used for modeling, including application rates, number of applications per year, application intervals, and the first application date for each crop. The date of first application was developed based on several sources of information including data provided by BEAD, a summary of individual applications from the CDPR PUR data, and Crop Profiles maintained by the USDA. A sample of the CDPR PUR data for 2005 used to determine the application date is provided in Figure 3-1, with all figures provided in APPENDIX G. The amount of esfenvalerate applied by month to almonds was used to pick January 1st and July 1st application dates for the tree nut scenarios.

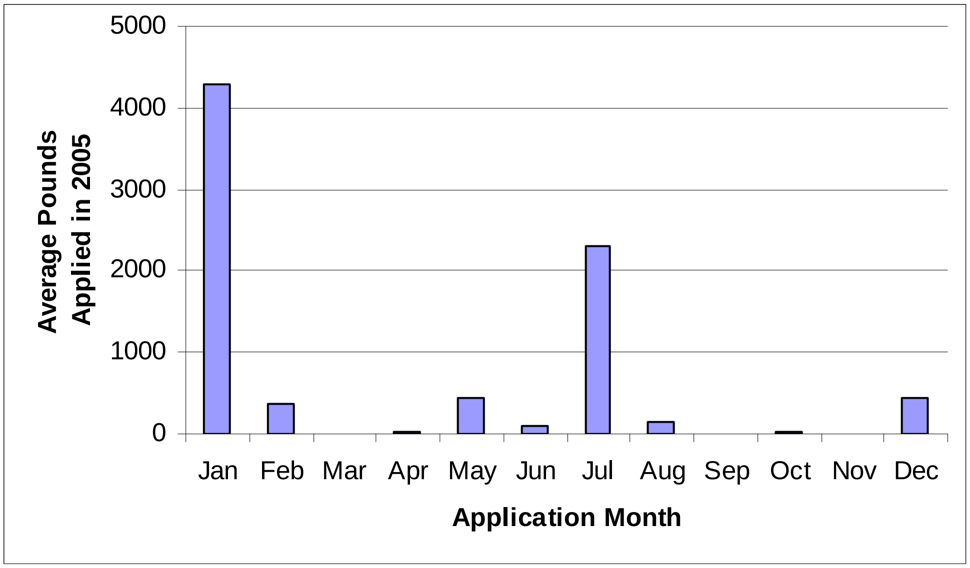


Figure 3-1. Total Pounds of Esfenvalerate Applied to Almonds by Month in 2005 based on CDPR PUR data.

More detail on the crop profiles and the previous assessments may be found at: http://pestdata.ncsu.edu/cropprofiles/cropprofiles.cfm. All other application information used to estimate concentrations in the aquatic environment is available in Table 3-1.

3.2.3 Results

The aquatic EECs for the various scenarios and application practices are listed in Table 3-4**.** The output from PRZM-EXAMS is provided in APPENDIX B. Peak water column concentrations for the agricultural applications ranged from 0.02 µg/L to 1.11 µg/L. Peak water column concentrations from non-agricultural uses were higher and ranged from 0.05 µg/L to 6.47 µg/L. The highest peak exposure predicted was for a scenario that assumed that the entire watershed/application area was impervious. Such conditions (100% impervious surface) are not expected to occur, even in a densely urban area. More accurate EECs, Residential Non-Agricultural Uses with Impervious Surfaces and Right-of-Way Non-Agricultural Uses with Impervious Surfaces, still have high peak EECs (~3 µg/L). The next highest exposures were predicted from the forestry and nursery scenarios, the uses with the highest number of applications. Pore water concentrations were relatively constant over time, e.g., peak, 21 day, and 60 day concentrations were all very similar and ranged from 0.001 – 0.241 µg/L.

3.2.4 Existing Monitoring Data

The USGS NAWQA data warehouse[27] included no monitoring results for esfenvalerate. While the pesticide was included in earlier analytical methods, poor recoveries in the methods led to

[27] http://infotrek.er.usgs.gov/traverse/f?p=NAWQA:HOME:543723453545295

both its removal from the analytical method and deletion of all historical data in 1997 (Foreman and Gilliom, 1997).

Esfenvalerate was included in surface water and sediment monitoring data obtained from the California Department of Pesticide Regulation[28]. Esfenvalerate was detected in 3 of 365 surface water samples (0.8% detections) where the limits of quantification ranged from 0.02 to 0.05 µg/L. The detections – 0.06, 0.14, and 0.17 µg/L – all occurred in Stanislaus County in 2003. The two highest detections occurred in tributaries of the San Joaquin River while the lowest detection was found in an irrigation distribution drain. Esfenvalerate was also detected in 21 out of 259 sediment samples (8% detections), with limits of quantification from 0.001 to 0.01 µg/g (ppm). The detections, ranging from 0.002 to 0.07 µg/g, or 20 to 70 ng/g (ppb), were reported in Imperial (2 detects), Monterey (5 detects), Placer (5 detects), and Stanislaus (9 detects) counties between 2003 and 2005. Because these samples were not specifically targeted to esfenvalerate use areas and were not collected at sites similar to the standard EXAMS pond (which is designed to present a high EEC scenario), these detections are not expected to be comparable to PRZM/EXAMS EECs. However, any agreement/disagreement can aid in characterizing the uncertainty of the PRZM/EXAMS esfenvalerate EECs.

Weston *et al*. (2004) evaluated sediment samples from the Central Valley of California, with a focus on the pyrethroid insecticides. Esfenvalerate was detected in 32% of 70 sediment samples collected from 10 counties in the Central Valley, with the highest detections ranging from 11 to 30 ng/g (0.01 to 0.03 ppb) in three sampled creeks and sloughs and from 10 to 28 ng/g (0.01 to 0.028 ppb) in three irrigation canals (Weston *et al.*, 2004).

[28] http://www.cdpr.ca.gov/docs/sw/surfdata.htm

Table 3-4. Aquatic EECs (µg/L) for Esfenvalerate Uses in California.[1]

Scenario: Uses Represented By Scenario	Maximum Single App. Rate (kg ai/hectare)	App. Date (Day-Month)	Number of App.	App. Interval (Days)	App. Method	Estimated Environmental Concentrations (EECs) in µg/L: Water Column Peak	Water Column 21 Day	Water Column 60 Day	Pore Water Peak	Pore Water 21 Day	Pore Water 60 Day
CA almond WirrigSTD: Almond, Filbert, Pecan, Walnut	0.11	1-Jan	2	7	Aerial	0.240	0.047	0.033	0.010	0.009	0.009
	0.11	1-Jan	2	7	Ground	0.054	0.011	0.009	0.003	0.003	0.003
	0.11	1-Jan	2	180	Aerial	0.239	0.035	0.028	0.009	0.009	0.009
	0.08	1-Jan	4	7, 170, 7	Aerial	0.192	0.050	0.041	0.013	0.013	0.013
CAColeCropRLF: Broccoli, Chinese Broccoli, Cabbage, Chinese Cabbage, Cauliflower, Collards, Kohlrabi, Mustard	0.06	1-May	24	7	Aerial	0.626	0.288	0.279	0.099	0.098	0.097
	0.06	1-May	24	7	Ground	0.538	0.171	0.162	0.055	0.055	0.054
	0.06	1-May	12	7	Aerial	0.261	0.141	0.139	0.045	0.045	0.044
	0.06	1-May	12	7	Ground	0.214	0.069	0.066	0.022	0.022	0.022
CAcornOP: Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.06	1-Apr	20	7	Aerial	1.112	0.279	0.264	0.088	0.087	0.086
	0.06	1-Apr	20	7	Ground	0.868	0.169	0.148	0.049	0.049	0.049
	0.06	1-Apr	5	7	Aerial	0.201	0.069	0.061	0.019	0.019	0.019
CAcornOP: At Plant Applications to Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.11	1-Apr	1	NA[2]	Ground	0.060	0.013	0.011	0.004	0.004	0.004
CAcotton_WirrigSTD: Cotton	0.06	1-Sep	10	7	Aerial	0.195	0.080	0.077	0.023	0.023	0.023
	0.06	1-Sep	10	7	Ground	0.107	0.029	0.026	0.008	0.008	0.008
CAfruit_WirrigSTD: Apple, Apricot, Cherry, Peach, Pear, Plum, Prune, Nectarine	0.08	1-Jan	9	7	Aerial	0.232	0.084	0.079	0.023	0.023	0.022
	0.08	1-Jan	9	7	Ground	0.065	0.014	0.013	0.004	0.004	0.004

Scenario: Uses Represented By Scenario	Maximum Single App. Rate (kg ai/hectare)	App. Date (Day-Month)	Number of App.	App. Interval (Days)	App. Method	Estimated Environmental Concentrations (EECs) in µg/L					
						Water Column			Pore Water		
						Peak	21 Day	60 Day	Peak	21 Day	60 Day
	0.08	1-Jan	9	7,7,7,7,7,115,7,7	Aerial	0.220	0.081	0.072	0.021	0.021	0.021
	0.08	1-Mar	7	7,7,7,7,210,7 (last 2 applications at 0.11)	Aerial	0.259	0.073	0.063	0.019	0.019	0.018
	0.08	1-Mar	7	7,7,7,7,210,7 (last 2 applications at 0.11)	Ground	0.034	0.010	0.010	0.003	0.003	0.003
CAlettuceSTD: Head Lettuce	0.06	1-Mar	14	7,7,7,7,7,7,7,120,7,7,7,7,7	Aerial	0.883	0.260	0.250	0.085	0.085	0.084
	0.06	1-Mar	14	7,7,7,7,7,7,7,120,7,7,7,7,7	Ground	0.847	0.189	0.171	0.059	0.059	0.059
CAMelonsRLF: Cucumber, Eggplant, Melons, Cantaloupe, Honeydew, Musk Melon, Watermelon, Pumpkin, Squash (all or unspecified), Summer Squash, Winter Squash	0.06	1-Apr	7	7	Aerial	0.152	0.051	0.046	0.013	0.013	0.012
	0.06	1-Apr	5	7	Aerial	0.142	0.041	0.033	0.009	0.009	0.009
	0.06	1-Apr	7	7	Ground	0.017	0.006	0.006	0.002	0.002	0.002
CAonion_WirrigSTD: Radish	0.06	1-Apr	7	7	Aerial	0.152	0.050	0.045	0.012	0.012	0.012
	0.06	1-Apr	7	7	Ground	0.040	0.009	0.008	0.003	0.003	0.003
CAPotatoRLF: White/Irish Potato, Turnip	0.06	1-Mar	10	7	Aerial	0.165	0.063	0.060	0.017	0.017	0.017
	0.06	1-Mar	7	7	Aerial	0.151	0.049	0.044	0.012	0.012	0.012
	0.06	1-Mar	10	7	Ground	0.041	0.010	0.010	0.003	0.003	0.003
CARowCropRLF: Artichoke, Dried Type Beans, Succulent (Snap) Beans, Carrot, Lentils,	0.06	1-Jun	3	7	Aerial	0.144	0.043	0.033	0.010	0.010	0.010

Scenario: Uses Represented By Scenario	Maximum Single App. Rate (kg ai/hectare)	App. Date (Day-Month)	Number of App.	App. Interval (Days)	App. Method	Estimated Environmental Concentrations (EECs) in µg/L					
						Water Column			Pore Water		
						Peak	21 Day	60 Day	Peak	21 Day	60 Day
Peas (Unspecified), Dried-Type Peas, Pepper	0.06	1-Jun	3	7	Ground	0.046	0.012	0.011	0.004	0.004	0.004
CAsugarbeet_WirrigOP: At Plant Application to Sugarbeet	0.11	1-Sep	1	NA	Ground	0.034	0.008	0.006	0.002	0.002	0.002
CAsugarbeet_WirrigOP: Sugarbeet	0.06	1-Sep	3	7	Aerial	0.137	0.036	0.026	0.008	0.008	0.007
	0.06	1-Sep	3	7	Ground	0.057	0.013	0.011	0.004	0.003	0.003
CAtomato_WirrigSTD: Tomato	0.06	1-Jul	10	7	Aerial	0.168	0.068	0.066	0.019	0.019	0.018
	0.06	1-Jul	10	7	Ground	0.052	0.012	0.012	0.004	0.004	0.004
CAresidentialRLF: Non Crop Land	0.06	1-Apr	10	7	Aerial	0.185	0.085	0.081	0.025	0.025	0.024
	0.06	1-Apr	10	7	Ground	0.023	0.011	0.011	0.003	0.003	0.003
CArightofwayRLF: Non Cropland	0.06	1-Apr	10	7	Aerial	0.193	0.091	0.088	0.027	0.027	0.027
	0.06	1-Apr	10	7	Ground	0.071	0.019	0.019	0.006	0.006	0.006
CAForestryRLF: Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries, and Forests	0.06	1-Mar	25	7	Aerial	2.266	0.618	0.588	0.207	0.206	0.204
	0.06	1-Jul	25	7	Aerial	2.562	0.740	0.706	0.245	0.244	0.241
	0.06	1-Jul	25	7	Ground	2.083	0.506	0.473	0.168	0.167	0.165
CAnurserySTD: Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries,	0.06	1-Mar	25	7	Aerial	3.494	0.630	0.530	0.178	0.177	0.175
	0.06	1-Jul	25	7	Aerial	3.862	0.780	0.649	0.216	0.215	0.212

Scenario: Uses Represented By Scenario	Maximum Single App. Rate (kg ai/hectare)	App. Date (Day-Month)	Number of App.	App. Interval (Days)	App. Method	Estimated Environmental Concentrations (EECs) in µg/L					
						Water Column: Peak	Water Column: 21 Day	Water Column: 60 Day	Pore Water: Peak	Pore Water: 21 Day	Pore Water: 60 Day
and Forests	0.06	1-Jul	25	7	Ground	3.383	0.638	0.523	0.170	0.169	0.167
CAresidentialRLF: Non-agricultural Uses[3]	0.22	1-Apr	1	NA	Ground	0.051	0.006	0.004	0.001	0.001	0.001
	0.22	1-Apr	2	7	Ground	0.055	0.011	0.008	0.003	0.002	0.002
	0.22	1-Apr	3	7	Ground	0.058	0.017	0.013	0.004	0.004	0.004
CAturfRLF: Lawns and Turf Grass	0.22	1-Apr	3	7	Ground	0.060	0.018	0.014	0.004	0.004	0.004
CArightofwayRLF: Non-agricultural Uses[3]	0.22	1-Apr	3	7	Ground	0.080	0.025	0.021	0.007	0.007	0.007
	0.22	1-Apr	1	NA	Ground	0.054	0.009	0.007	0.002	0.002	0.002
CAImperviousRLF: Non-agricultural Uses[4,5]	0.22	1-Apr	1	NA	Ground	6.463	0.568	0.347	0.092	0.091	0.090
Residential Non-Agricultural Uses with Impervious Surfaces[4]	NA	1-Apr	1	NA	Ground	3.183	0.347	0.000[6]	ND[7]	ND[7]	ND[7]
Right-of-Way Non-Agricultural Uses with Impervious Surfaces[4]	NA	1-Apr	1	NA	Ground	3.185	0.348	0.205	ND[7]	ND[7]	ND[7]

[1] Application is abbreviated with App.

[2] Not Applicable is abbreviated with NA.

[3] The results from this scenario represent EECs in an area where the entire surface treated is pervious. Exposure was also estimated for residential and right of way areas that also have a percentage of impervious surface present.

[4] An entire impervious surface is not expected to be treated and some surfaces in residential and right-of-way uses will have impervious surfaces. The results from the output from the impervious surface scenario were used as described in APPENDIX K to estimate EECs in residential and right of way scenarios that have impervious surfaces.

[5] This represents a high end exposure that is not expected to occur

[6] A value of 0.000 indicates that the estimated EEC was less than 0.001.

[7] Not determined is abbreviated with ND.

3.3 Terrestrial Animal Exposure Assessment

T-REX (Version 1.3.1) is used to calculate dietary and dose-based EECs of esfenvalerate for the CRLF and its potential prey (e.g. small mammals and terrestrial insects) inhabiting terrestrial areas. EECs used to represent the CRLF are also used to represent exposure values for frogs that serve as potential prey of CRLF adults. T-REX simulates a 1-year time period. For this assessment, spray/granular applications of esfenvalerate are considered, as discussed below.

Terrestrial EECs for foliar formulations of esfenvalerate were derived for the uses summarized in Table 3-5. Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Esfenvalerate with T-REX. T-REX requires an estimate of the foliar dissipation half-life, which can be obtained for many chemicals from Willis and McDowell (1987). There is no value available for esfenvalerate, but this document does contain several estimates for fenvalerate, which is closely related. EFED's policy is to use the 90% upper confidence limit if multiple values are available. Based on the nine values available, the estimated half-life to be used is 12.3. An example output from T-REX is available in Appendix E. T-REX does not have the capability of modeling multiple seasons as is possible for determining aquatic EECs. Therefore, EECs were determined for terrestrial animals for only one season of application. This differs from the aquatic exposure analysis, which did take multiple seasons per year into account. Results of this analysis would impact chronic exposure estimates, possibly resulting in higher chronic RQs. The impact of multiple growing seasons per year on this analysis is discussed in the Risk Characterization section.

Table 3-5. Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Esfenvalerate with T-REX.

Use (Application method)	Application rate (lbs ai/A)	Number of Applications
Field Corn	0.05	1
Radish	0.05	2
Artichoke, Sugarbeet (broadcast), Peanuts	0.05	3
Collards, Mustard, Sunflower, Beans (Dried, Succulent), Lentils, Peas, Sugarcane	0.05	4
Field Corn, Cucumber, Melons (all, Cantaloupe, Honeydew, Musk, Water), Pumpkin, Squash (Unspecified, Summer, Winter), Turnip, Sugarbeet (row application)	0.05	5
Kohlrabi, Eggplant, Potato (White, Irish), Pepper	0.05	7
Broccoli, Chinese broccoli, Cauliflower, Cabbage, Chinese Cabbage	0.05	8
Corn, Pop Corn, Sweet Corn, Carrot, Cotton, Tomato, Non-cropland	0.05	10
Forestry	0.05	25
Pecan	0.075	4
Apple, Pear, Kiwi, Lettuce (Head)	0.075	7
Apricot, Cherry, Nectarine, Peach, Plum, Prune	0.075	9
Kennels and housing areas	0.1	1
Almond, Filbert, Walnut	0.1	2
Buildings, Lawns and turf grass, Mosquito breeding areas	0.2	1
General Outdoor Surfaces	0.51	1

T-REX is also used to calculate EECs for terrestrial insects exposed to esfenvalerate. Esfenvalerate residues on small and large insects (units of a.i./g), calculated as dietary-based EECs in T-REX, are used to bound an estimate of exposure to bees. These EECs are adjusted for comparison to available acute contact toxicity data for bees exposed to esfenvalerate (in units of µg a.i./bee), by multiplying the EEC (in µg a.i./g insect) by 0.128 g-bw/bee to get the adjusted EEC in units of µg a.i./bee. The EECs are later compared to the adjusted acute contact toxicity data for bees in order to derive RQs.

For modeling purposes, exposures of the CRLF to esfenvalerate through contaminated food are estimated using the EECs for a surrogate, the small bird (20 g), which consumes small insects. Dietary-based and dose-based exposures of potential small mammalian prey are assessed using a scenario of a small mammal (15 g) which consumes short grass (the dietary item that contains the highest residues). Upper-bound Kenega nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential small mammalian prey (Table 3-6) and its terrestrial insect prey (Table 3-7). Dietary-based EECs for small and large insects reported by T-REX as well as the resulting adjusted EECs are available in Table 3-7. An example output from T-REX v. 1.3.1 is available in Appendix C.

Table 3-6.Upper-Bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of the CRLF and its Small Mammalian Prey to Esfenvalerate.

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
Field Corn	6.75	7.69	12.00	11.44
Radish	11.30	12.87	20.09	19.50
Artichoke, Sugarbeet (broadcast), Peanuts	14.37	16.36	25.54	24.35
Collards, Mustard, Sunflower, Beans (Dried, Succulent), Lentils, Peas, Sugarcane	16.43	18.72	29.22	27.85
Field Corn, Cucumber, Melons (all, Cantaloupe, Honeydew, Musk, Water), Pumpkin, Squash (Unspecified, Summer, Winter), Turnip, Sugarbeet (row application)	17.83	20.30	31.69	30.22
Kohlrabi, Eggplant, Potato (White, Irish), Pepper	19.40	22.09	34.49	32.88
Broccoli, Chinese broccoli, Cauliflower, Cabbage, Chinese Cabbage	19.83	22.58	35.25	33.60
Corn, Pop Corn, Sweet Corn, Carrot, Cotton, Tomato, Non-cropland	20.31	23.13	36.10	34.42
Forestry	20.71	23.58	36.81	35.10
Pecan	24.65	28.07	43.82	41.78
Apple, Pear, Kiwi, Lettuce	29.10	33.14	51.73	49.32

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
(Head)				
Apricot, Cherry, Nectarine, Peach, Plum, Prune	30.17	34.36	53.63	51.14
Kennels and housing areas	13.50	15.38	24.00	27.33
Almond, Filbert, Walnut	22.60	25.74	40.18	38.31
Buildings, Lawns and turf grass, Mosquito breeding areas	27.00	30.75	48.00	45.76
General Outdoor Surfaces	68.85	78.41	122.40	116.70

Table 3-7. EECs (ppm) for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items.

Use	Small Insect Dietary EEC (ppm)	Small Insect Adjusted EEC (µg a.i./bee)	Large Insect Dietary EEC (ppm)	Large Insect Adjusted EEC (µg a.i./bee)
Field Corn	6.75	0.86	0.75	0.10
Radish	11.30	1.44	1.26	0.16
Artichoke, Sugarbeet (broadcast), Peanuts	14.37	1.84	1.60	0.20
Collards, Mustard, Sunflower, Beans (Dried, Succulent), Lentils, Peas, Sugarcane	16.43	2.10	1.83	0.23
Field Corn, Cucumber, Melons (all, Cantaloupe, Honeydew, Musk, Water), Pumpkin, Squash (Unspecified, Summer, Winter), Turnip, Sugarbeet (row application)	17.83	2.28	1.98	0.25
Kohlrabi, Eggplant, Potato (White, Irish), Pepper	19.40	2.48	2.16	0.28
Broccoli, Chinese broccoli, Cauliflower, Cabbage, Chinese Cabbage	19.83	2.54	2.20	0.28
Corn, Pop Corn, Sweet Corn, Carrot, Cotton, Tomato, Non-cropland	20.31	2.60	2.26	0.29
Forestry	20.71	2.65	2.30	0.29
Pecan	24.65	3.16	2.74	0.35
Apple, Pear, Kiwi, Lettuce (Head)	29.10	3.72	3.23	0.41
Apricot, Cherry, Nectarine, Peach, Plum, Prune	30.17	3.86	3.35	0.43
Kennels and housing areas	13.50	1.73	1.50	0.19
Almond, Filbert, Walnut	22.60	2.89	2.51	0.32
Buildings, Lawns and turf grass, Mosquito breeding areas	27.00	3.46	3.00	0.38
General Outdoor Surfaces	68.85	8.81	7.65	0.98

3.4 Terrestrial Plant Exposure Assessment

Risk to terrestrial plants cannot be determined quantitatively due to lack of terrestrial plant toxicity data.

4.0 Effects Assessment

This assessment evaluates the potential for esfenvalerate to directly or indirectly affect the CRLF and/or modify its designated critical habitat. As previously discussed in Section 2.8, assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth, as well as indirect effects, such as reduction of the prey base or modification of its habitat. In addition, potential modification of critical habitat is assessed by evaluating effects to the PCEs, which are components of the critical habitat areas that provide essential life cycle needs of the CRLF. Direct effects to the aquatic-phase of the CRLF are based on toxicity information for freshwater fish, while terrestrial-phase effects are based on avian toxicity data, given that birds are generally used as a surrogate for terrestrial-phase amphibians. Because the frog's prey items and habitat requirements are dependent on the availability of freshwater fish and invertebrates, small mammals, terrestrial invertebrates, and aquatic and terrestrial plants, toxicity information for these taxa are also discussed. Toxicity data used to evaluate direct effects, indirect effects, and modification to critical habitat in this risk assessment for esfenvalerate are summarized in Table 4-1.

Information on the toxicity of esfenvalerate to selected taxa is characterized based on registrant-submitted studies and a comprehensive review of the open literature on esfenvalerate (primarily SS stereoisomer) and the sterioisomeric related compound fenvalerate (approximately equal mixture of RR, RS, SR, and SS isomers). Esfenvalerate contains more of the insecticidally active isomer; however, the more evenly isomeric mixture, fenvalerate, is more toxic than esfenvalerate for some taxa. Ultimately, organisms exposed to esfenvalerate in water are exposed to a mixture of isomers because esfenvalerate sterioisomerizes in water. Therefore, fenvalerate toxicity endpoints that are more sensitive than that of esfenvalerate are used in this assessment where applicable. Fenvalerate data are also used where data are lacking for esfenvalerate.

Values used for each measurement endpoint identified in Table 2-8 are selected from these data. Currently, no FIFRA data requirements exist for aquatic-phase or terrestrial-phase frogs and are therefore not part of typical registrant submitted data packages. A summary of the available ecotoxicity information; the selected individual, population, and community-level endpoints for characterizing risks; and interpretation of the LOC, in terms of the probability of an individual effect based on probit dose response relationship are provided in Sections 4.1 through 4.3.

Toxicity measurement endpoints are selected from data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (U.S. EPA, 2004). Open literature data presented in this assessment were obtained from a search of the ECOTOX database (July 2007). Table 4-1 summarizes the most sensitive results for each measurement endpoint, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment is presented below. Additional information is provided in APPENDIX D-F.

In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

(1) the toxic effects are related to single chemical exposure;
(2) the toxic effects are on an aquatic or terrestrial plant or animal species;
(3) there is a biological effect on live, whole organisms;
(4) a concurrent environmental chemical concentration/dose or application rate is reported; and
(5) there is an explicit duration of exposure.

Data that pass the ECOTOX screen are further evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature, matching measurement endpoints listed in Table 2-8, that are more conservative than the registrant-submitted data and that are found to be scientifically sound based on a review of the paper are used quantitatively. The degree to which open literature data are used quantitatively or qualitatively is dependent on whether the information is scientifically sound and whether it is quantitatively linked to the assessment endpoints (*e.g.*, maintenance of California Red-Legged Frog survival, reproduction, and growth) identified in Table 2-8. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because quantitative relationships between degree and type of behavior modifications and reduction in species survival, reproduction, and/or growth are usually not available.

Citations of all open literature not considered as part of this assessment because they were either rejected by the ECOTOX screen or accepted by ECOTOX but not used (*e.g.*, the endpoint is less sensitive and/or not appropriate for use in this assessment) are included in Appendices D-F. Appendices D-F also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment.

Among the ECOTOX studies that were reviewed, none reported the necessary information or were of sufficient quality to be used quantitatively. Many of these studies used fenvalerate as the test material. As discussed above, fenvalerate is utilized when no data are available for esfenvalerate, so information from these studies is qualitatively incorporated where appropriate.

Table 4-1. Summary of Esfenvalerate Toxicity Data Used to Assess Direct Effects, Indirect Effects, and Adverse Modification to Critical Habitat for the CRLF.

Assessment Endpoints	Measures of Effect	Species	Toxicity Value and Slope (where applicable)	Study Classification (selection basis)	Reference
Survival and reproduction of individuals and communities of	Freshwater fish acute 96-hr LC_{50}	Rainbow trout (*Oncorhynchus mykiss*)	0.07 ppb ai Slope = 7.0 (95% CI 3.2 – 10.7)	Acceptable (Most sensitive value)	43358311 Baer 1994

Assessment Endpoints	Measures of Effect	Species	Toxicity Value and Slope (where applicable)	Study Classification (selection basis)	Reference
freshwater fish	Freshwater fish early life-stage NOAEC estimated from ACR	Rainbow trout (*O. mykiss*)	0.035 ppb ai	N/A (ACR estimate)	ACR approach used see Section 4.1.2.2
Survival and reproduction of individuals and communities of freshwater invertebrates	Freshwater invertebrate acute 48-hr EC_{50}	Waterflea (*Daphnia magna*)	0.05 ppb ai Slope not available	Acceptable (Most sensitive value)	41891914 Baer 1991
	Freshwater invertebrate NOAEC estimated from ACR	Water flea (*D. magna*)	0.017 ppb ai	N/A (ACR estimate)	ACR approached used see Section 4.1.3.2
Survival and growth of aquatic plants	Vascular and nonvascular aquatic plant EC_{50} and NOAEC	No studies available			
Abundance (i.e., survival, reproduction, and growth) of individuals and populations of birds	Avian (single dose) acute oral LD_{50}	Northern bobwhite (*Colinus virginianus*)	381 mg ai/kg	Acceptable (Only value available)	41698401 Campbell et al. 1991
	Avian subacute 5-day dietary LC_{50}	Mallard (*Anas platyrhynchos*)	4894 ppm ai	Acceptable (Most sensitive value)	41637802 Driscoll et al. 1990
	Avian reproduction NOAEC	No studies available[1]			
Abundance (i.e., survival, reproduction, and growth) of individuals and populations of mammals	Mammalian acute oral (single dose) LD_{50}	Laboratory rat (*Rattus norvegicus*)	59.0 mg/kg Slope not reported	Acceptable (Most sensitive value)	46765601 Finlay, 2005
	Mammalian reproductive NOAEL	Laboratory rat (*Rattus norvegicus*)	4.21 mg/kg/day	Acceptable (Most sensitive value)	43489001 Biegel 1994
Survival of beneficial insect populations	Honey bee acute contact LD_{50}	Honey bee (*Apis mellifera*)	0.017 µg/bee Slope not determined	Acceptable (Only value available)	41698402 Hoxter and Smith 1990
Survival and growth of terrestrial plants	Seedling emergence and vegetative vigor EC_{25} and NOAEC	No studies available			

[1] A study is available that used fenvalerate instead of esfenvalerate and was not sufficient to produce a definitive NOAEC. Therefore, potential risk using the value from this study (NOAEC <25 ppm) will be discussed qualitatively, but contains too much uncertainty to be used quantitatively.

4.1 Evaluation of Aquatic Ecotoxicity Studies

Data collected on freshwater fish and invertebrates are utilized in this risk assessment to estimate direct effects to the aquatic-phase CRLF resulting from acute and chronic exposure, indirect effects to the CRLF resulting from loss of prey and loss/disturbance of aquatic habitat and modification of Critical Habitat PCEs. Toxicity endpoints available for this assessment and the endpoints actually selected for quantitative assessment of direct and indirect effects to the CRLF are summarized in the sections below.

4.1.1 Toxicity to Amphibians

Two toxicity studies with frogs are available from the ECOTOX database. Neither of these studies provides an adequate estimate of toxicity that may be used; however they do provide some information regarding the hazard of esfenvalerate to amphibians.

Johansson et al. (2006) tested the toxicity of esfenvalerate on tadpoles of the common frog (*Rana temporaria*). Tadpoles of common frogs were exposed to 0.3, 1.3 and 5.0 ppb esfenvalerate for 72 hours in acute tests, wherein their mean dry weight, body length, and tail length were measured along with survival. Esfenvalerate did not show any significant effects on size parameters, indicating no effects on growth, nor was there any significant effect on survival. The study cites an estimate of esfenvalerate toxicity to amphibians (LC_{50} = 7.3 ppb ai), which it uses as a basis for setting the exposure levels for the study, although they provide no information as to what species this value is for.

Materna et al. (1995) used tadpoles of three species of leopard frogs (*Rana pipiens*, *Rana sphenocephala*, and *Rana blairi*) to test acute effects of esfenvalerate in the laboratory and in the field. *R. pipiens* was exposed in the laboratory to concentrations of esfenvalerate at 0.8, 1.3, 2.2, 3.6, 6.0, and 10.0 ppb ai for 96 hours at 20°C, and behavioral effects, including convulsive and spasmodic behavior, twitching, and twisting of the body and tail. The test levels were based on a range-finding study in which mortality occurred at concentrations of 100 ppb ai and higher. Since the goal of the study was to examine sublethal effects, the test concentrations were set lower than this value. Additionally, the effects of temperature (18°C and 22°C) on behavior were observed in tadpoles exposed to nominal concentrations of 0.0, 1.23, 1.76, 2.64, 5.07, 7.47, and 11.47 ppb ai. In the field experiment, tadpoles of *R. blairi* and *R. sphenocephala* were contained within enclosures treated with 0.0, 3.6, 6.0 and 10.0 ppb ai, and growth and behavioral abnormalities were measured.

In the laboratory study, an EC_{50} of 4.85 ppb ai was determined based on behavioral effects. Some mortality was observed at 2.2, 6.0, and 10.0 ppb ai. The EC_{50} at 18°C was 3.4 ppb ai and was 6.14 ppb ai at 22°C based on tail-kink abnormalities. In the pond study, effects observed were decreased activity, convulsions, tail kinking, and mortality. Mortality occurred in nearly a dose-response fashion, but an LC_{50} could not be calculated due to extreme variability in the measured concentrations. Mortality reached nearly 85% in the highest concentration in this study, and occurred rapidly (within the 96-hour test period).

There was wide variation in the nominal and measured concentrations used in this study that result in uncertainty in the results of these studies. Results are presented with nominal concentrations, but the actual concentrations varied. Concentrations decreased by up to 80% of nominal in some of the laboratory tests. In the field test, the actual concentrations measured in the test chambers ranged 35% to 206% of nominal, which could have been the result of inadequate mixing within the test system.

Both of these studies provide information about toxicity to amphibians, and it appears that *Rana* spp. may be less sensitive to esfenvalerate than the surrogate species (freshwater fish) used to estimate risk. Therefore, although the results of these studies cannot be used quantitatively, they provide evidence that the Agency's use of fish acute toxicity values result in a conservative estimate of risk for the CRLF.

4.1.2 Toxicity to Freshwater Fish

No aquatic-phase amphibian studies are available for esfenvalerate. Therefore, toxicity studies with freshwater fish are used to assess direct acute and chronic effects to the aquatic phase CRLF as well as indirect acute and chronic effects to its food sources. Freshwater fish are considered to be surrogates for the CRLF, and toxicity to each taxon is assumed to be comparable. Fish toxicity studies for two freshwater species using the technical grade active ingredient (TGAI) are required to establish the acute toxicity of esfenvalerate to fish. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warm water fish); however, tests with other species are also submitted.

*4.1.2.1 **Freshwater Fish: Acute Exposure (Mortality) Studies***

One study with the esfenvalerate TGAI and five studies with formulated products are available with which to estimate the hazard of esfenvalerate to the CRLF (Table 4-2). An additional study with the TGAI on bluegill was available in the chemical file, but was not assigned a MRID and has not been used in previous risk assessments. This study was found to be acceptable by the EFED reviewer, and findings were similar to that of other studies listed below (96-hour LC_{50} = 0.26 ppb ai, with 98.8% test material purity). However, the history of this study is not known, so it has not been included. Based on the studies presented, esfenvalerate is very highly toxic to freshwater fish on an acute basis. Toxicity was determined to be the same for both bluegill and trout in the TGAI studies. The most sensitive value comes from the study with the 44.4% formulated product (MRID 43358311). MRID 41215201 is a study with the SS-isomer only, and the test material did not contain the other three isomers found in esfenvalerate. However, since the toxicity of the other formulated products appears to be comparable to that of the TGAI, the toxicity value from MRID 43358311 (LC_{50} = 0.07 ppb ai) will be used to quantitatively estimate risk to the CRLF and its freshwater fish food base.

Several studies with fenvalerate are available; however, none of these provided a more sensitive estimate of toxicity than the studies listed below. LC_{50} values from acceptable or supplemental studies using the TGAI range from 0.42 to 1.13 ppb ai. Formulated products were less toxic, with LC_{50}s ranging from 1.02 to 4.3 ppb ai.

Table 4-2. Acute Toxicity of Esfenvalerate to Freshwater Fish.

Species study type	%ai	96-hr LC_{50}	Toxicity Category	Reference (MRID, Author)	Study Classification
Rainbow trout (*Oncorhynchus mykiss*) static	98.8 (TGAI)	0.26 ppb ai (nominal)	Very Highly Toxic	41233001 Forbis et al. 1985	Supplemental
Rainbow trout (*Oncorhynchus mykiss*) static	32.0[1]	0.51 ppb ai (nominal)	Very Highly Toxic	41233002 Forbis et al. 1985	Supplemental
Rainbow trout (*Oncorhynchus mykiss*) flow-through	44.4[2]	0.07 ppb ai (measured)	Very Highly Toxic	43358311 Baer 1994	Acceptable
Bluegill sunfish (*Lepomis macrochirus*) static	32.0[1]	0.69 ppb ai (nominal)	Very Highly Toxic	41215202 Forbis et al. 1985	Supplemental
Bluegill sunfish (*Lepomis macrochirus*) flow-through	44.4[2]	0.23 ppb ai (measured)	Very Highly Toxic	43358312 Baer 1994	Acceptable
Fathead minnow (*Pimephales promelas*) static	98.0[3]	0.18 ppb ai (nominal)	Very Highly Toxic	41215201 Ward 1984	Supplemental

[1]Emulsifiable concentrate formulation
[2]Wettable powder formulation
[3]SS-isomer (Asana)

4.1.2.2 *Freshwater Fish: Chronic Exposure (Early Life Stage and Reproduction) Studies*

A freshwater fish early life-stage test using the esfenvalerate TGAI was required for esfenvalerate because the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, and (2) any aquatic acute LC_{50} or EC_{50} is less than 1 mg/l (ppm). Results of the study are presented in Table 4-3. Studies using fenvalerate as the test material did not provide a more sensitive estimate of chronic toxicity. One study using the fathead minnow determined a LOAEC of 0.25 ppb ai and a NOAEC of 0.13 ppb ai (MRID 09700009). No other studies were available.

Table 4-3. Chronic Toxicity of Esfenvalerate to Freshwater Fish.

Species	%ai	LOAEC/NOAEC	Endpoints Affected	Reference (MRID, Author)	Study Classification
Fathead minnow (*Pimephales promelas*)	96.0	0.21 ppb ai / 0.09 ppb ai (measured)	Number of spawns per female, survival and growth of fry	Accession # 97000 Windberg 1978	Acceptable

Despite providing a more sensitive value than the fenvalerate study, there is uncertainty associated with the LOAEC in the esfenvalerate chronic study, since it is a greater value than three of the acute toxicity values listed in Table 4-2. Additionally, the NOAEC is greater than the acute LC_{50} chosen to assess acute risk. Therefore, an estimate of the chronic NOAEC for freshwater fish will be calculated using the ratio of the acute LC_{50} to the chronic NOAEC for the fathead minnow (*Pimephales promelas*). The acute-to-chronic ratio (ACR) of these values is 2.0. With application of this to the LC_{50} of 0.07 ppb ai from MRID 43358311, the estimated value of the NOAEC for freshwater fish and the CRLF is **0.035 ppb ai**. This value will be used in this assessment to estimate the chronic risk of esfenvalerate to the CRLF.

4.1.2.3 Freshwater Fish: Sublethal Effects and Additional Open Literature Information

No suitable studies on sublethal effect to fish were available in ECOTOX.

4.1.3 Toxicity to Freshwater Invertebrates

Toxicity studies on freshwater invertebrates were evaluated to assess the potential for uses of esfenvalerate to produce indirect effects to the aquatic phase CRLF via a reduction in invertebrate prey. Five acute studies with the waterflea (*Daphnia magna*) with the TGAI and formulated products are available, along with one chronic study with *Daphnia*. The results of these studies are presented in the sections below.

4.1.3.1 Freshwater Invertebrates: Acute Exposure (Mortality) Studies

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of esfenvalerate to aquatic invertebrates. The preferred test species is *Daphnia magna*. Results of studies using the technical grade material or formulated product are presented in A10-day sediment study with midge (*Chironomus tentans*) larvae (MRID 46591505) is also available. This is a non-guideline study that has not received secondary review within EFED; therefore, without further review the uncertainty of the results is not known. However, it does provide some information regarding the toxicity of sediment contaminated with esfenvalerate as well as an estimate of the acute toxicity (LC_{50} and EC_{50}) of pore-water concentrations. Sediment toxicity was determined to be 1000 ppb ai and 450 ppb ai based on survival and dry weight, respectively. Pore-water toxicity was determined to be 0.93 ppb ai and 0.41 ppb ai based on survival and dry weight, respectively. These estimates are similar to those for open water determined for .*D. magna*. Since higher concentrations of esfenvalerate are found in the pore water, and because the *D. magna* study with fenvalerate provides a more sensitive endpoint, the *D. magna* EC_{50} will be used with the pore water concentration estimates to determine risk to aquatic invertebrates.

Table 4-4. All studies indicate that esfenvalerate technical and formulations are very highly toxic to freshwater aquatic invertebrates. One study with the emulsifiable concentrate (MRID 41798301) produced the most sensitive endpoint among the esfenvalerate studies; however, the water samples used to determine test concentrations in this study were determined to be contaminated and the reliability of the results from this study is uncertain. With the exception of this study, however, the toxicity values for formulated products and the TGAI are similar; however, results from a study with fenvalerate as the test material (MRID 41891914) are also presented, since this study provides a more sensitive estimate of the EC_{50} for aquatic invertebrates. The LC_{50} value of 0.05 ppb ai from this study will be used in the assessment of risk to aquatic invertebrates inhabiting the water column.

A10-day sediment study with midge (*Chironomus tentans*) larvae (MRID 46591505) is also available. This is a non-guideline study that has not received secondary review within EFED; therefore, without further review the uncertainty of the results is not known. However, it does provide some information regarding the toxicity of sediment contaminated with esfenvalerate as well as an estimate of the acute toxicity (LC_{50} and EC_{50}) of pore-water concentrations. Sediment toxicity was determined to be 1000 ppb ai and 450 ppb ai based on survival and dry weight, respectively. Pore-water toxicity was determined to be 0.93 ppb ai and 0.41 ppb ai based on survival and dry weight, respectively. These estimates are similar to those for open water determined for .*D. magna*. Since higher concentrations of esfenvalerate are found in the pore water, and because the *D. magna* study with fenvalerate provides a more sensitive endpoint, the *D. magna* EC_{50} will be used with the pore water concentration estimates to determine risk to aquatic invertebrates.

Table 4-4. Acute Toxicity of Esfenvalerate to Freshwater Invertebrates.

Species **study type**	**%ai**	**48-hr EC_{50}[1]**	**Toxicity Category**	**Reference (MRID, Author)**	**Study Classification**
Waterflea (*Daphnia magna*) static	97.6 (TGAI) **fenvalerate**	0.05 ppb ai	Very Highly Toxic	41891914 Baer 1991	Acceptable
Waterflea (*Daphnia magna*) static	98.6 (TGAI)	0.9 ppb ai	Very Highly Toxic	40444002 Hutton 1987	Acceptable
Waterflea (*Daphnia magna*) static	8.4[2]	0.008 ppb ai	Very Highly Toxic	41798301 Baer 1991	Supplemental
Waterflea (*Daphnia magna*) static-renewal	44.4[3]	0.15 ppb ai	Very Highly Toxic	43758313 Baer 1994	Supplemental
Waterflea (*Daphnia magna*) static	8.4[2]	0.33 ppb ai	Very Highly Toxic	42492601 Baer 1992	Supplemental
Waterflea (*Daphnia magna*) static	15.8	0.24 ppb ai	Very Highly Toxic	42492602 Baer 1992	Acceptable

[1]All EC_{50}s reported as mean measured concentrations.
[2]Asana emulsifiable concentrate formulation.
[3]Wettable powder formulation.

4.1.3.2 Freshwater Invertebrates: Chronic Exposure (Reproduction) Studies

A freshwater aquatic invertebrate life-cycle test using the TGAI was required for esfenvalerate, since the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, and (2) aquatic acute LC_{50} or

EC_{50} is less than 1 mg/l. The preferred test species is *Daphnia magna*. Results of the test are presented in Table 4-5.

Table 4-5. Chronic Toxicity of Esfenvalerate to Freshwater Invertebrates.

Species	%ai	LOAEC/NOAEC	Endpoints Affected	Reference (MRID, Author)	Study Classification
Waterflea (*Daphnia magna*)	98.6	0.079 ppb ai / 0.052 ppb ai (measured)	Number of young, survival and growth	40444001 Hutton 1987	Acceptable

Since the fenvalerate *D. magna* 48-hr EC_{50} will be used for estimates of acute risk to aquatic invertebrates, the NOAEC presented in Table 4-5 for esfenvalerate cannot be used since it is approximately equal to the 48-hr fenvalerate EC_{50}. However, no reliable *D. magna* chronic studies with fenvalerate were found. Therefore an estimate of a fenvalerate *D. magna* NOAEC, calculated using the ACR from the esfenvalerate data was used. The ACR in this case is determined using the most sensitive and reliable 48-hr EC_{50} (0.15 ppb ai) for esfenvalerate (from MRID 43758313) and the NOAEC of 0.052 ppb ai. These result in an ACR of 2.88. Thus, an estimate of a fenvalerate life cycle NOAEC for freshwater invertebrates based on this ACR and the fenvalerate 48-hr EC_{50} of 0.05 ppb ai is **0.017 ppb ai**.

4.1.3.3 Freshwater Invertebrates: Sublethal Effects and Open Literature Data

Two suitable studies were found in the ECOTOX literature database that provides further information on the potential effects of esfenvalerate on aquatic invertebrates. All of these studies utilized fenvalerate as the test substance, which is closely related to esfenvalerate.

Reynaldi *et al*. (2006) exposed *D. magna* to sublethal (0.1, 0.3, 0.6, and 1.0 ppb ai, and also 0 ppb ai for controls) concentrations of fenvalerate for 24 hours and observed effects on feeding activity and body size. Reduced feeding activity and smaller body size was observed in *D. magna* exposed to 0.3 ppb ai and higher concentrations. Delayed maturation was observed at concentrations of 0.6 ppb ai and higher. Although filtering (feeding) rates recovered within 2 days after exposure, long-term effects due to reduced feeding, such as growth retardation, did occur. Growth retardation leading to delayed maturity affects freshwater invertebrates at the population level, as this affects population dynamics through delayed reproduction. Therefore, this study provides an indication that even short-term sublethal exposure to fenvalerate (and presumably esfenvalerate) may have the effect of reducing populations of freshwater aquatic invertebrates. However, these effects are at levels above the selected acute and chronic measurement endpoint values.

Day and Kaushik (1987) studied the chronic effects of fenvalerate on the crustacean, *D. galeata mendotae*, by estimating alterations in life table parameters that indicate population effects that may result from exposure. *D. galeata mendotae* were raised through several generations, and adults of the final generation were exposed to 0, 0.005, 0.01, 0.05, or 0.10 ppb ai fenvalerate from a stock solution of 30% ai emulsifiable concentrate (EC) formulated product. An additional EC control containing the EC without fenvalerate was included, and it was determined that the other ingredients did not have a toxic effect in the experiment. Survivorship was lower in all fenvalerate treatments except the 0.005 ppb concentration, in which survivorship was significantly higher. No young were produced at the 0.10 ppb concentration, and the average number of young produced at the 0.01 and 0.05 ppb concentrations were reduced due to lower survivorship. The average brood size was reduced in all treatments. Life table parameters were affected by the exposure to fenvalerate. The intrinsic rate of increase was reduced in the 0.05 ppb group and was reduced to 0 in the 0.10 ppb group. The net reproductive rate was reduced in the 0.01 ppb treatments and higher, and generation time was reduced in these treatments, as well.

This study provides additional information about chronic effects on aquatic invertebrates, and also substantiates the potential for effects on populations that result from sublethal exposures to individuals.

4.1.4 Toxicity to Aquatic Plants

No laboratory studies were available that examined the effects of esfenvalerate in aquatic plants.

4.1.5 Freshwater Field Studies

Mesocosm Study

A mesocosm study (MRID 41573901) was submitted to EFED as a rebuttal to a presumption of hazard to aquatic systems resulting from a worst case exposure scenario assumed by OPP. In this study, nine 0.1-hectare ponds were treated with low, medium, or high doses of esfenvalerate (three ponds per treatment), and three additional ponds that did not receive esfenvalerate served as controls. Treatments were meant to simulate exposure to aquatic systems through both drift and runoff, where 10 drift events and five runoff events were simulated to provide total esfenvalerate loads of 0, 232.5, 4125, and 23270 mg ai/pond for the control, low, medium, and high treatments, respectively. Observations were made on effects to phytoplankton, zooplankton, macroinvertebrate and juvenile fish populations occurring within multiple zones (benthic, littoral, open water) of the ponds throughout the study. At the end of the study, additional measurements were made on the relative health of populations of fish exposed during the study.

Effects on phytoplankton and emergent aquatic vegetation were not observed. Significant effects were not observed on the animal taxa studied in the ponds receiving the low treatment, but eradication of some insect populations and reductions in small fish were found in both the medium and high treatment levels. Adverse effects were apparent almost immediately in aquatic insect populations. The most dramatic population reductions in aquatic invertebrate species were apparent in benthic samples when they were compared to controls and open-water and littoral samples. This result is particularly significant because esfenvalerate residues are expected to occur predominately in the sediment.

Significant changes in relative health of the fish populations studied at the end of the experiment were not observed, and the authors dismissed any long term effects of esfenvalerate on fish populations. However, the decline in populations of certain aquatic zooplankton and macroinvertebrates at times that coincide with fish reproduction will represent a decrease in a significant food base which will affect fish larval growth and possibly year-class strength. Furthermore, the comparative applicability of this study to aquatic environments outside of the study area (Alabama) is debatable. Changes in aquatic chemistry during the study (increased alkalinity and rising pH from supplemental fertilization) appeared to affect esfenvalerate exposure potential in the study and may mask higher toxicity concerns for esfenvalerate.

Mesocosm and Field Studies from Open Literature

Bouldin et al. (2004) examined the effect of esfenvalerate on aquatic invertebrates in an agricultural ditch mesocosm. A storm event (0.64 cm on a 20.23-ha field) producing runoff with esfenvalerate was simulated in an agricultural drainage ditch. Aqueous grab samples and a composite sediment sample from several locations were collected prior to the application. Aqueous and sediment samples were then taken after application at 0.5-, 3-, and 24 hours and 28 days post application at 0, 20, 80, 200, and 600 m downstream (also at 56 days for sediment). Reference upstream samples were also collected at -10 m. These were analyzed for esfenvalerate residues and were used in aqueous and sediment toxicity tests with fish and invertebrates.

Toxicity tests were conducted on an aquatic invertebrate (*Ceriodaphnia dubia*) and a fish (*Pimphales promelas*), and sediment toxicity tests were conducted with midge (*Chironomus tentans*). The highest concentration of esfenvalerate was detected at the injection point (0 m) at 3 hours post application. Survival of *C. dubia* and *P. promelas* was 0% at 0 and 20 m at 0.5 and 3 hours post application. At 3 hours post application, survival of *C. dubia* was 0% at 80 m and was 17.5 % for *P. promelas*. Survival was ≥72.5% for all other times and distances, with the exception of *C. dubia* at 80m 24 hours post application (45 ± 44%) and *P. promelas* at 80 m 28 days post application (60 ± 25.8 %). Survival and growth of *Chironomus tentans* was significantly lower than control at the injection site only, but at all sampling times. Survival was highest 3 hours post application (25 ±16%) and declined through Day 56 to 6.3 ± 7.4%. Pesticides were also measured in plant material at 20, 80, 200 and 6000 m from the injection site at 3 hours, 24 hours, 28 days, and 56 days post application. Concentrations in plant material were highest at 20 m, 3 hours post application (2010.34 ppb) and declined with distance and time.

The application rate that the runoff event was expected to simulate was not reported, and likely the amount of esfenvalerate that would reach surface water via runoff would vary with environmental conditions. The water velocity in this study was measured at 0.04 m/s, so it is not known how these results, especially for sediments, would compare to a faster moving system. However, this study is useful for this assessment, since it provides an indication of the potential effects of esfenvalerate in an aquatic system.

Pieters *et al.* (2005) investigated the effects of fenvalerate under field conditions (including food restriction) on *D. magna*. The main goal of this study was to examine the effects of low food conditions on life history characteristics of *Daphnia magna*, especially the intrinsic rate of increase, during pulses of pesticide exposure. Fenvalerate was used as a model pesticide, but the study does provide some information on the effects of this pesticide under field conditions. *D. magna* were exposed to control, 0.03, 0.1, 0.3, 0.6, 1.0, and 3.2 ppb fenvalerate concentrations (nominal) for 24 hours under two different feeding regimes (low and high). The effect on the intrinsic rate of increase was measured over the course of 21 days post-exposure. Under both food levels, the highest concentration caused 100% mortality by Day 8 post-exposure, and most mortality in all groups was complete by this day. In the high food group, mortality did not exceed 35% in any test concentration group, whereas in the low food group mortality was higher in all test concentrations above 0.1 ppb. Low food conditions significantly increased age at first reproduction and decreased mean brood number, mean brood size, and cumulative reproduction per living female by the end of the test (Day 21). As a result, the intrinsic rate of increase was significantly lower in the low food concentration test groups, indicating that greater detrimental population effects would be expected under these conditions.

4.2 Evaluation of Terrestrial Ecotoxicity Studies

Data collected on birds, mammals, terrestrial plants, and terrestrial insects are utilized to estimate direct effects to the terrestrial phase CRLF resulting from acute and chronic exposure, indirect effects to the CRLF resulting from loss of prey and loss/disturbance of riparian, upland, and dispersal habitat, and modification of Critical Habitat PCEs. Toxicity endpoints available for this assessment and the endpoints actually selected for quantitative assessment of direct and indirect effects to the CRLF are summarized in the sections below.

4.2.1 Toxicity to Birds

4.2.1.1 Birds: Acute Exposure (Mortality) Studies

.

No terrestrial phase amphibian studies are available for esfenvalerate. Therefore birds are used as a surrogate for the terrestrial phase CRLF. An oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the acute toxicity of esfenvalerate to birds. Two dietary studies using the TGAI are also required to establish the subacute toxicity to birds. The preferred guideline test species is mallard (a waterfowl) or Northern bobwhite (an upland gamebird). For esfenvalerate, acute exposure studies are available for the guideline species. These data indicate that on an acute oral basis, esfenvalerate is moderately toxic to an upland game bird and is slightly toxic to practically non-toxic to birds on a subacute basis (Table 4-6). Studies with fenvalerate did not provide more sensitive endpoint values.

Table 4-6. Acute Oral and Subacute Dietary Toxicity of Esfenvalerate to Birds.

Species	% ai	Endpoint	Toxicity Category	Reference (MRID, Author)	Study Classification
Acute Oral					
Northern bobwhite (*Colinus virginianus*)	98.6	LD_{50} = 381 mg ai/kg-bw	Moderately Toxic	41698401 Campbell et al. 1991	Acceptable
Subacute Dietary					
Northern bobwhite (*Colinus virginianus*)	98.6	LC_{50} > 5620 ppm ai	Practically Non-toxic	41637803 Driscoll et al. 1990	Acceptable
Mallard (*Anas platyrhynchos*)	98.6	LC_{50} = 4894 ppm ai	Slightly Toxic	41637802 Driscoll et al. 1990	Acceptable

4.2.1.2 Birds: Chronic Exposure (Chronic/Reproduction) Studies

Avian reproduction studies using the TGAI are required when birds may be subject to repeated or continuous exposure to esfenvalerate; however, avian reproduction data have not been submitted for esfenvalerate. Two studies were submitted for fenvalerate (Fink and Beavers, report #109-122 and 109-123, MRIDs 00037111 and 00037112, respectively). These studies were determined to be scientifically sound, and their results were determined to be inconclusive, but suggested the possibility that fenvalerate may result in reproductive effects in birds. Cracking of eggs was observed in the study and was determined to be the result of exposure to fenvalerate; however, the effect was not great enough to affect the overall reproductive success of the test animals. The reviewer concluded that this may not be the case in the field, since eggs are incubated in an incubator in lab tests and are not handled with the same care in the field. There was also some question over the amount of fenvalerate contained in the highest treatment level (125 ppm), which actually contained, based on samples tested, 60 – 85 ppm. This has introduced uncertainty with the results. Based on this study, however, an estimate of the LOAEC and NOAEC may be determined to be 25 and <25 ppm, respectively, although RQs determined with this value will have uncertainty due to the study and the lack of a definitive NOAEC endpoint.

Avian reproductive data have been requested in previous risk assessments, but they have not been submitted to date.

4.2.1.3 Birds: Sublethal Effects and Open Literature Data

No studies were available in the ECOTOX database that describe sublethal effects on birds.

4.2.2 Toxicity to Mammals

Data submitted to OPP's Health Effects Division (HED) in order to estimate human risks are used to determine the risks to wild mammals. For purposes of estimating non-target wild mammal risk, an acute-oral LD_{50} study and a two-generation reproduction study with the laboratory rat (*Rattus norvegicus*) are used.

4.2.2.1 Wild Mammals: Acute Exposure (Mortality) Studies

Previous ecological risk assessments for esfenvalerate have included lists of several acute oral toxicity studies with laboratory rats (e.g., see EFED risk assessment for California section 24C dated October 14, 1999). However, many of these have been performed with formulated products or test substances containing esfenvalerate and other active ingredients. HED's toxicology chapter for re-registration of esfenvalerate (dated August 23, 2004, obtained via their Integrated Hazard Assessment Database) provides an endpoint with technical grade esfenvalerate, as does a more recent up-and-down study (MRID 46765601) (Table 4-7). Based on these values, esfenvalerate is moderately toxic to small mammals. Since the more recent study provides the more sensitive value, it will be used in this assessment. This value has been cross-validated with HED to ensure it is the value they have chosen to use in their assessments. A more sensitive endpoint based on studies with fenvalerate was not found.

Table 4-7. Toxicity of Esfenvalerate to Mammals.

Species	% ai	Endpoint	Toxicity Category	Reference (MRID, Author)	Study Classification
Laboratory rat (*Rattus norvegicus*)	97.0	LD_{50} = 87.2 mg/kg-bw	Moderately toxic	00144973 Bilsback et al. 1984	Acceptable
Laboratory rat (*Rattus norvegicus*)	99.09	LD_{50} = 59.0 mg/kg-bw	Moderately toxic	46765601 Finlay, 2005	Acceptable

4.2.2.2 Wild Mammals: Chronic Exposure (Chronic/Reproduction) Studies

Chronic toxicity data for mammals are needed to assess the potential for esfenvalerate to induce indirect effects to the terrestrial phase CRLF via a reduction in prey base due to chronic effects of prey items. Chronic tests are not conducted on wild mammals, so the two-generation rat reproduction study required by HED is used as a substitute. The study presented in Table 4-8 is included in HED's toxicology chapter as referenced above for acute toxicity. The NOAEL/NOAEC from this study will be used to estimate chronic toxicity to mammals. Studies with fenvalerate did not provide a more sensitive endpoint value.

Table 4-8. Chronic Toxicity of Esfenvalerate to Mammals.

Species	% ai	Toxicity Values	Endpoints Affected	Reference (MRID, Author)	Study Classification
Laboratory rat (*Rattus norvegicus*)	98.8	Parental Systemic: LOAEC=75 ppm ai (4.21 mg/kg-bw/day, ♀,♂) NOAEC < 75 ppm ai Offspring: LOAEC=100 ppm ai (7.18 mg/kg-bw/day , ♀) NOAEC=75 ppm ai (5.56 mg/kg-bw/day, ♀)	Dermal lesions, decreased body weight Decreased pup weight, decreased litter size, increased subcutaneous hemorrhage	43489001 Biegel 1994	Acceptable

4.2.2.3 Wild Mammals: Sublethal Effects and Open Literature Information

Most available open literature studies in ECOTOX described relevant sublethal effects other than effects on reproduction. None of these studies provided a more sensitive endpoint than reported in guideline studies. One study did, however, find a dose-dependent reduction in motor function in rats (ED_{30} = 1.2 mg/kg-bw) for esfenvalerate, indicating the possibility of effects on neuronal transmission. Such effects could potentially alter behavior in wild mammals, making them at least temporarily more susceptible to predation.

4.2.3 Toxicity to Non-Target Terrestrial Invertebrates

4.2.3.1 Guideline Honeybee Toxicity Studies

Toxicity studies on terrestrial invertebrates are utilized to assess the potential for esfenvalerate to induce indirect effects to the terrestrial phase CRLF via a reduction in invertebrate prey base. The acute contact LD_{50}, using the honey bee, *Apis mellifera*, is a single-dose laboratory study designed to estimate the quantity of toxicant required to cause 50% mortality in a test population of bees. One acute contact study is available for honeybees (Table 4-9). Based on this value, esfenvalerate is classified as highly toxic to honey bees on an acute contact basis. Studies with fenvalerate did not provide a more sensitive endpoint value.

Table 4-9. Toxicity of Esfenvalerate to Non-Target Terrestrial Insects.

Species	% ai	Endpoint	Toxicity Category	Reference (MRID, Author)	Study Classification
Honeybee (*Apis mellifera*)	98.6	LD_{50} = 0.017 µg/bee (acute contact)	Highly toxic	41698402 Hoxter and Smith 1990	Acceptable

4.2.3.2 Non-Target Terrestrial Invertebrate Studies from Open Literature

Further information on toxicity of fenvalerate to the earthworm (*Eisenia foetida*) is available from the ECOTOX database (Roberts and Dorough 1984, ECOTOX ref. # 40531). In this study, acute contact toxicity with fenvalerate was tested by exposing the earthworm to technical grade fenvalerate soaked into a filter paper for 48 hours. Based on this study, the authors considered fenvalerate to be "very toxic," with an acute contact toxicity measured at 74.1 µg ai/cm^2. EFED has not established an acute contact toxicity rating based on these units, and it is not known from this study how much active ingredient the earthworms were exposed to. However, this study does provide some information by which to make a qualitative judgment of the hazard of esfenvalerate to soil-dwelling invertebrates. Reduction of parasitism of pest species by beneficial parasitoid wasps has also been observed, as well as avoidance of treated areas by pollinators (Awchar et al. 1995, ECOTOX Reference # 92825).

4.2.4 Toxicity to Terrestrial Plants

Guideline studies with terrestrial plants are not available for esfenvalerate or fenvalerate. Some ancillary information is available in the ECOTOX database on fenvalerate that provide some information about the potential hazard of esfenvalerate to plants.

Toscano *et al*. (1982, ECOTOX ref. #41092) found no effects of fenvalerate on lettuce. Fenvalerate (2.4 EC) was applied via backpack sprayer at 0.22 kg ai/ha (0.20 lbs ai/ac), and lettuce plants received either one or two treatments over the course of approximately 1.5 months. No difference in growth (measured in mass) was observed between plants treated with fenvalerate one or two times and the untreated controls.

In contrast with the above study, two studies did observe detrimental effects of fenvalerate on plants, though neither provides enough information to calculate an endpoint that can be used quantitatively. Chauhan *et al.* (1999, ECOTOX Ref. #72820) tested the dose-response of fenvalerate on onion root growth and cytogenesis. Onions were grown in test concentrations of fenvalerate of 7, 14, and 28 ppm for five days, and root growth compared to the control was determined on the fifth day. The EC_{50} was calculated as the concentration that inhibited growth by 50%, and this was determined to be 14.25 ppm. Through examinations of cells at the onion root tip, the authors concluded that growth reductions were caused by chromosome and mitosis aberrations. El-Daly (2006) tested germination and growth of radishes following exposure to fenvalerate. Radish seeds were germinated on moist filter paper containing 1-1000 M concentration (0.42 – 420 mg/L) of fenvalerate. Germination and plant growth was observed immediately afterward. The study noted that with fenvalerate, an increase in growth was observed in some growth parameters at the lowest levels, but a decrease was observed at the highest levels. The authors also noted a decrease in percent germination, which was also not dose-dependent.

4.3 Use of Probit Slope Response Relationship to Provide Information on the Endangered Species Levels of Concern

The Agency uses the probit dose response relationship as a tool for providing additional information on the potential for acute direct effects to the CRLF and aquatic and terrestrial animals that may indirectly affect the CRLF (U.S. EPA, 2004). As part of the risk characterization, an interpretation of acute RQ for listed species is discussed. This interpretation is presented in terms of the chance of an individual event (*i.e.*, mortality) should exposure at the EEC actually occur for a species with sensitivity to esfenvalerate on par with the acute toxicity endpoint selected for RQ calculation. To accomplish this interpretation, the Agency uses the slope of the dose-response relationship available from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group that is relevant to this assessment. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available.

Individual effect probabilities are calculated based on an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The model allows for such calculations by entering the mean slope estimate (and the 95% confidence bounds of that estimate) as the slope parameter for the spreadsheet. In addition, the acute RQ is entered as the desired threshold.

For esfenvalerate, mortality was observed in acute toxicity studies for freshwater fish, freshwater invertebrates, birds, mammals, and honey bees. Where probit slopes are provided, they are used along with their upper and lower confidence limits to estimate the probability of individual mortality and its potential variability. In cases where they are unavailable, the default slope assumption of 4.5 with default upper and lower slope bounds of 2 and 9 are used as per original Agency assumptions of a typical slope cited in Urban and Cook (1986). The chance of individual mortality will be determined using the listed species LOC as the threshold of concern and also the RQ determined for each taxon. These analyses are presented below in the Risk Characterization along with calculations of RQs for each taxon.

4.4 Incident Database Review

Twelve incidents involving esfenvalerate and one incident involving fenvalerate are available in OPP's Ecological Incident Information System (EIIS). These incidents primarily involve aquatic animals, but incidents with terrestrial animals and plants were also reported. Many incidents occurred after applications or spills of esfenvalerate included in mixtures with other chemicals. Each incident is described briefly below.

Fenvalerate

- Incident # B0000-502-83 - An incident with fenvalerate occurred in Madison County, GA in 1998. The report states that over the course of the summer, a resident found birds dead on his property. One of the birds was submitted for examination and it was determined that fenvalerate was present in the crop contents at 164 ppm. No organophosphates or carbamates were detected. The decision made by the Department of Parasitology, University of Georgia, was that toxicosis was suspected but the specific toxicant was not determined. Specifically, the report stated, "Synthetic pyrethroids, such as fenvalerate, are relatively non-toxic to warm-blooded animals. In large amounts they can cause nervous system problems. The levels of fenvalerate in this bird were not high enough to diagnose toxicosis as the cause of death."

Esfenvalerate

- Incident # I000109-009 - An aerial application of esfenvalerate and azinphos-methyl (AZM) to sugarcane in Iberville County, LA in July 1999 was suspected to have resulted in an incident involving over 2300 freshwater fish (species of gar, buffalo, and drum). It was assumed that the application, in concert with heavy rainfall, led to runoff that caused fish kills in three waterways associated with the Whitewater Canal. According to the investigative reports there was lack of agreement between the investigating teams as to what caused the fish kill, specifically whether it was attributable to low dissolved oxygen levels or AZM. Dissolved oxygen levels were measured and found to be satisfactory. Screening analysis detected AZM in "low but possibly significant quantities." A panel group that reviewed the incident felt that a combination of the two was responsible for the observed mortality, although AZM was determined to be the "probable" cause, while esfenvalerate was determined to be a "possible" cause.

- Incident # I008168-001 - On May 25, 1998, a cornfield in Broadway, Rockingham County, VA was sprayed with a mixture of Princep 4L (simazine), Extrazine II 4L (atrazine and simazine), Asana XL (esfenvalerate), and Gramoxone Extra (paraquat). Two weeks later a neighbor noticed five dead Canada geese (*Branta canadensis*) and notified the Office of Pesticide Services, Division of Consumer Protection, Dept. of Agriculture and Consumer Services of Virginia. An inspection was made on June 26 at which time soil and vegetation samples were taken along the bank near the creek in which the geese were found. Substantial concentrations of simazine, atrazine, and cyanazine were found in these samples even though they were taken a month after the spraying. No analyses were made for paraquat or esfenvalerate, although the certainty with which the incident was cause by paraquat was considered to be probable. All other chemicals involved were considered possible. The applicator was fined $520 for spraying too close to the creek that was affected.

- Incident # I000247-004 - A fish kill took place in Theriot Canal in LaFourche County, LA some time before August 15, 1992, which involved an unknown amount of bass, bream, gar, and catfish. The incident was two miles long. The notification of the fish kill was made on August 15, but by that time the fish were in a state of advanced decay and none were taken for analysis. Sugar cane fields are in the area and on 8/12 Asana (esfenvalerate) was sprayed on 147 acres. On 8/13 and 8/15, AZM was sprayed on a total of 270 acres. AZM was suspected to be the more probable cause of the fish kill, with esfenvalerate listed as possible.

- Incident # I000710-001 - On September 7, 1993, six goats and two ducks were reported to have been exposed to esfenvalerate in an agricultural area. The effect noted was incapacitation, but not mortality. This incident occurred in Twin Falls County, ID. Few details are provided, and the certainty of causality by esfenvalerate was determined to be possible.

- Incident # I002166-001 - It was reported that a spill occurred between April 28 and May 1, 1995 on a tree farm in Wautauga County, NC when an insecticide-laden tank was being towed uphill. The tank contained esfenvalerate and lindane. Subsequently several hundred small brook trout were found dead in a nearby stream. Soil residue analyses were made between the spill site and the stream as well as near the edge of the stream. Tissue residue analyses were made on live and dead stream fish in order to determine the contribution of each pesticide to the event. Various amounts of lindane were found in soil, water and fish tissue, so this pesticide was assigned a causality certainty rating of probable. Esfenvalerate was found in soil, a trace in stream water and was not found in fish tissue, so it was ruled as a possible cause.

- Incident # I003596-001 and I002200-001 - A fish kill involving approximately 10,000 trout took place on August 8, 1994 in Aroostook County, Maine at the Maine/New Brunswick border where high acreages of potatoes are grown. Two compounds used just prior to the incident on the U.S. side were Manex (maneb) and Asana (esfenvalerate); on the Canadian side chlorothalonil had been used 5 days prior to the incident, after which occurred heavy rains. Approximately 10,000 brook trout were found dead in a nearby pond that was fed by a brook. These fish had recently been released from a hatchery. Three samples of water were taken from the brook and the pond; a soil sample was taken from the bank of the brook. According to the report all of these samples were below the detection limit for the pesticides. Three fish tissue samples were assayed for each of the pesticides, and because of other environmental variables, there was insufficient data to implicate these pesticides as sole causative agent in the fishkill. The conclusion reached in the report was that the cause of the fish kill was not determinable.

- Incident # I006173-001 - A citizen reported that on October 2, 1997 Asana XL (esfenvalerate) was applied at a rate of 0.02 lb a.i/acre, along with Thiodan (endosulfan) at rate of 1 qt/acre, to treat cowpeas for curculio. In addition a 4-11-11 fertilizer had recently been applied to the field at rate of 20 gal./acre. Five days later, it rained 3"-5" in a short amount of time, thus causing runoff to the nearby fishpond that resulted in a fish kill in the pond. The number and species of fish killed was not reported. This incident occurred in Texas.

- Incident # I003659-001 – An incident occurred in Accomack County, VA on July 1, 1996 in which thousands of clams in a hatchery were killed when exposed to esfenvalerate, AZM, and endosulfan. A farmer that raised the clams used water from nearby Gargatha Creek, which was contaminated with pesticides as the result of tomato fields nearby. Runoff from these fields contaminates nearby streams and kills shellfish.

- Incident # I009262-113 - As part of its August, 1999 report of pesticide incidents, Scotts Co. included a complaint from Marion County, Ohio. The complainant sprayed an apple tree with Bug-B-Gon Multi-Insect Liquid at the rate of 4 tbs/gal and all of the leaves turned brown. The accepted rate of spraying for a garden is 2 tablespoons/gallon and the product is not registered for fruit trees.

- Incident # I003781-002 - A private citizen from Ledbetter, KY, called DuPont reported that a private citizen from Ledbetter, KY reported a fish kill in her pond in June 1996. A neighbor had used Asana XL on his tomatoes, and a subsequent rainfall washed the Asana into the pond, killing the fish.

- Incident # I007984-010 – In March 1995, a spray rig containing 400 gallons of Asana and lindane overturned on a large farm and the mixture seeped into a boggy area and nearby stream resulting in the death of an unknown number of brook trout. The spill was contained and remediation included removing the soil and placing it in a plastic lined bed. The contaminated water was irrigated onto a Fraser Fir field. Charcoal was placed at the point of runoff to bind up any future chemical seepage. This incident occurred in Ashe County, NC.

5.0 Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and indirect effects to the CRLF or for modification to its designated critical habitat from the use of esfenvalerate in CA. The risk characterization provides an estimation (Section 5.1) and a description (Section 5.2) of the likelihood of effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of effects to the CRLF or its designated critical habitat (i.e., “no effect,” “likely to adversely affect,” or “may affect, but not likely to adversely affect”).

5.1 Risk Estimation

Risk is estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (APPENDIX L). For acute exposures to the CRLF and its animal prey in aquatic habitats, as well as terrestrial invertebrates, the LOC is 0.05. For acute exposures to the CRLF and mammals, the LOC is 0.1. The LOC for chronic exposures to CRLF and its prey, as well as acute exposures to plants is 1.0.

Risk to the aquatic-phase CRLF is estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended esfenvalerate usage scenarios summarized in Table 3-3 and the appropriate aquatic toxicity endpoint from Table 4-1. Risks to the terrestrial-phase CRLF and its prey (*e.g*. terrestrial insects, small mammals and terrestrial-phase frogs) are estimated based on exposures resulting from applications of esfenvalerate (Table 3-5 through 3.6) and the appropriate toxicity endpoint from Table 4-1. Exposures are also derived for terrestrial plants, as discussed in Section 3.3 and summarized in Table 3-7, based on the highest application rates of esfenvalerate use within the action area.

5.1.1 Exposures in the Aquatic Habitat

*5.1.1.1 **Direct Effects to the Aquatic-Phase CRLF***

Direct acute effects to the aquatic-phase CRLF are based on modeled peak EECs in the water and sediment pore-water of a small surface water body and the lowest acute toxicity value for freshwater fish. Direct chronic risks to the CRLF are calculated using modeled 60-day EECs in the water and pore-water and the lowest chronic toxicity value for freshwater fish. Risk estimates were calculated from EECs occurring in both the water column and in the sediment pore water because esfenvalerate is also expected to parse to the sediment compartment (Table 5-1). Multiple scenarios were included for some uses; these scenarios are varied by number of applications and application method (aerial or ground) where appropriate.

Based on these RQ estimates, a “may effect” determination is made for direct effects to the aquatic-phase CRLF for all uses as a result of acute risk due to exposure in the water column. Acute risk due to exposure to pore water, and chronic risk is also a concern for many uses. Sediment pore water concentrations result in fewer exceedances. Uses that require high numbers of applications, regardless of the maximum single application rate, also result in direct chronic risk to the CRLF.

Table 5-1. RQs for Determination of Direct Effects to the Aquatic-Phase CRLF.

Uses	Max. Single App. Rate (lbs ai/A)	No. Apps.	App. Method	RQs			
				Water Column		Pore Water	
				Acute[1]	Chronic[2]	Acute[1]	Chronic[2]
Artichoke, Dried Type Beans, Succulent (Snap) Beans, Carrot, Lentils, Peas (Unspecified), Dried-Type Peas, Pepper	0.05	3	Ground	**0.66**	0.31	**0.06**	0.11
	0.05	3	Aerial	**2.06**	0.94	**0.14**	0.29
Sugarbeet	0.05	3	Ground	**0.81**	0.31	**0.06**	0.09
	0.05	3	Aerial	**1.96**	0.74	**0.11**	0.20
Cucumber, Eggplant, Melons, Cantaloupe, Honeydew, Musk Melon, Watermelon, Pumpkin, Squash (all or unspecified), Summer Squash, Winter Squash	0.05	5	Aerial	**2.03**	0.94	**0.13**	0.26
	0.05	7	Ground	**0.24**	0.17	0.03	0.06
	0.05	7	Aerial	**2.17**	**1.31**	**0.19**	0.34
Radish	0.05	7	Ground	**0.57**	0.23	0.04	0.09
	0.05	7	Aerial	**2.17**	**1.29**	**0.17**	0.34
White/Irish Potato, Turnip	0.05	7	Aerial	**2.16**	**1.26**	**0.17**	0.34
	0.05	10	Ground	**0.59**	0.29	0.04	0.09
	0.05	10	Aerial	**2.36**	**1.71**	**0.24**	0.49
Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.05	5	Aerial	**2.87**	**1.74**	**0.27**	0.54
	0.05	20	Ground	**12.40**	**4.23**	**0.70**	**1.40**
	0.05	20	Aerial	**15.89**	**7.54**	**1.26**	**2.46**
Cotton	0.05	10	Ground	**1.53**	0.74	**0.11**	0.23
	0.05	10	Aerial	**2.79**	**2.20**	**0.33**	0.66
Tomato	0.05	10	Aerial	**2.40**	**1.89**	**0.27**	0.51
	0.05	10	Ground	**0.74**	0.34	**0.06**	0.11
Non Crop Land (residential)	0.05	10	Aerial	**2.64**	**2.31**	**0.36**	0.69
	0.05	10	Ground	**0.33**	0.31	0.04	0.09
Non Cropland (Right-of-Way)	0.05	10	Aerial	**2.76**	**2.51**	**0.39**	0.77
	0.05	10	Ground	**1.01**	0.54	**0.09**	0.17
Head Lettuce	0.05	14	Aerial	**12.61**	**7.14**	**1.21**	**2.40**
	0.05	14	Ground	**12.10**	**4.89**	**0.84**	**1.69**
Broccoli, Chinese Broccoli, Cabbage, Chinese Cabbage, Cauliflower, Collards, Kohlrabi, Mustard	0.05	12	Ground	**3.06**	**1.89**	**0.31**	0.63
	0.05	12	Aerial	**3.73**	**3.97**	**0.64**	**1.26**
	0.05	24	Ground	**7.69**	**4.63**	**0.79**	**1.54**
	0.05	24	Aerial	**8.94**	**7.97**	**1.41**	**2.77**
Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries, and Forests (Forestry)	0.05	25	Aerial	**32.37**	**16.80**	**2.96**	**5.83**
	0.05	25	Aerial	**36.60**	**20.17**	**3.50**	**6.89**
	0.05	25	Ground	**29.76**	**13.51**	**2.40**	**4.71**
Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries, and Forests (Nursery)	0.05	25	Aerial	**49.91**	**15.14**	**2.54**	**5.00**
	0.05	25	Aerial	**55.17**	**18.54**	**3.09**	**6.06**
	0.05	25	Ground	**48.33**	**14.94**	**2.43**	**4.77**
Almond, Filbert, Pecan,	0.075	4	Aerial	**2.74**	**1.17**	**0.19**	0.37

Uses	Max. Single App. Rate (lbs ai/A)	No. Apps.	App. Method	RQs			
				Water Column		Pore Water	
				Acute[1]	Chronic[2]	Acute[1]	Chronic[2]
Walnut	0.1	2	Ground	**0.77**	0.26	0.04	0.09
	0.1	2	Aerial	**3.41**	0.80	**0.13**	0.26
	0.1	2	Aerial	**3.43**	0.94	**0.14**	0.26
Apple, Apricot, Cherry, Peach, Pear, Plum, Prune, Nectarine	0.075	9	Aerial	**3.31**	**2.26**	**0.33**	0.63
	0.075	9	Ground	**0.93**	0.37	**0.06**	0.11
	0.075	9	Aerial	**3.14**	**2.06**	**0.30**	0.60
	0.075	7	Aerial	**3.70**	**1.80**	**0.27**	0.51
	0.075	7	Ground	**0.49**	0.29	0.04	0.09
At Plant Applications to Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.1	1	Ground	**0.86**	0.31	**0.06**	0.11
At Plant Application to Sugarbeet	0.1	1	Ground	**0.49**	0.17	0.03	0.06
Non-agricultural Uses (Residential Non-Ag 100% impervious surfaces)	0.2	1	Ground	**0.73**	0.11	0.01	0.03
	0.2	2	Ground	**0.79**	0.23	0.04	0.06
	0.2	3	Ground	**0.83**	0.37	**0.06**	0.11
Lawns and Turf Grass	0.2	3	Ground	**0.86**	0.40	**0.06**	0.11
Non-agricultural Uses (Right of Way)	0.2	3	Ground	**1.14**	0.60	**0.10**	0.20
	0.2	1	Ground	**0.77**	0.20	0.03	0.06
Non-agricultural Uses (Impervious Surfaces)	0.2	1	Ground	**92.33**	**9.91**	**1.31**	**2.57**
Residential Non-Agricultural Uses with Impervious Surfaces	NA	1	Ground	**45.47**	0.02	N/A	N/A
Right-of-Way Non-Agricultural Uses with Impervious Surfaces	NA	1	Ground	**45.50**	**5.86**	N/A	N/A

[1] Calculated using the peak EECs from PRZM-EXAMS and the rainbow trout acute LC_{50} of 0.07 ppb ai. Values in bold exceed the acute endangered LOC.
[2] Calculated using the 60-day EECs from PRZM-EXAMS and the chronic NOAEC (estimated with ACR) of 0.035 ppb ai. Values in bold exceed the chronic LOC.

5.1.1.2 Indirect Effects to Aquatic-Phase CRLF via Reduction in Prey (non-vascular aquatic plants, aquatic invertebrates, fish, and frogs)

Aquatic Plants

Data are not available with which to calculate RQs for aquatic plants. Without these data we cannot make a definitive "no effect" determination; therefore, **a determination of "may effect" to** the **aquatic-phase CRLF is made for all uses as a result of losses of algal food sources.**

Aquatic Invertebrates

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on modeled peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. For chronic risks, 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive chronic RQs. A summary of the acute and chronic RQ values for exposure to aquatic invertebrates (as prey items of aquatic-phase CRLFs) is provided in Table 5-2. As with the RQs calculated for freshwater fish, multiple scenarios were included that provide estimates for different numbers of applications and situations in which drift does or does not occur.

Based on these RQ estimates, a "may effect" determination is made for indirect effects to the aquatic-phase CRLF for all uses primarily as a result of acute risk to aquatic invertebrates due to exposure within the water column. In many cases, acute risk is also problematic for invertebrates exposed to pore water. Chronic risks are also a concern with uses requiring relatively high numbers of applications.

Table 5-2. RQs for Determination of Indirect Effects to the Aquatic-Phase CRLF Through Loss of Aquatic Invertebrate Food Base.

Uses	Max. Single App. Rate (lbs ai/A)	No. Apps.	App. Method	RQs			
				Water Column		Pore Water	
				Acute[1]	Chronic[2]	Acute[1]	Chronic[2]
Artichoke, Dried Type Beans, Succulent (Snap) Beans, Carrot, Lentils, Peas (Unspecified), Dried-Type Peas, Pepper	0.05	3	Ground	**0.92**	0.71	**0.08**	0.24
	0.05	3	Aerial	**2.88**	**2.53**	**0.20**	0.59
Sugarbeet	0.05	3	Ground	**1.14**	0.76	**0.08**	0.18
	0.05	3	Aerial	**2.74**	**2.12**	**0.16**	0.47
Cucumber, Eggplant, Melons, Cantaloupe, Honeydew, Musk Melon, Watermelon, Pumpkin, Squash (all or unspecified), Summer Squash, Winter Squash	0.05	5	Aerial	**2.84**	**2.41**	**0.18**	0.53
	0.05	7	Ground	**0.34**	0.35	0.04	0.12
	0.05	7	Aerial	**3.04**	**3.00**	**0.26**	0.76
Radish	0.05	7	Aerial	**3.04**	**2.94**	**0.24**	0.71
	0.05	7	Ground	**0.80**	0.53	**0.06**	0.18
White/Irish Potato, Turnip	0.05	7	Aerial	**3.02**	**2.88**	**0.24**	0.71
	0.05	10	Ground	**0.82**	0.59	**0.06**	0.18
	0.05	10	Aerial	**3.30**	**3.71**	**0.34**	**1.00**
Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.05	5	Aerial	**4.02**	**4.06**	**0.38**	**1.12**
	0.05	20	Ground	**17.36**	**9.94**	**0.98**	**2.88**
	0.05	20	Aerial	**22.24**	**16.41**	**1.76**	**5.12**
Cotton	0.05	10	Ground	**2.14**	**1.71**	**0.16**	0.47
	0.05	10	Aerial	**3.90**	**4.71**	**0.46**	**1.35**
Tomato	0.05	10	Ground	**1.04**	0.71	**0.08**	0.24
	0.05	10	Aerial	**3.36**	**4.00**	**0.38**	**1.12**
Non Crop Land (Residential)	0.05	10	Ground	**0.46**	0.65	**0.06**	0.18
	0.05	10	Aerial	**3.70**	**5.00**	**0.50**	**1.47**
Non Cropland (Right-of-Way)	0.05	10	Ground	**1.42**	**1.12**	**0.12**	0.35
	0.05	10	Aerial	**3.86**	**5.35**	**0.54**	**1.59**
Head Lettuce	0.05	14	Ground	**16.94**	**11.12**	**1.18**	**3.47**
	0.05	14	Aerial	**17.66**	**15.29**	**1.70**	**5.00**
Broccoli, Chinese Broccoli, Cabbage, Chinese Cabbage,	0.05	12	Ground	**4.28**	**4.06**	**0.44**	**1.29**
	0.05	12	Aerial	**5.22**	**8.29**	**0.90**	**2.65**

Uses	Max. Single App. Rate (lbs ai/A)	No. Apps.	App. Method	RQs			
				Water Column		Pore Water	
				Acute[1]	Chronic[2]	Acute[1]	Chronic[2]
Cauliflower, Collards, Kohlrabi, Mustard	0.05	24	Ground	**10.76**	**10.06**	**1.10**	**3.24**
	0.05	24	Aerial	**12.52**	**16.94**	**1.98**	**5.76**
Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries, and Forests (Forestry)	0.05	25	Ground	**41.66**	**29.76**	**3.36**	**9.82**
	0.05	25	Aerial	**45.32**	**36.35**	**4.14**	**12.12**
	0.05	25	Aerial	**51.24**	**43.53**	**4.90**	**14.35**
Christmas Tree Plantings, Conifer Plantations, Orchards, Forest Tree Nurseries, and Forests (Nursery)	0.05	25	Ground	**67.66**	**37.53**	**3.40**	**9.94**
	0.05	25	Aerial	**69.88**	**37.06**	**3.56**	**10.41**
	0.05	25	Aerial	**77.24**	**45.88**	**4.32**	**12.65**
Apple, Apricot, Cherry, Peach, Pear, Plum, Prune, Nectarine	0.075	7	Ground	**0.68**	0.59	**0.06**	0.18
	0.075	7	Aerial	**5.18**	**4.29**	**0.38**	**1.12**
	0.075	9	Ground	**1.30**	0.82	**0.08**	0.24
	0.075	9	Aerial	**4.40**	**4.76**	**0.42**	**1.24**
	0.075	9	Aerial	**4.64**	**4.94**	**0.46**	**1.35**
Almond, Filbert, Pecan, Walnut	0.075	4	Aerial	**3.84**	**2.94**	**0.26**	0.76
	0.1	2	Ground	**1.08**	0.65	**0.06**	0.18
	0.1	2	Aerial	**4.80**	**2.76**	**0.20**	0.53
	0.1	2	Aerial	**4.78**	**2.06**	**0.18**	0.53
At Plant Applications to Corn (unspecified), Field Corn, Pop Corn, Sweet Corn, Sunflower	0.1	1	Ground	**1.20**	0.76	**0.08**	0.24
At Plant Application to Sugarbeet	0.1	1	Ground	**0.68**	0.47	0.04	0.12
Non-agricultural Uses (Residential Non-Ag 100% impervious surfaces)	0.2	1	Ground	**1.02**	0.35	0.02	0.06
	0.2	2	Ground	**1.10**	0.65	**0.06**	0.12
	0.2	3	Ground	**1.16**	**1.00**	**0.08**	0.24
Lawns and Turf Grass	0.2	3	Ground	**1.20**	**1.06**	**0.08**	0.24
Non-agricultural Uses (Right of Way)	0.2	3	Ground	**1.60**	**1.47**	**0.14**	0.41
	0.2	1	Ground	**1.08**	0.53	0.04	0.12
Non-agricultural Uses (Impervious Surfaces)	0.2	1	Ground	**129.26**	**33.41**	**1.84**	**5.35**
Residential Non-Agricultural Uses with Impervious Surfaces	N/A	1	Ground	**63.66**	**20.41**	N/A	N/A
Right-of-Way Non-Agricultural Uses with Impervious Surfaces	N/A	1	Ground	**63.70**	**20.47**	N/A	N/A

[1] Calculated using the peak EECs from PRZM-EXAMS and the *D. magna* acute fenvalerarte 48-hr LC_{50} of 0.05 ppb ai. Values in bold exceed the acute endangered LOC.
[2] Calculated using the 21-day EECs from PRZM-EXAMS and the *D. magna* chronic estimated life cycle NOAEC of 0.017 ppb ai. Values in bold exceed the chronic LOC.

Fish and Frog Prey Items

Fish and frogs also represent potential prey items of adult CRLFs. RQs associated with acute and chronic direct toxicity to the CRLF (Table 5-1) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. **Based on the RQs determined for this taxon, a "may effect" determination is expected to occur for all uses as a result of indirect effects to the CRLF due to losses of amphibian and fish food resources.**

5.1.1.3 Indirect Effects to CRLF via Reduction in Habitat and/or Primary Productivity (Freshwater Aquatic Plants)

Data are not available with which to calculate RQs for aquatic plants. A definitive "no effect" determination cannot be made without unknown uncertainty. Therefore, **a determination of "may effect" to the aquatic-phase CRLF is made for all uses as a result of losses of habitat and reduction in primary productivity.**

5.1.2 Exposures in the Terrestrial Habitat

5.1.2.1 Direct Effects to Terrestrial-phase CRLF

As previously discussed in Section 3.3, potential direct effects to terrestrial-phase CRLFs are based on residues on dietary items due to spray applications of esfenvalerate.

Potential direct acute effects to the terrestrial-phase CRLF are derived by considering dose- and dietary-based EECs modeled in T-REX for a small bird (20 g) consuming small invertebrates (Table 3-6) and acute oral and subacute dietary toxicity endpoints for avian species. Table 5-3 provides the acute RQs based on these EECs, and LC_{50} and LD_{50} (adjusted for a 20g bird) toxicity data presented in Table 4-1. Based on the dose-based acute RQs, a **"may affect"** determination is made for uses allowing multiple applications at and above 0.075 lbs ai/Aand single applications at and above 0.2 lbs ai/acre (pecan, apple, pear, kiwi, head lettuce, apricot, cherry, peach, plum, prune, buildings, lawns and turf grass, mosquito breeding areas, and wide-area general outdoor surface applications).

Table 5-3. Dietary- and Dose-Based Acute RQs for Determination of Direct Effects to the Terrestrial-Phase CRLF.

Use	Number of Seasons	Application rate (lbs ai/A)	Number of Applications[1]	Dietary-based Acute RQs	Dose-based Acute RQs[2]
Field Corn (ground)	1	0.05	1	<0.01	0.03
Radish	3 to 5	0.05	2	<0.01	0.05
Artichoke, Sugarbeet (broadcast), Peanuts	1	0.05	3	<0.01	0.06
Beans (Dried, Succulent), Lentils, Peas, Sugarcane	1	0.05	4	<0.01	0.07
Sunflower	1 to 2	0.05	4	<0.01	0.07
Collards, Mustard	2 to 3	0.05	4	<0.01	0.07
Field Corn, Cucumber, Melons (all, Cantaloupe, Honeydew, Musk, Water), Pumpkin, Squash (Unspecified, Summer, Winter), Turnip, Sugarbeet (row application)	1	0.05	5	<0.01	0.07
Eggplant, Potato (White, Irish), Pepper	1	0.05	7	<0.01	0.08
Kohlrabi	2 to 3	0.05	7	<0.01	0.08

Use	Number of Seasons	Application rate (lbs ai/A)	Number of Applications[1]	Dietary-based Acute RQs	Dose-based Acute RQs[2]
Broccoli, Chinese broccoli, Cauliflower	1 to 2	0.05	8	<0.01	0.08
Cabbage, Chinese cabbage	1 to 3	0.05	8	<0.01	0.08
Pop Corn, Carrot, Cotton, Tomato	1	0.05	10	<0.01	0.08
Corn, Sweet corn	1 to 2	0.05	10	<0.01	0.08
Non-cropland	N/A	0.05	10	<0.01	0.08
Forestry	N/A	0.05	25	<0.01	0.09
Pecan	1	0.075	4	<0.01	**0.10**
Apple, Pear, Kiwi	1	0.075	7	<0.01	**0.12**
Head lettuce	1 to 2	0.075	7	<0.01	**0.12**
Apricot, Cherry, Nectarine, Peach, Plum, Prune	1	0.075	9	<0.01	**0.13**
Kennels and housing areas	N/A	0.1	1	<0.01	0.06
Almond, Filbert, Walnut	1	0.1	2	<0.01	0.09
Buildings, Lawns and turf grass, Mosquito breeding areas	N/A	0.2	1	<0.01	**0.11**
General Outdoor Surfaces	N/A	0.51	1	0.01	**0.29**

[1]Based on a single season only.
[2]Based on an adjusted LD_{50} of 274.48 mg/kg-bw for a 20g bird, values in bold exceed the acute endangered LOC of 0.1.

The avian reproduction study with fenvalerate identified a NOAEC value of <25 ppm. Esfenvalerate is more acutely toxic than fenvalerate[29], and thus may be of greater chronic toxicity as well. Using a NOAEC of 25 ppm, 1 to 25 applications at 0.05 lbs ai/acre would result in chronic RQs ranging from 0.27 to 0.92. Applications at 0.075 lbs ai/acre (4 – 9 applications) result in chronic RQs ranging from 1.04 to 1.32; 1 or 2 applications at 0.1 lbs ai/acre would be 0.54 and 0.92, respectively; while single applications at higher rates (0.2 and 0.51 lbs ai/acre) would range from 1.08 to 2.75.

Since the fenvalerate NOAEC is <25 ppm, and the esfenvalerate NOAEC is likely lower than that of fenvalerate, the actual chronic RQs for esfenvalerate are expected to be higher than those calculated above. Therefore, it is likely that, at least at higher application rates, chronic RQs for esfenvalerate would exceed the chronic LOC. In the absence of a study that provides a definitive chronic NOAEC value for esfenvalerate, we presume that chronic effects would also occur for uses with lower application rates. Therefore, a **"may effect"** determination is made for all uses as a result of direct chronic risk to the CRLF. Submission of an avian chronic toxicity test would reduce uncertainties with this conclusion.

5.1.2.2 Indirect Effects to Terrestrial-Phase CRLF via Reduction in Prey (terrestrial invertebrates, mammals, and frogs)

[29] Only one definitive acute value is available for the Mallard, for which the LD50 is 9,932 mg/kg (MRID 00096385). Other LD50 values are >2,000 and >3,000 for Northern bobwhite and partridge, respectively; LC50 values are listed as >5,000 and >10,000 for Mallards and Northern bobwhite.

Terrestrial Invertebrates

In order to assess the risks of esfenvalerate to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the honey bee is used as a surrogate for terrestrial invertebrates. EECs (µg a.i./g of bee) converted from values from T-REX for small and large insects are divided by the toxicity value for terrestrial invertebrates, which is 0.017 µg a.i./g of bee. RQs for terrestrial invertebrates are presented in Table 5-4. **Based on these RQs, a "may effect" determination is made for indirect effects to the CRLF as a result of losses of terrestrial invertebrate food base. This is concluded for all uses of esfenvalerate.**

Table 5-4. RQs for Terrestrial Invertebrates for Determination of Indirect Effects to the Terrestrial-Phase CRLF.

Use	Application rate (lbs ai/A)	Number of Applications[1]	Large Insect RQ[2,3]	Small Insect RQ[2,4]
Field Corn (ground)	0.05	1	**50.6**	**5.9**
Radish	0.05	2	**84.7**	**9.4**
Artichoke, Sugarbeet (broadcast), Peanuts	0.05	3	**108.2**	**11.8**
Collards, Mustard, Sunflower, Beans (Dried, Succulent), Lentils, Peas, Sugarcane	0.05	4	**123.5**	**13.5**
Field Corn, Cucumber, Melons (all, Cantaloupe, Honeydew, Musk, Water), Pumpkin, Squash (Unspecified, Summer, Winter), Turnip, Sugarbeet (row application)	0.05	5	**134.1**	**14.7**
Kohlrabi, Eggplant, Potato (White, Irish), Pepper	0.05	7	**145.9**	**16.5**
Broccoli, Chinese broccoli, Cauliflower, Cabbage, Chinese Cabbage	0.05	8	**149.4**	**16.5**
Corn, Pop Corn, Sweet Corn, Carrot, Cotton, Tomato, Non-cropland	0.05	10	**152.9**	**17.1**
Forestry	0.05	25	**155.9**	**17.1**
Pecan	0.075	4	**185.9**	**20.6**
Apple, Pear, Kiwi, Lettuce (Head)	0.075	7	**218.8**	**24.1**
Apricot, Cherry, Nectarine, Peach, Plum, Prune	0.075	9	**227.1**	**25.3**
Kennels and housing areas	0.1	1	**101.8**	**11.2**
Almond, Filbert, Walnut	0.1	2	**170.0**	**18.8**
Buildings, Lawns and turf grass, Mosquito breeding areas	0.2	1	**203.5**	**22.4**
General Outdoor Surfaces	0.51	1	**518.2**	**57.7**

[1]Based on a single season only.
[2]Values in bold exceed the acute LOC of 0.05.
[3]Uses the small insect adjusted EEC calculated in Table 3-7 and the honeybee contact LD_{50} of 0.017 µg/bee.
[4]Uses the large insect adjusted EEC calculated in Table 3-7 and the honeybee contact LD_{50} of 0.017 µg/bee.

Mammals

Risks associated with ingestion of small mammals by large terrestrial-phase CRLFs are derived for dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass. Acute and chronic effects are estimated using the most sensitive mammalian toxicity data. EECs are divided by the toxicity value to estimate acute and chronic dose-based RQs as well as chronic dietary-based RQs. **Based on these estimates, a "may effect" determination is made for all uses for indirect effects to the CRLF as a result of loss in the terrestrial mammal food base. This results from both acute and chronic risks to mammals, except for the at-plant ground application to corn (chronic risk only).**

Table 5-5. RQs for Terrestrial Mammals for Determination of Indirect Effects to the Terrestrial-Phase CRLF.

Use	Application rate (lbs ai/A)	Number of Applications[1]	Dose-based Acute RQ[2]	Dose-based Chronic RQ[3]	Dietary-Chronic RQ[4]
Field Corn (ground)	0.05	1	0.09	**1.24**	0.14
Radish	0.05	2	**0.15**	**2.11**	0.24
Artichoke, Sugarbeet (broadcast), Peanuts	0.05	3	**0.19**	**2.63**	0.30
Collards, Mustard, Sunflower, Beans (Dried, Succulent), Lentils, Peas, Sugarcane	0.05	4	**0.21**	**3.01**	0.35
Field Corn, Cucumber, Melons (all, Cantaloupe, Honeydew, Musk, Water), Pumpkin, Squash (Unspecified, Summer, Winter), Turnip, Sugarbeet (row application)	0.05	5	**0.23**	**3.27**	0.38
Kohlrabi, Eggplant, Potato (White, Irish), Pepper	0.05	7	**0.25**	**3.55**	0.41
Broccoli, Chinese broccoli, Cauliflower, Cabbage, Chinese Cabbage	0.05	8	**0.26**	**3.63**	0.42
Corn, Pop Corn, Sweet Corn, Carrot, Cotton, Tomato, Non-cropland	0.05	10	**0.27**	**3.72**	0.43
Forestry	0.05	25	**0.27**	**3.79**	0.44
Pecan	0.075	4	**0.32**	**4.52**	0.52
Apple, Pear, Kiwi, Lettuce (Head)	0.075	7	**0.38**	**5.33**	0.61
Apricot, Cherry, Nectarine, Peach, Plum, Prune	0.075	9	**0.39**	**5.53**	0.64
Kennels and housing areas	0.1	1	**0.21**	**2.95**	0.29
Almond, Filbert, Walnut	0.1	2	**0.30**	**4.14**	0.48
Buildings, Lawns and turf grass, Mosquito breeding areas	0.2	1	**0.35**	**4.95**	0.57
General Outdoor Surfaces	0.51	1	**0.90**	**12.62**	**1.45**

[1]Based on a single season only.
[2]Based on the adjusted LD_{50} of 129.67 mg/kg-bw for a 15-g mammal. Values in bold exceed the acute endangered LOC of 0.10.
[3]Dose-based chronic RQs determined using the adjusted NOAEL of 9.25 mg/kg-bw for a 15-g mammal. Values in bold exceed the chronic LOC of 1.0.
[4]Dietary-based chronic RQs determined using the estimated NOAEC of 84.2 mg/kg/day based on the standard FDA conversion.

Frogs

An additional prey item of the adult terrestrial-phase CRLF is other species of frogs. In order to assess risks to these organisms, dietary-based and dose-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates are used. **Based on the information presented above, a "may effect" determination is made for the terrestrial-phase CRLF as a result of the loss of the amphibian food base.** This is as a result of acute risk to frogs; chronic risk cannot be determined because chronic toxicity data for birds is not available.

5.1.2.3 Indirect Effects to CRLF via Reduction in Terrestrial Plant Community (Riparian and Upland Habitat)

Guideline data are not available with which to determine the risks of esfenvalerate exposure to terrestrial plants. Some information available from the open literature suggests that fenvalerate reduces growth and seed emergence; however, at some test levels fenvalerate increased growth and germination. Furthermore, the applicability of these studies to the field environment and the comparative toxicity of fenvalerate and esfenvalerate to plants are not known. Another study failed to find effects of fenvalerate on terrestrial plants. Although one incident of plant damage from esfenvalerate was reported, it resulted from overuse (twice the application rate) of a product that was not registered for the type of plant to which it was applied. Therefore, it appears that the potential risk of esfenvalerate to terrestrial plants is low. However, since we cannot make a definitive "no effect" determination, **a preliminary determination of "may affect" to the CRLF resulting from a reduction in the terrestrial plant community is made.**

5.1.3 Primary Constituent Elements of Designated Critical Habitat

For esfenvalerate use, the assessment endpoints for designated critical habitat primary constituent elements (PCEs) involve a reduction and/or modification of food sources necessary for normal growth and viability of aquatic-phase CRLFs, and/or a reduction and/or modification of food sources for terrestrial-phase juveniles and adults. Because these endpoints are also being assessed relative to the potential for indirect effects to aquatic- and terrestrial-phase CRLF, the effects determinations for indirect effects from the potential loss of food items are used as the basis of the effects determination for potential modification to designated critical habitat.

5.2 Risk Description

The risk description synthesizes an overall conclusion regarding the likelihood of adverse impacts leading to an effects determination (*i.e.*, "no effect," "may affect, but not likely to adversely affect," or "likely to adversely affect") for the CRLF and its designated critical habitat.

If the RQs presented in the Risk Estimation (Section 5.1) show no direct or indirect effects for the CRLF, and no modification to PCEs of the CRLF's designated critical habitat, a "no effect" determination is made, based on esfenvalerate's use within the action area. However, if direct or indirect effect LOCs are exceeded, or effects may modify the PCEs of the CRLF's critical habitat, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding esfenvalerate. A summary of the results of the risk estimation (*i.e.*, "no effect" or "may affect" finding) is provided in Table 5-6 for direct and indirect effects to the

CRLF. Because effects to aquatic and terrestrial plants are not expected, these preliminary determinations also apply to PCEs of designated critical habitat for the CRLF.

Table 5-6. Preliminary Effects Determination Summary for Esfenvalerate - Direct and Indirect Effects to the CRLF.

Assessment Endpoint	Preliminary Effects Determination	Basis For Preliminary Determination
Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	May Affect	Acute RQs exceed the endangered acute LOC for direct effects to the CRLF for all uses and application rates. Uses that require high numbers of applications, regardless of their maximum single application rate, also result in direct chronic risk to the aquatic-phase CRLF.
Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants, fish, and amphibians)	May Affect	Acute RQs for aquatic invertebrates, fish, and other amphibians exceed the endangered species LOC for aquatic animals for all uses and application rates. Uses that require high numbers of applications also result in exceedance of the chronic LOC for these taxa. Data are not available with which to quantitatively assess risk to plants. Some data indicate that losses of aquatic vascular and non-vascular plants as a food source should not be expected; however, without more data risk cannot be disregarded.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	May Affect	Data are not available with which to quantitatively assess risk to plants. Some data indicate that losses of aquatic vascular and non-vascular plants as a food source should not be expected; however, without more data risk cannot be disregarded.
Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	May Affect	Data are not available with which to quantitatively assess risk to plants. Some data indicate that losses of terrestrial plants as a food source should not be expected; however, without more data risk cannot be disregarded.
Terrestrial Phase (Juveniles and adults)		

Assessment Endpoint	Preliminary Effects Determination	Basis For Preliminary Determination
Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	May Affect	Dose-based acute RQs exceed the LOC for the CRLF for uses requiring numerous applications of 0.05 lbs ai/acre (forestry uses – 25 apps/year), multiple applications at 0.075 lbs ai/acre and 0.1 lbs ai/acre, or single applications at higher rates. A “no effect” determination cannot be made for uses receiving applications of 0.05 lbs ai/acre at 10 or fewer applications/year because of the possibility of chronic risk to the terrestrial-phase CRLF. Chronic risk is expected at least for uses with high application rates, but cannot be quantified with certainty for any particular use.
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial mammals and terrestrial phase amphibians)	May Affect	RQs for terrestrial insects exceed the acute LOC based on EECs for both large and small insects for all uses. Acute and chronic RQs exceed the LOCs for small mammals for all uses. As noted above for direct effects, indirect effects are also expected to result from effects to terrestrial-phase amphibians as a result of acute exposures to several uses.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	May Affect	Data are not available with which to quantitatively assess risk to plants. Some data indicate that losses of terrestrial plants as a food source should not be expected; however, without more data risk cannot be disregarded.

Following a “may affect” determination, additional information is considered to refine the potential for exposure at the predicted levels based on the life history characteristics (*i.e.*, habitat range, feeding preferences, etc.) of the CRLF. Based on the best available information, the Agency uses the refined evaluation to distinguish those actions that “may affect, but are not likely to adversely affect” from those actions that are “likely to adversely affect” the CRLF and its designated critical habitat.

The criteria used to make determinations that the effects of an action are “not likely to adversely affect” the CRLF and its designated critical habitat include the following:

- <u>Significance of Effect</u>: Insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where “take” occurs for even a single individual. “Take” in this context means to harass or harm, defined as the following:
    - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.
    - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

- Likelihood of the Effect Occurring: Discountable effects are those that are extremely unlikely to occur.
- Adverse Nature of Effect: Effects that are wholly beneficial without any adverse effects are not considered adverse.

A description of the risk and effects determination for each of the established assessment endpoints for the CRLF and its designated critical habitat is provided in **Sections 5.2.1 through 5.2.3**.

5.2.1 Direct Effects

*5.2.1.1 **Aquatic-Phase CRLF***

The aquatic-phase considers life stages of the frog that are obligatory aquatic organisms, including eggs and larvae. It also considers submerged terrestrial-phase juveniles and adults, which spend a portion of their time in water bodies that may receive runoff and spray drift containing esfenvalerate.

Acute RQs determined from EECs in the water column exceed the LOC for all uses, and as a result a preliminary "may affect" conclusion was determined for the aquatic-phase CRLF. This was true for all scenarios. Similar conclusions were drawn based on risks associated with sediment pore water, although RQs did not exceed LOCs for some uses. However, acute risks due to sediment pore water concentrations are more likely to impact organisms that are potential food items for the CRLF, such as benthic invertebrates, and this is discussed below in Section 0, which covers indirect effects.

The chance of individual effect (mortality) to the aquatic-phase CRLF can be determined as described above in Section 5.1 using the acute endangered LOC (0.05) as threshold values for effects and the actual acute RQs calculated from water column EEC. This determination uses the probit slope of 6.0 determined from the Rainbow trout acute LC_{50} test that was used to calculate RQs. At the acute endangered LOC (0.05), the chance of individual mortality is less than one in trillion (1 in 2.3x 10^{19}; 95% CI = 1 in 63,800 to 1 in 4.24 x 10^{43}). This probability is low. However, water-column acute RQs for all uses exceed the acute endangered LOC by an order of magnitude or more, so the probability of individual mortality is much higher than this estimate. In the water column the acute RQ for all uses is at or above 0.5 which translates to an individual chance of mortality of greater than 1 in 28. The exception is for the ground spray label application rate on cucumber, eggplant, melons, cantaloupe, honeydew, muskmelon, watermelon, pumpkin, and squash, which has an acute RQ of 0.24. This value translates as an individual probability of mortality of 1 in 10,000. Acute RQs for pore-water exposures were lower than those for peak water column exposures with acute RQs of 0.15 or less having individual probability of acute mortality of less than 1 in a million.

Chronic RQs exceed the chronic LOC with fewer esfenvalerate uses. A higher probability of chronic risk is associated with esfenvalerate uses involving single applications at or above 0.2 lbs ai/A, multiple aerial applications at or above 0.35 lbs ai/A total, or multiple ground applications above 0.5 lbs ai/A total for most uses. The exception to these is uses on head lettuce, cole crops, and impervious surfaces which have higher acute risks at lower application rates.

Usage data (Table 2-6) indicate that, although single application rates are generally <0.1 lb ai/ac, average annual usage is high for several uses (i.e., in the 1,000's of pounds per year). Therefore, esfenvalerate usage is either very widespread or frequent or both. Figure 2-4 indicates high usage in California during the time of year in which eggs and tadpoles are prevalent. Since esfenvalerate has a variety of agricultural and non-agricultural uses, it is likely to be used practically anywhere in the state of California. Therefore we assume 100% overlap of esfenvalerate use with CRLF habitat.

Based on the evidence discussed above, a "Likely to Adversely Affect" determination is made for direct effects to the aquatic-phase CRLF.

5.2.1.2 Terrestrial-Phase CRLF

All uses had dietary-based acute RQs <0.01 whereas acute dose-based RQs for birds (surrogate for the terrestrial-phase CRLF) exceed the acute LOC for uses with single application rates at or above 0.2 lbs ai/Aand multiple applications at and above 0.075 lbs ai/A. Since terrestrial EECs are based on applications in a single season only, it is possible that for those crops with multiple seasons the RQs may be higher if applications are considered over the course of one year. However, the T-REX spreadsheet model does not have the capability to estimate EECs for multiple seasons.

The chance of individual mortality to a CRLF in the terrestrial phase must be estimated using the default probit slope value of 4.5 (95% CI = 2 - 9). With dietary-based acute RQs of <0.01, the individual probability of mortality is less than 1 in a trillion (95% CI of <1 in 30,000 to <1 in 10^{72}). For the dietary-based acute RQs at the acute endangered LOC (0.1), the chance of individual mortality is 1 in 290,000 (95% CI = 1 in 44 to 1 in 1 x 10^{16}). Most dose-based acute RQ values are at or below 0.10. Of the six scenario categories above the acute LOC, five scenarios are between 0.11 and 0.13 and the sixth, general outdoor surface uses, is 0.29. For 0.11 to 0.13, the probability of individual mortality is 1 in 125,000 to 1 in 29,000, respectively. At an acute RQ of 0.29, the probability of individual morality is 1 in 129 (0.8%) (CI = 1 in 7 to 1 in 1.5 x 10^{6}). At the acute RQ of 0.29, the probability of individual effect is relatively high. Therefore, these results may indicate that the possibility of individual mortality is high enough for the CRLF to warrant concern for its exposure to esfenvalerate.

However, RQs determined by T-REX may be overestimated for a poikilotherm, as well, since homeotherms are expected to consume a greater daily amount of food relative to body weight due to a higher metabolism. EFED's T-HERPS spreadsheet model provides a better characterization of the dose-based risk to the CRLF based on the estimated consumption of a terrestrial-phase amphibian. The details of this analysis are provided in Appendix C. Based on this analysis, dose-based acute RQs do not exceed the acute LOC under any uses.

Sufficient data are not available for quantifying chronic risks and determining which uses would in concert with not exceeding the acute LOC would result in a "not likely to adversely affect" conclusion for the terrestrial-phase CRLF. Based on the logic presented in Section 5.1.2.1, it is expected that uses especially those with relatively lower application rates would not pose chronic risks of concern. However, it cannot be said with certainty which uses would be involved; therefore, until such time as avian reproduction data are provided to the Agency, we assume that chronic risk above levels of concern may be associated with all uses.

Further information on actual usage would be beneficial to making a more definite conclusion, especially since many of the RQs are just above the LOC, and there are some assumptions built into the analysis with T-REX that may not be realistic for all scenarios. For example, for non-agricultural uses such as around buildings, mosquito breeding areas, and "general outdoor surfaces," the actual amount used may vary considerably. Some of these uses are likely to be spot treatments, and the application rate may be lower. However, these are poorly characterized with usage information, so EFED must utilize maximum possible rates allowed on the labels. Since RQs are near the LOC, a reduction in the application rates, especially in the numbers of applications, is expected to reduce risk to the CRLF.

Since the assumption that esfenvalerate use overlaps all areas inhabited by the CRLF, and because chronic risk levels can not be definitively declared below levels of concern, a "Likely to Adversely Affect" determination is made for the terrestrial-phase CRLF for all uses of esfenvalerate.

5.2.2 Indirect Effects to the CRLF (via reductions in prey base)

*5.2.2.1 **Algae (Non-Vascular Aquatic Plants)***

As discussed in Section 2.5.3, the diet of CRLF tadpoles is composed primarily of unicellular aquatic plants (i.e., algae and diatoms) and detritus. Data are not available with which to calculate RQs for aquatic plants. However, qualitative information provided in the mesocosm study submitted to OPP and field studies available in the open literature indicate that effects to aquatic plants are unlikely at current use rates. A preliminary "may affect" determination was made earlier. Since the available data suggest a low likelihood of effects to aquatic plants, **a determination of "Not Likely to Adversely Affect" is made for the aquatic-phase CRLF for all uses as a result of losses of algal food sources.**

*5.2.2.2 **Aquatic Invertebrates***

The potential for esfenvalerate to elicit indirect effects to the CRLF via effects on freshwater invertebrate food items is dependent on several factors including: (1) the potential magnitude of effect on freshwater invertebrate individuals and populations; and (2) the number of prey species potentially affected relative to the expected number of species needed to maintain the dietary needs of the CRLF. Together, these data provide a basis to evaluate whether the number of individuals within a prey species is likely to be reduced such that it may indirectly affect the CRLF.

Based on RQs calculated from EECs in the water column, a preliminary "may effect" determination was made for indirect effects to the aquatic-phase CRLF due to effects on aquatic invertebrates. A probit slope value is not available from the *D. magna* acute toxicity test with fenvalerate that was used to estimate acute risk. Therefore, the default value of 4.5 must be used. Based on this slope, at the acute LOC of 0.05 the chance of individual mortality to an invertebrate that would serve as a food item for the CRLF is 1 in 4.18 x 10^8 (95% CI = 1 in 216 to 1 in 1.75 x 10^{31}). However, all acute RQ values were above this value ranging from 0.34 to 129. The probability of mortality for an individual ranges from 1 in 57 to 1 in 1. These probabilities are high, indicating that if an individual is exposed at the modeled levels it is likely to die, and therefore population sizes may be reduced to a point that the CRLF is affected by losses of invertebrate food items.

Given the chemical nature of esfenvalerate, effects are expected to sediment-dwelling invertebrates. The field study from the open literature described in Section 4.0, wherein esfenvalerate was introduced into a slow-moving irrigation ditch, indicated that esfenvalerate is toxic to sediment-dwelling invertebrates. Therefore, based on this information and RQs calculated for sediment-dwelling invertebrates, risk to the invertebrate community is also expected to extend to those inhabiting sediments within surface waters.

Chronic RQs exceed the LOC for invertebrates under many of the use scenarios examined. However, reduction in chronic risk does not change the determination for indirect effects.

Based on this evidence, as well as the assumption that esfenvalerate use overlaps all areas in which the CRLF occurs, a "Likely to Adversely Affect" determination is made for the aquatic-phase CRLF as a result of reduction in invertebrate food base.

*5.2.2.3 **Fish and Aquatic-Phase Frogs***

Findings for direct effects to the CRLF extend to other amphibians and fish that may serve as food items for the aquatic-phase CRLF. **Therefore, a "Likely to Adversely Affect" determination is made for indirect effects to the CRLF as a result of losses of amphibian and fish food items.**

*5.2.2.4 **Terrestrial Invertebrates***

When the terrestrial-phase CRLF reaches juvenile and adult stages, its diet is mainly composed of terrestrial invertebrates. Since esfenvalerate is an insecticide, the impact to populations of terrestrial invertebrates is expected to be great enough to cause a reduction in invertebrate food items for the terrestrial-phase CRLF.

The RQs for terrestrial invertebrates on the treated site are presented in Table 5-4 based on residues expected on large and small insects determined from T-REX. In all cases, the RQs exceed the LOC by two orders of magnitude or more. Assuming the default slope and its associated 95% confidence interval, and based on the highest and lowest RQs determined for terrestrial invertebrates, the chance of individual effect is expected to be 100% in all cases. The field study from open literature presents a conclusion that not only is esfenvalerate very toxic, but it also results in avoidance of treated areas by insect pollinators. Therefore, some effects to populations may be mitigated by such behaviors, but they will nonetheless be unavailable for consumption by the CRLF.

Based on the above conclusion of high risk to terrestrial invertebrates, a "Likely to Adversely Affect" determination is made for the terrestrial-phase CRLF based on effects to terrestrial invertebrates that serve as food items.

5.2.2.5 Mammals

Life history data for terrestrial-phase CRLFs indicate that large adult frogs consume terrestrial vertebrates, including mice. A preliminary "may effect" determination was made for indirect effects to the CRLF as a result of losses of mammalian food items for the terrestrial-phase adult.

Based on a default probit slope, the estimated chance of individual effect is presented here using the acute LOC as a threshold value, as well as RQ values. At the LOC, the chance of individual effect is 1 in 294,000 (95% CI = 1 in 44 to 1 in 1 x 10^{16} [limit value, as described above]). At the median RQ (0.27), the chance is 1 in 190 (95% CI = 1 in 7.8 to 1 in 6.5 x 10^{6}). Since the probability of individual effect is relatively high for most uses, esfenvalerate may affect enough individuals to impact the mammalian population present in the CRLF habitat such that its food base is affected. Chronic risk to mammals is also a concern for all uses.

Based on these risks and the assumption that esfenvalerate uses overlap all areas inhabited by the CRLF, a "Likely to Adversely Affect" determination is made for the CRLF due to potential losses of mammalian food based for terrestrial-phase adults from all uses.

5.2.2.6 Terrestrial-Phase Amphibians

Terrestrial-phase adult CRLFs also consume frogs. RQ values representing direct exposures of esfenvalerate to terrestrial-phase CRLFs are used to represent exposures of esfenvalerate to frogs in terrestrial habitats. Since direct effects to the terrestrial-phase CRLF were identified as a result of both acute and chronic risks. **Based on these same conclusions, a "Likely to Adversely Affect" determination is made for the terrestrial-phase CRLF due to potential reduction in the amphibian food base.**

5.2.3 Indirect Effects (via Habitat Effects)

5.2.3.1 Aquatic Plants (Vascular and Non-Vascular)

Aquatic plants serve several important functions in aquatic ecosystems. Non-vascular aquatic plants are primary producers and provide the autochthonous energy base for aquatic ecosystems. Vascular plants provide structure, rather than energy, to the system, as attachment sites for many aquatic invertebrates, and refugia for juvenile organisms, such as fish and frogs. Emergent plants help reduce sediment loading and provide stability to near-shore areas and lower streambanks. In addition, vascular aquatic plants are important as attachment sites for egg masses of CRLFs.

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production are assessed quantitatively using RQs from freshwater aquatic vascular and non-vascular plant data. These data are not available for esfenvalerate; however, information has been presented above that lead to a conclusion that effects are not expected to aquatic plants. Based on qualitative information presented in field and mesocosm studies, effects to aquatic plants are not expected. **Therefore, a determination of "Not Likely to Adversely Affect" is made for indirect effects to the CRLF via effects on habitat provided by aquatic plants.**

*5.2.3.2 **Terrestrial Plants***

Terrestrial plants serve several important habitat-related functions for the CRLF. In addition to providing habitat and cover for invertebrate and vertebrate prey items of the CRLF, terrestrial vegetation also provides shelter for the CRLF and cover from predators while foraging. Upland vegetation including grassland and woodlands provides cover during dispersal. Riparian vegetation helps to maintain the integrity of aquatic systems by providing bank and thermal stability, serving as a buffer to filter out sediment, nutrients, and contaminants before they reach the watershed, and serving as an energy source.

Guideline toxicity tests with terrestrial plants are not available for esfenvalerate. However, based on qualitative information presented in open literature as discussed above, effects to terrestrial plants are not expected. Additionally, since the mechanism of action of type two pyrethroids is to act on neuronal transmission, esfenvalerate is not expected to have high toxicity to plants. **Therefore, a "Not Likely to Adversely Affect" determination is made for indirect effects to the CRLF as a result of reduction in terrestrial plants that serve as riparian and upland habitat for the CRLF.**

5.2.4 Modification of Designated Critical Habitat

Since risks to plants are not being assessed quantitatively, risk conclusions for designated critical habitat are the same as those for indirect effects.

5.3 Risk Hypotheses Revisited

Table 5-7 below revisits the risk hypotheses presented in section 2.9.1. The risk hypotheses were accepted or rejected in accordance with the "Likely to Adversely Affect," or "Not Likely to Adversely Affect" findings in this assessment.

Table 5-7. Risk Hypothesis Revisited

Risk Hypothesis	Conclusions
Labeled uses of esfenvalerate within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity	Accepted for aquatic phase. "Likely to Adversely Affect" finding. Accepted for terrestrial phase. "Likely to

Risk Hypothesis	Conclusions
	Adversely Affect" finding.
Labeled uses of esfenvalerate within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply	Accepted for aquatic phase. "Likely to Adversely Affect" finding. Accepted for terrestrial phase. "Likely to Adversely Affect" finding.
Labeled uses of esfenvalerate within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover	Rejected. "Not Likely to Adversely Affect" finding for terrestrial plants.
Labeled uses of esfenvalerate within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat	Rejected. "Not Likely to Adversely Affect" finding for aquatic plants.
Labeled uses of esfenvalerate within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation)	Rejected. "Not Likely to Adversely Affect" finding for aquatic and terrestrial plants.
Labeled uses of esfenvalerate within the action area may adversely modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs	Accepted for aquatic and terrestrial phase. "Likely to Adversely Affect" finding for prey.
Labeled uses of esfenvalerate within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance	Accepted for aquatic and terrestrial phase. "Likely to Adversely Affect" finding for indirect effect via effects on food.
Labeled uses of esfenvalerate within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	Accepted. Presence of esfenvalerate in terrestrial habitat is believed to have direct and indirect effects on CRLF.
Labeled uses of esfenvalerate within the action area may adversely modify the designated critical habitat of the	Accepted. "Likely to Adversely Affect" finding for indirect effect via effects on

Risk Hypothesis	Conclusions
CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs	food.

6.0 Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

The screening-level risk assessment focuses on characterizing potential ecological risks resulting from a maximum use scenario, which is determined from labeled statements of maximum application rate and number of applications with the shortest time interval between applications. The frequency at which actual uses approach this maximum use scenario may be dependant on pest resistance, timing of applications, cultural practices, and market forces.

6.1.2 Aquatic Exposure Modeling of Esfenvalerate

The standard ecological water body scenario (EXAMS pond) used to calculate potential aquatic exposure to pesticides is intended to represent conservative estimates, and to avoid underestimations of the actual exposure. The standard scenario consists of application to a 10-hectare field bordering a 1-hectare, 2-meter deep (20,000 m^3) pond with no outlet. Exposure estimates generated using the EXAMS pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and lower order streams. As a group, there are factors that make these water bodies more or less vulnerable than the EXAMS pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher peak EECs than the EXAMS pond. These water bodies will be either smaller in size or have larger drainage areas. Smaller water bodies have limited storage capacity and thus may overflow and carry pesticide in the discharge, whereas the EXAMS pond has no discharge. As watershed size increases beyond 10-hectares, it becomes increasingly unlikely that the entire watershed is planted with a single crop that is all treated simultaneously with the pesticide. Headwater streams can also have peak concentrations higher than the EXAMS pond, but they likely persist for only short periods of time and are then carried and dissipated downstream.

The Agency acknowledges that there are some unique aquatic habitats that are not accurately captured by this modeling scenario and modeling results may, therefore, under- or over-estimate exposure, depending on a number of variables. For example, aquatic-phase CRLFs may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than the EXAMS pond. The Agency does not currently have sufficient information regarding the hydrology of these aquatic habitats to develop a specific alternate scenario for the CRLF. CRLFs prefer habitat with perennial (present year-round) or near-perennial water and do not frequently inhabit vernal (temporary) pools because conditions in these habitats are generally not suitable (Hayes and Jennings 1988). Therefore, the EXAMS pond is assumed to be representative of exposure to aquatic-phase CRLFs. In addition, the Services agree that the existing EXAMS pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004).

In general, the linked PRZM/EXAMS model produces estimated aquatic concentrations that are expected to be exceeded once within a ten-year period. The Pesticide Root Zone Model is a process or “simulation” model that calculates what happens to a pesticide in an agricultural field on a day-to-day basis. It considers factors such as rainfall and plant transpiration of water, as well as how and when the pesticide is applied. It has two major components: hydrology and chemical transport. Water movement is simulated by the use of generalized soil parameters, including field capacity, wilting point, and saturation water content. The chemical transport component can simulate pesticide application on the soil or on the plant foliage. Dissolved, adsorbed, and vapor-phase concentrations in the soil are estimated by simultaneously considering the processes of pesticide uptake by plants, surface runoff, erosion, decay, volatilization, foliar wash-off, advection, dispersion, and retardation.

Uncertainties associated with each of these individual components add to the overall uncertainty of the modeled concentrations. Model inputs from the soil degradation studies represent the upper confidence bound on the mean values that are not expected to be exceeded in the environment approximately 90 percent of the time. No aerobic or anaerobic aquatic metabolism studies were available for esfenvalerate. A default input parameter of twice the soil metabolism half-life was used. For aerobic aquatic metabolism, representing esfenvalerate persistence in the water column, this was twice the upper 90th percent bound on the mean (138 days), or 276 days. For anaerobic aquatic metabolism, representing esfenvalerate persistence in sediment, this was twice the anaerobic aquatic metabolism half-life (3 times the single value of 77 days, 231 days), or 462 days. Such default inputs increase the uncertainty in aquatic exposure estimates, particularly chronic exposures and exposures in sediment.

Mobility input values are chosen to be representative of conditions in the environment. The natural variation in soils adds to the uncertainty of modeled values. Factors such as application date, crop emergence date, and canopy cover can also affect estimated concentrations, adding to the uncertainty of modeled values. Factors within the ambient environment such as soil temperatures, sunlight intensity, antecedent soil moisture, and surface water temperatures can cause actual aquatic concentrations to differ for the modeled values.

The aquatic exposure estimates account for the effect of labeled spray drift setbacks (450-foot buffers for aerial ULV applications; 25-foot buffers for ground applications) on the fraction of esfenvalerate reaching the water body as a result of drift. However, it did not account for the effect of the setback on the amount of esfenvalerate that would reach the water body in runoff (primarily sorbed to sediment). While the Agency would expect that the increased distance between the field of application and the water body would result in less loads for a pesticide such as esfenvalerate that is primarily transported on sediment, the amount or reduction cannot be quantified. Unlike spray drift, tools are currently not available to evaluate the effectiveness of a vegetative setback on runoff and loadings. The effectiveness of vegetative setbacks is highly dependent on the condition of the vegetative strip. For example, a well-established, healthy vegetative setback can be a very effective means of reducing runoff and erosion from agricultural fields. Alternatively, a setback of poor vegetative quality or a setback that is channelized can be ineffective at reducing loadings. Until such time as a quantitative method to estimate the effect of vegetative setbacks on various conditions on pesticide loadings becomes available, the aquatic exposure predictions are likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

6.1.3 Action Area Uncertainties

This assessment differs from other assessments for the CRLF in that extensive mapping was not used to define the action area. Instead, because the use patterns allowed on esfenvalerate labels result in the potential for it to be used anywhere in the state of California, it was assumed that the action area represented the entire state. Some areas may be excluded; however, usage data are not sufficient to determine the location of such areas, and no areas are listed for exclusion on the labels. Therefore, it is expected that the action area may be overestimated; however, this assumption is expected to be conservative and thus protective of the CRLF.

6.1.4 Usage Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. Four years of data (2002 – 2005) were included in this analysis because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was provided by CDPR for these years only. No methodology for removing outliers was provided by CDPR for 2001 and earlier pesticide data; therefore, this information was not included in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been canceled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide usage data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

6.1.5 Terrestrial Exposure Modeling of Esfenvalerate

The Agency relies on the work of Fletcher et al. (1994) for setting the assumed pesticide residues in wildlife dietary items. These residue assumptions are believed to reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify. It is important to note that the field measurement efforts used to develop the Fletcher estimates of exposure involve highly varied sampling techniques. It is entirely possible that much of these data reflect residues averaged over entire above ground plants in the case of grass and forage sampling.

It was assumed that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy differences. Direct comparison of a laboratory dietary concentration-based effects threshold to a fresh-weight pesticide residue estimate would result in an underestimation of field exposure by food consumption by a factor of 1.25 – 2.5 for most food items.

Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods do not account for a potentially important aspect of food requirements. Depending upon species and dietary matrix, bird assimilation of wild diet energy ranges from 23 – 80%, and mammal's assimilation ranges from 41 – 85% (U.S. Environmental Protection Agency, 1993). If it is assumed that laboratory chow is formulated to maximize assimilative efficiency (e.g., a value of 85%), a potential for underestimation of exposure may exist by assuming that consumption of food in the wild is comparable with consumption during laboratory testing. In the screening process, exposure may be underestimated because metabolic rates are not related to food consumption.

For the terrestrial exposure analysis of this risk assessment, a generic bird or mammal was assumed to occupy either the treated field or adjacent areas receiving a treatment rate on the field. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the modeled treatment area. Spray drift model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field exclusively and permanently.

6.1.6 Spray Drift Modeling

Spray drift modeling was not used as extensively in this assessment as in other CRLF assessments, due to the fact that esfenvalerate is expected to be used in all areas occupied by the CRLF. However, it has been used to characterize the role of drift in exposure to aquatic and terrestrial organisms as described in Section 2.0. The uncertainties associated with use of spray drift modeling are included below.

It is unlikely that the same organism would be exposed to the maximum amount of spray drift from every application made. In order for an organism to receive the maximum concentration of esfenvalerate from multiple applications, each application of esfenvalerate would have to occur under identical atmospheric conditions (e.g., same wind speed and same wind direction) and (if it is an animal) the animal being exposed would have to be located in the same location (which receives the maximum amount of spray drift) after each application. Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT model (*i.e.*, it models spray drift from aerial and ground applications in a flat area with little to no ground cover and a steady, constant wind speed and direction). Therefore, in most cases, the drift estimates from AgDRIFT may overestimate exposure, especially as the distance increases from the site of application, since the model does not account for potential obstructions (*e.g.*, large hills, berms, buildings, trees, *etc*.). Furthermore, conservative assumptions are made regarding the droplet size distributions being modeled ('ASAE Very Fine to Fine' for orchard uses and 'ASAE Very Fine' for agricultural uses), the application method (*i.e.*, aerial), release heights and wind speeds. Alterations in any of these inputs would decrease the area of potential effect.

6.2 Effects Assessment Uncertainties

6.2.1 Age Class and Sensitivity of Effects Thresholds

It is generally recognized that test organism age may have a significant impact on the observed sensitivity to a toxicant. The acute toxicity data for fish are collected on juvenile fish between 0.1 and 5 grams. Aquatic invertebrate acute testing is performed on recommended immature age classes (e.g., first instar for daphnids, second instar for amphipods, stoneflies, mayflies, and third instar for midges).

Testing of juveniles may overestimate toxicity at older age classes for pesticide active ingredients that act directly without metabolic transformation because younger age classes may not have the enzymatic systems associated with detoxifying xenobiotics. In so far as the available toxicity data may provide ranges of sensitivity information with respect to age class, this assessment uses the most sensitive life-stage information as measures of effect for surrogate aquatic animals, and is therefore, considered as protective of the CRLF.

6.2.2 Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on esfenvalerate are not available for frogs or any other aquatic-phase amphibian; therefore, freshwater fish are used as surrogate species for aquatic-phase amphibians. Although no data are available for esfenvalerate, the available open literature information on esfenvalerate toxicity to aquatic-phase amphibians shows that acute ecotoxicity endpoints for aquatic-phase amphibians are generally about 24 times less sensitive than freshwater fish. Therefore, endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase amphibians including the CRLF, and extrapolation of the risk conclusions from the most sensitive tested species to the aquatic-phase CRLF is likely to overestimate the potential risks to those species. Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency's LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

6.2.3 Sublethal Effects

When assessing acute risk, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the assessment is exercised on a case-by-case basis and only after careful consideration of the nature of the sublethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sublethal endpoint) and the assessment endpoints.

Sublethal effects to several organisms were discussed in Section 4.0. Reduction in feeding activity, reduced body size, and reduced brood size were observed in open literature studies on *Daphnia*. Reductions in motor function were also observed in laboratory rats. To the extent to which sublethal effects are not considered in this assessment, the potential direct and indirect effects of esfenvalerate on CRLF may be underestimated.

6.2.4 Location of Wildlife Species

For the terrestrial exposure analysis of this risk assessment, a generic bird or mammal was assumed to occupy either the treated field or adjacent areas receiving a treatment rate on the field. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the modeled treatment area. Spray drift model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field exclusively and permanently.

7.0 Risk Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this endangered species risk assessment represents the best data currently available to assess the potential risks of esfenvalerate to the CRLF and its designated critical habitat.

Based on the best available information, the Agency makes a Likely to Adversely Affect determination for the CRLF from the use of esfenvalerate. Additionally, the Agency has determined that there is the potential for modification of CRLF designated critical habitat from the use of the chemical. All uses of esfenvalerate are expected to affect the CRLF and its critical habitat in both its aquatic and terrestrial phases. Buffers included on the label are not sufficient to protect the CRLF or its potential vertebrate and invertebrate food items from exposure that is high enough to cause acute or chronic effects. This assessment does not include extensive mapping of estimated areas in which exposure to the CRLF is expected; instead, since esfenvalerate use can occur anywhere in the state of California, it is assumed that use of esfenvalerate occurs in all areas occupied by the CRLF.

A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat, given the uncertainties discussed in Section 6.0, is presented in Table 7-1. Since plant risks were not quantitatively assessed, effects to Designated Critical Habitat are expected to be the same as for indirect effects to the CRLF.

Table 7-1. Effects Determination Summary for Direct and Indirect Effects of Esfenvalerate on the CRLF.

Assessment Endpoint	Effects Determination[1]	Basis for Determination
	Aquatic-Phase CRLF (Eggs, Larvae, and Adults)	
Direct Effects: Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	Likely to Adversely Affect	Acute RQs exceed the LOC for direct effects to the CRLF for all uses and application rates. Uses that require high numbers of applications, regardless of their maximum single application rate, also result in direct chronic risk to the aquatic-phase CRLF. Probability of individual effect was determined to be high based on RQs. Incidents indicate potential for mortality with exposure to runoff following labeled uses. Exposure is expected in all areas occupied by CRLF.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants, fish, and frogs)	Freshwater invertebrates, fish, and other amphibians: Likely to Adversely Affect	Acute RQs for aquatic invertebrates, fish, and other amphibians exceed the LOC for aquatic animals for all uses and application rates. The probability of mortality is high for aquatic invertebrates and fish. Uses that require high numbers of applications also result in chronic risk to these taxa.
	Non-vascular aquatic plants: Not Likely to Adversely Affect	Indirect effects resulting from losses of aquatic vascular and non-vascular plants as a food source are not expected due to qualitative conclusion of low likelihood of effects. Based on information gathered in a mesocosm study submitted to OPP and from the field studies described

Assessment Endpoint	Effects Determination[1]	Basis for Determination
		above, it appears that risk to aquatic plants is low.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	Vascular and Non-vascular aquatic plants: Not Likely to Adversely Affect	EFED does not have aquatic plant toxicity data to estimate the risk to plants; however, indirect effects resulting from losses of aquatic vascular and non-vascular plants as a food source are not expected due to qualitative conclusion of low likelihood of effects. Based on information gathered in a mesocosm study submitted to OPP and from the field studies described above, it appears that risk to aquatic plants is low.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	Not Likely to Adversely Affect	EFED does not have aquatic plant toxicity data to estimate the risk to plants; however, based on studies in available in the ECOTOX database, effects on terrestrial plants are expected to be unlikely.
Terrestrial-Phase CRLF (Juveniles and adults)		
Direct Effects: Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Likely to Adversely Affect	Acute risk to the CRLF has been identified for uses requiring numerous applications of 0.05 lbs ai/acre (forestry uses – 25 apps/year), multiple applications at 0.075 lbs ai/acre and 0.1 lbs ai/acre, or single applications at higher rates. Probability of individual effect is expected to be high. Chronic risk is also expected for these and possibly other uses; however, data are not available to quantify risk and determine which uses result in chronic risk. Therefore, a conservative conclusion is made that chronic risk may result from all uses. Overlap of esfenvalerate use is expected in all areas occupied by the CRLF.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	Terrestrial invertebrates: Likely to Adversely Affect	RQs exceed the LOCs for small and large insects in all cases and probability of individual effect is high. Overlap of use is expected for all areas occupied by the CRLF.
	Mammals: Likely to Adversely Affect	RQs exceed the acute LOC for all but one use; probability of individual effect is high; RQs exceed the chronic LOC for all uses. Overlap of use is expected for all areas occupied by the CRLF.
	Frogs: Likely to Adversely Affect	Since this conclusion was drawn for direct effects to the CRLF, risk is also presumed for other amphibians.
Indirect Effects and Effects to Critical Habitat: Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	Not Likely to Adversely Affect	EFED does not have aquatic plant toxicity data to estimate the risk to plants; however, based on studies in available in the ECOTOX database, effects on terrestrial plants are expected to be unlikely.

8.0 References

Adelsbach, T. L. and R.S. Tjeerdema. 2003. Chemistry of fenvalerate and esfenvalerate. Reviews of Environmental Contamination and Toxicology 176: 137-154.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. Toxicological Profile for Pyrethrins and Pyrethroids. U. S. Department of Health and Human Services, September 1993. Available online at http://www.atsdr.cdc.gov/toxprofiles/tp155.html#bookmark08 (accessed on December 1, 2007).

Altig, R. and R.W. McDiarmid. 1999. Body Plan: Development and Morphology. In R.W. McDiarmid and R. Altig (Eds.), Tadpoles: The Biology of Anuran Larvae. University of Chicago Press, Chicago. pp. 24-51.

Alvarez, J. 2000. Letter to the U.S. Fish and Wildlife Service providing comments on the Draft California Red-legged Frog Recovery Plan.

Bintein, S. Devillers, J, and W. Karcher. 1993. Nonlinear dependence of fish bioconcentration on n-Octanol/water partition coefficients. SAR and QSAR in Env. Res. 1: 29-39.

Bouldin, J.L., C.D. Milam, J.L. Farris, M.T. Moore, S. Smith Jr., and C.M. Cooper. 2004. Evaluating toxicity of Asana XL (esfenvalerate) amendments in agricultural ditch mesocosms. Chemosphere 56:677-683. ECOTOX Reference # 89542.

Castle S., K. Shepler, and L.O. Ruzo. 1990. Photodegradation of [14] esfenvalerate in/on soil surface by natural sunlight. Performed by Pharmacology and Toxicology Research Laboratory, Richmond, CA for E.I. du Pont de Nemours and Company. MRID 41728501.

Castle S., K. Shepler, and L.O. Ruzo. 1990. Field soil dissipation studies of esfenvalerate – a 1990 study dated 11/10/1989. Performed by Bioanalytika Laboratories, Raleigh, NC and E.I. du Pont de Nemours and Company. MRID 41728502.

Comb, A. 2002. Esfenvalerate (pure grade): Physico-chemical properties. Project Number: VFX013/022699. Unpublished study prepared by Huntingdon Life Sciences, Ltd. and submitted for LG Chemical Investment, Ltd. MRID 46725304.

Crawshaw, G.J. 2000. Diseases and Pathology of Amphibians and Reptiles *in:* Ecotoxicology of Amphibians and Reptiles; ed: Sparling, D.W., G. Linder, and C.A. Bishop. SETAC Publication Series, Columbia, MO.

Day, K., and N. K. Kaushik. 1987. An assessment of the chronic toxicity of the synthetic pyrethroid, fenvalerate, to Daphnia galeata mendotae, using life tables. Environ. Pollut. 44:13-26. ECOTOX reference #12714.

DiToro, D. M., Zarba, C. S., Hansen, D. J., Berry, W. J., Schwartz, R. C., Cowan, C. E., Pavlou, S. P., Allen, H. E., Thomas, N. A., and R. R. Paquin. 1991. Technical Basis for establishing sediment quality criteria for nonionic organic chemicals using equilibrium partitioning. Environmental Toxicology & Chemistry 10: 1541-1586.

Dynamac Corporation. 1986. Summary of the contribution of all studies that have been reviewed to date towards the fulfillment of data requirements. Contract No. 68-01-6679. March 18, 1986.

Dynamac Corporation. 1988. Fenvalerate addendum. Task 1: Review and evaluation of individual studies. Contract No. 68-02-4250. March 9, 1988. Review of Stevenson, I. 1987. Photodegradation of (chlorophenyl (U)-(Carbon 14)(DPX-GB800 in Water at pH 5: Laboratory Project ID: AMR-868-87. Unpubublished study prepared by E. I. du Pont de Nemours & Co.

European Commission. 2005. Review report for the active substance esfenvalerate. European Commission: Directorate-General Health & Consumer Protection. Available online at http://ec.europa.eu/food/plant/protection/evaluation/existactive/list1-15_en.pdf (accessed on November 30, 2007).

Eisler, R. 1992. Fenvalerate Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service, Washington, DC. Biological Report No 85(2). Available online at http://www.pwrc.usgs.gov/infobase/eisler/CHR_24_Fenvalerate.pdf (accessed on January 11, 2008).

Fellers, G. M., et al. 2001. Overwintering tadpoles in the California red-legged frog (*Rana aurora draytonii*). Herpetological Review, 32(3): 156-157.

Fellers, G.M, L.L. McConnell, D. Pratt, S. Datta. 2004. Pesticides in Mountain Yellow-Legged Frogs (*Rana mucosa*) from the Sierra Nevada Mountains of California, USA. Environmental Toxicology & Chemistry 23 (9):2170-2177.

Fellers, Gary M. 2005a. *Rana draytonii* Baird and Girard 1852. California Red-legged Frog. Pages 552-554. *In*: M. Lannoo (ed.) Amphibian Declines: The Conservation Status of United States Species, Vol. 2: Species Accounts. University of California Press, Berkeley, California. (http://www.werc.usgs.gov/pt-reyes/pdfs/Rana%20draytonii.PDF)

Fellers, Gary M. 2005b. California red-legged frog, *Rana draytonii* Baird and Girard. Pages 198-201. *In*: L.L.C. Jones, et al (eds.) Amphibians of the Pacific Northwest.

Fletcher J.S., Nellessen, J. E. and T. G. Pfleeger. 1994. Literature Review and Evaluation of the EPA Food-chain (Kenaga) Nomogram, an Instrument for Estimating Pesticide Residues on Plants. Environmental Toxicology and Chemistry, 13:9 (1383-1391).

Foreman, B., and B. Gilliom. 1997. Changes in Reporting Levels and Data Qualifiers for Selected Pesticides and Degradation Products in Schedules 2050 and 2051. USGS

National Water Quality Laboratory Technical Memorandum 98.03S. December 8, 1997. http://nwql.usgs.gov/Public/tech_memos/sup_nwql.98-03S.html

Gaddamidi, V and S. Bookhard. 1992. Anaerobic soil metabolism of esfenvalerate: Lab Project Number: DUPONT-3438. Unpublished study prepared by E.I. du Pont de Nemours and Company. MRID 42396801.

Ghosh, T. K. 1990. Biochemical changes induced by the insecticide fenvalerate in the male gonads of albino rat. Environment and Ecology 8(1):63-67. ECOTOX reference #92573.

Gobas, F. A.P.C., and H. A. Morrison. Chapter 9. Bioconcentration and Biomagnification in the Aquatic Environment. In *Handbook of Property Estimation Methods for Chemicals;* R. S. Boethling, D. Mackay, Eds.; Lewis Publishers: Boca Raton, 2000, 189-227.

Graebing, P. and J. S. Chib. Soil photolysis in a moisture-and temperature-controlled environment. 2. insecticides. Journal of Agricultural and Food Chemistry 52: 2606-2614.

Greulich, K. and S. Pflugmacher. 2003. Differences in susceptibility of various life stages of amphibians to pesticide exposure. Aquatic Toxicology 65: 329-336.

Hayes, M. P., and M. R. Jennings. 1988. Habitat correlates of distribution of the California red-legged frog (*Rana aurora draytonii*) and the foothill yellow-legged frog (*Rana boylii*): Implications for management. Pages 144-158 In: R. Sarzo, K. E. Severson, and D. R. Patton (technical coordinators). Proceedings of the Symposium on the Management of Amphibians, Reptiles, and small mammals in North America. U.S.D.A. Forest Service General Technical Report RM-166.

Hayes, M.P. and M.M. Miyamoto. 1984. Biochemical, behavioral and body size differences between *Rana aurora aurora* and *R. a. draytonii*. Copeia 1984(4): 1018-22.

Hayes and Tennant. 1985. Diet and feeding behavior of the California red-legged frog. The Southwestern Naturalist 30(4): 601-605.

Hoerger, F. and E. E. Kenaga. 1972. Pesticide residues on plants; Correlation of representative data as a basis for estimation of their magnitude in the environment. In. F. Coulston and F. Korte, Eds., Environmental Quality and Safety: Chemistry, Toxicology, and Technology. Georg Thieme Publishers, Stuttgart, West Germany, pp. 9-28.

Holmstead, R. L., Fullmer, D. G., and L. O. Ruzo. 1978. Pyrethroid photodecomposition: Pydrin. J. Agric. Food. Chem. 26(4): 954-959.

Houston, C.K. 1978. Dissipation of SD43775 in undisturbed soil receiving fifteen ground spray applications of SD 43775 to cotton, a Louisiana study. TIR-24-391-78. Acc. No. 243109.

Jennings, M.R. and M.P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): The inducement for bullfrog (*Rana catesbeiana*) introduction. Herpetological Review 31(1): 94-103.

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Report prepared for the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. 255 pp.

Jennings, M.R., S. Townsend, and R.R. Duke. 1997. Santa Clara Valley Water District California red-legged frog distribution and status – 1997. Final Report prepared by H.T. Harvey & Associates, Alviso, California. 22 pp.

Johansson, M., H. Piha, H. Kylin, and J. Merila. 2006. Toxicity of six pesticides to common frog (*Rana temporaria*) tadpoles. Environ. Toxicol. Chem. 25:3164-3170. ECOTOX Reference # 88266.

Jones, R.D. 2002. Chemical properties of the pyrethroid insecticides to support surface water modeling. EPA Office of Pesticide Programs, Environmental Fate and Effects Division.

Katagi, T. 1991. Photodegradation of the pyrethroid insecticide esfenvalerate on soil, clay minerals, and humic acid surfaces. Journal of Agricultural and Food Chemistry 39: 1351-1356.

Katagi, T. 1993. Photodegradation of esfenvalerate in clay suspensions. Journal of Agricultural and Food Chemistry 41: 2178-2183.

Kelley, K. 2007. Environmental fate of esfenvalerate. Department of Pesticide Regulation. California Environmental Protection Agency. Sacramento, CA.

Kupferberg, S. 1997. Facilitation of periphyton production by tadpole grazing: Functional differences between species. Freshwater Biology 37:427-439.

Kupferberg, S.J., J.C. Marks and M.E. Power. 1994. Effects of variation in natural algal and detrital diets on larval anuran (*Hyla regilla*) life-history traits. Copeia 1994:446-457.

Laskowski, D.A. 2002. Physical and chemical properties of pyrethroids. Reviews of Environmental Contamination and Toxicology 174: 49-170.

Lee, P.W., S. M. Sterns, and W. R. Powell. 1985. Comparative aerobic soil metabolism of SD 43775 (racemic) and SD 47443 (A-alpha). Unpublished report MO-RIR-22-011-85 submitted by Shell Development Company, Modesto, CA. Acc. No. 258842. MRID 00146578.

Lee, P.W. 1989. Hydrolysis of [Chlorophenyl-14C] DPX-GB800 in buffer solutions of pH 5, 7, and 9. Unpublished study submitted by E.I. du Pont de Nemours and Co., Inc., Wilmington, DE. Laboratory Project ID AMR-1185-88. MRID 40999303.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, J.N. Seiber. 1999. Summertime Transport of Current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range, USA. Environmental Toxicology & Chemistry 18(12): 2715-2722.

Materna E. J., C. F. Rabeni, and T. W. LaPoint. 1995. Effects of the synthetic pyrethroid insecticide, esfenvalerate, on larval leopard frogs (*Rana* spp.). Environ. Toxicol. Chem. 14(4):643-622. ECOTOX Reference # 15117.

McConnell, L.L., J.S. LeNoir, S. Datta, J.N. Seiber. 1998. Wet deposition of current-use pesticides in the Sierra Nevada mountain range, California, USA. Environmental Toxicology & Chemistry 17(10):1908-1916.

Merritt, R. L. 1992. Leaching studies of SD 43775 and selected reference pesticides by soil thin-layer chromatography. Performed by Nelson Laboratories, Stockton, CA. Unpublished study submitted by E. I. dupont de Nemours and Laboratories. MRID 42350201.

Moniz, A. C. , P. E. Cruz-Casallas, C. A. Oliveira, A. Lucisano, J. C. Florio, A. A. Nicolau, H. S. Spinosa, and M. M. Bernardi. 1999. Perinatal fenvalerate exposure: behavioral and endocrinology changes in male rats. Neurotoxicology and Teratology 21(5):611-618. ECOTOX reference #92486.

Moniz, A. C., P. E. Cruz-Casallas, S. A. Salzbeger, F. M. F. Varoli, H. S. Spinsoa, and M. M. Bernardi. 2005. Behavioral and endocrine changes induced by perinatal fenvalerate exposure in female rats. Neurotoxicology and Teratology 27:609-614. ECOTOX reference #92485.

Ohm, M. 2001. Adsorption/Desorption of (Carbon 14)-esfenvalerate at a single concentration in six soils: Lab Project Number: DUPONT-3438. Unpublished study prepared by E.I. du Pont de Nemours and Company. MRID 45555102.

Oshima, M and N. Mikami. 1991. Accumulation and metabolism of 14C-esfenvalerate in carp (*Cyprinus carpio*). Performed by Environmental Health Science Laboratory, Sumitomo Chemical Co., Hyogo, Japan for E.I. du Pont de Nemours and Company, Inc., Wilmington, DE. MRID 42170501.

Oshima, M. and G. Schneiders. 1993. Accumulation of (carbon14) esfenvalerate in Carp (*Cyprinus carpio*): Lab project number: AMR 2192-91: LLM-10-0031. Unpublished study prepared by Environmental Health Science Lab., Sumitomo Chemical co., Ltd. MRID 42922401. Accepted 11/29/1994.

Pieters, B. J., A. Paschke, S. Reynaldi, M. H. S. Kraak, W. Admiraal, and M. Liess. 2005. Influence of food limitation on the effects of fenvalerate pulse exposure on the life history and population growth rate of Daphnia magna. Environ. Toxicol. Chem. 24(9):2254-2259. ECOTOX reference #87183.

Porter, P.E. 19?? Sorption of SD 43775 on soils. TIR-14-101-77. Acc. No. 09685.

Rathburn, G.B. 1998. *Rana aurora draytonii* egg predation. Herpetological Review, 29(3): 165.

Reis, D.K. Habitat characteristics of California red-legged frogs (*Rana aurora draytonii*): Ecological differences between eggs, tadpoles, and adults in a coastal brackish and freshwater system. M.S. Thesis. San Jose State University. 58 pp.

Reynaldi, S., S. Duquesne, K. Jung, and M. Liess. 2006. Linking feeding activity and maturation of *Daphnia magna* following short-term exposure to fenvalerate. Environmental Toxicology and Chemistry 25(7):1826-1830. ECOTOX reference #92483.

Roberts, B. L., and H. W. Dorough. 1984. Relative toxicities of chemicals to the earthworm *Eisenia foetida*. Env. Tox. Chem. 3:67-78. ECOTOX reference #40531.

Samsoe-Petersen, L., K. Gustavson, T. Madsen, B. B. Mogensen, P. Lassen, K. Skjernov, K. Christoffersen, and E. Jorgensen. 2001. Fate and effects of esfenvalerate in agricultural ponds. Environmental Toxicology and Chemistry 20(7): 1570-1578.

Seale, D. B., and N. Beckvar. 1980. The comparative ability of anuran larvae (genera: *Hyla*, *Bufo***,** and *Rana*) to ingest suspended blue-green algae. Copeia 1980: 495-503.

Solomon, K. R., Giddings, J. M., and S. J. Maund. 2001. Probabilistic risk assessment of cotton pyrethroids: I. Distributional analyses of laboratory aquatic toxicity data. Environmental Toxicology & Chemistry 20(3): 652-659.

Sparling, D.W., G.M. Fellers, L.L. McConnell. 2001. Pesticides and amphibian population declines in California, USA. Environmental Toxicology & Chemistry 20(7): 1591-1595.

Stevenson, I. E. 1987. Photodegradation of [chlorophenyl(U)-14C}DPX-GB800 in water at pH 5. DuPont Report No. AMR-686-87. Prepared and submitted by E.I. du Pont de Nemours and Company, Inc., Wilmington, DE. MRID 40443801.

Toscano, N. C., F. V. Sances, M. W. Johnson, and L. F. LaPre. 1982. Effect of various pesticides on lettuce physiology and yield. J. Econ. Entom. 75:738-741. ECOTOX reference # 41092.

Urban, D.J. and N.J. Cook. 1986. Hazard Evaluation Division Standard Evaluation Procedure Ecological Risk Assessment. EPA 540/9-85-001. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC.

U.S. Environmental Protection Agency (U.S. EPA). 1993. Wildlife Exposure Factors Handbook. EPA/600/R-13/187a, Office of Research and Development, Washington, DC. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2799 (accessed 1/31/2008).

U.S. EPA. 1998. Guidance for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-95/002F, April 1998.

U.S. EPA. 2003. Technical basis for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: Nonionic organics. EPA-600-R-02-014. Office of Research and Development, Washington, DC. (draft)

U.S. EPA. 2004. Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs. Office of Prevention, Pesticides, and Toxic Substances. Office of Pesticide Programs. Washington, D.C. January 23, 2004.

U.S. EPA. 2006. Risks of Atrazine Use to Federally Listed Endangered Barton Springs Salamanders (*Eurycea sosorum*). Pesticide Effects Determination. Office of Pesticide Programs, Environmental Fate and Effects Division. August 22, 2006.

U.S. Fish and Wildlife Service (USFWS). 1996. Endangered and threatened wildlife and plants: determination of threatened status for the California red-legged frog. Federal Register 61(101):25813-25833.

USFWS. 2002. Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*). Region 1, USFWS, Portland, Oregon. (http://ecos.fws.gov/doc/recovery_plans/2002/020528.pdf)

USFWS. 2006. Endangered and threatened wildlife and plants: determination of critical habitat for the California red-legged frog. 71 FR 19244-19346.

USFWS. Website accessed: 30 December 2006. http://www.fws.gov/endangered/features/rl_frog/rlfrog.html#where

U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 1998. Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. Final Draft. March 1998.

USFWS/NMFS. 2004. 50 CFR Part 402. Joint Counterpart Endangered Species Act Section 7 Consultation Regulations; Final Rule. FR 47732-47762.

Wassersug, R. 1984. Why tadpoles love fast food. Natural History 4/84.

Weston, D.P., J. You, and M.J. Lydy. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. Environ. Sci. Technol. 38:2752-2759.

Willis, G. H. and L.L. McDowell. 1987. Pesticide persistence on foliage. Reviews of Environmental Contamination and Toxicology 100: 23–73.