Risks of Oxyfluorfen Use to the Federally Threatened California Red-legged Frog
(*Rana aurora draytonii*)

Pesticide Effects Determination

Environmental Fate and Effects Division
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1. 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 oxyfluorfen 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 (USEPA 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.

Oxyfluorfen is an herbicide used for broad spectrum pre- and post-emergent control of annual broadleaf and grassy weeds in a variety of tree fruit, nut, vine, and field crops. Two of the largest agricultural markets in terms of total pounds active ingredient are almonds and wine grapes. There are also nonagricultural ornamental and forestry uses. Oxyfluorfen is also used for weed control in landscapes, patios, driveways, and similar areas at residential sites. Oxyfluorfen can be applied as a liquid formulation via ground sprayer, banded application, or aerial broadcast. It can also be applied as a granular formulation, which is common for ornamental nursery uses. Oxyfluorfen must not be incorporated into the soil for effective treatment. There are several ready-to-use products as well as a liquid concentrate available for residential use.

Oxyfluorfen is a diphenyl-ether, one of a class of herbicides sometimes referred to as light-dependent peroxidizing herbicides (LDPHs), which have enhanced toxicity in the presence of solar ultra-violet (UV) radiation. Oxyfluorfen inhibits the enzyme protoporphyrin-III oxidase, whose function is to catalyze the formation of protoporphyrin IX. Protoporphyrin IX is a precursor molecule common to both plants and animals. In plants, it is a step in chlorophyll biosynthesis, and in animals, it is a step in hemoglobin biosynthesis. Other herbicides in this group include acifluorfen, lactofen, nitrofen, and fomesafen. Because toxicity of the LDPHs is affected by the presence of UV radiation, toxicity tests conducted under standard laboratory lighting conditions, which generally only include visible light, may underestimate the toxicity of oxyfluorfen to some taxa.

An analysis of oxyfluorfen use results in our determination that those relevant to the CRLF and considered part of the federal action evaluated in this assessment include the following agricultural uses: avocado, broccoli, cabbage, cauliflower, horseradish, leafy vegetables, garlic, cucurbit vegetables, cantaloupe, watermelons, squash, olive, potato, root and tuber vegetables, artichoke, carrot, celery, fruiting vegetables, pepper, dried-type beans, legume vegetables, strawberry, safflower, cereal grains, grapes, almond, beechnut, Brazil nut, butternut, cashew, chestnut, chinquapin, filbert, hickory nut, jojoba, macadamia nut, pecan, pistachio, tree nuts, walnut, calamondin, citron, citrus, citrus hybrids, grapefruit, kiwi fruit, kumquat, lemon, lime, orange, pummelo, tangelo, tangerines, cotton, apple, apricot, cherry, crabapple, date, feijoa, fig, unspecified fruits, loquat, mayhaw, nectarine, peach, pear, persimmon, plum, pomegranate, prune, quince, grapes, lettuce, onion, tomato, clover, sugarbeet, deciduous fruit trees, peppermint, and spearmint.

In addition, the following specific non-food and non-agricultural uses are considered: Christmas tree plantations, conifers, cottonwood, forest trees, commercial storage/warehouses/premises, industrial areas (outdoor), non-agricultural outdoor buildings/structures, agricultural uncultivated areas, intermittently flooded areas/waters, mulch, paved areas (private roads/sidewalks), paths/patios, fencerows/hedgerows, non-agricultural right-of-ways/fencerows/hedgerows, airports/landing fields, non-agricultural uncultivated areas/soils, ornamental lawns and turf, nursery stock, conifers (seed orchard), ornamental and/or shade trees, ornamental ground cover, ornamental herbaceous plants, ornamental nonflowering plants, and ornamental woody shrubs and vines.

The major route of oxyfluorfen dissipation is aqueous photolysis. The chemical appears to have low mobility and is expected to persist in the environment for months following its application. Oxyfluorfen degrades very slowly in both soil and water and adsorbs strongly to soil containing sediment or organic matter. As demonstrated by the laboratory and field data, oxyfluorfen is expected to reach surface water via transport during runoff events and via spray drift during application events. The chemical is unlikely to leach into groundwater, although limited vertical movement through soils may be possible in sandy soils of low organic matter. Based on its low vapor pressure and Henry's Law constant, volatilization loss of oxyfluorfen from soil and water systems is expected to be insignificant, and movement through long-range atmospheric transport is not expected.

Available fate and transport laboratory and field studies indicated that several degradates are formed in various oxyfluorfen degradation pathways, and all but one (2-chloro-1-(3-ethoxy-4-hydroxy-phenoxy)-4-(trifluoromethyl) benzene (MW-332); MRID 421423-07 and 421423-08) are minor degradates formed in small quantities. Many of these minor degradates were isolated but not identified. In addition, no fate and ecotoxicological data are available for oxyfluorfen degradates, and the Agency is not aware of any toxicological concerns associated with oxyfluorfen degradates. Therefore, degradates were not evaluated in this assessment.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey, and its habitats to oxyfluorfen are assessed separately for the two habitats. Tier-II aquatic exposure models are used to estimate high-end exposures of oxyfluorfen in aquatic habitats resulting from runoff and spray drift from different uses. Peak model-estimated environmental concentrations resulting from different oxyfluorfen uses range from 0.347 to 46.40 µg/L. These estimates are supplemented with analysis of available California non-targeted surface water monitoring data from U.S. Geological Survey’s National Water Quality Assessment (NAWQA) program and the California Department of

Pesticide Regulation. The maximum concentration of oxyfluorfen reported by NAWQA for California surface waters with agricultural watersheds is 0.0875 µg/L. This value is approximately 530 times less than the maximum model-estimated environmental concentration. There was no surface water monitoring data available for oxyfluorfen at the California Department of Pesticide Regulation (CDPR).

To estimate oxyfluorfen exposures to the terrestrial-phase CRLF and its potential prey, the T-REX model is used for spray and granular applications. The AgDRIFT model is also used to estimate deposition of oxyfluorfen on terrestrial and aquatic habitats from spray drift. The TerrPlant model is used to estimate oxyfluorfen exposures to terrestrial-phase CRLF habitat, including plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar oxyfluorfen applications. The T-HERPS model is used to allow for further characterization of dietary exposures of terrestrial-phase CRLFs. An earthworm fugacity model is used to predict concentrations of oxyfluorfen in soil (as a result of granular use) as well as concentrations in terrestrial invertebrates as food items for terrestrial-phase CRLFs.

The effects determination assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF itself, 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 generally used as a surrogate for aquatic-phase amphibians. In the terrestrial habitat, direct effects are based on toxicity information for birds, which are used as a surrogate for terrestrial-phase amphibians. Given that the CRLF's prey items and designated critical habitat requirements in the aquatic habitat 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 due to depletion of prey are assessed by considering effects to terrestrial invertebrates, small terrestrial mammals, and frogs. Indirect effects due to modification of the terrestrial habitat are characterized by available data for terrestrial monocots and dicots.

Risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. Acute and chronic RQs are compared to the Agency's levels of concern (LOCs) to identify instances where oxyfluorfen use within the action area has the potential to affect the CRLF and its designated critical habitat via direct toxicity or indirectly based on direct 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). When RQs for each particular type of effect are below LOCs, the pesticide is determined to have "no effect" on the CRLF. Where RQs exceed LOCs, a potential to cause effects is identified, leading to a conclusion of "may affect." If a determination is made that use of oxyfluorfen 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 critical habitat.

Based on the best available information, the Agency makes a "may affect, and likely to adversely affect" determination for the CRLF from the use of oxyfluorfen. Based on potential for effects to aquatic and terrestrial plants, all currently registered uses of oxyfluorfen in California have the potential to cause indirect effects to the CRLF. Applied at certain rates to certain crops, oxyfluorfen may also have the potential to cause direct effects to the CRLF. Additionally, the Agency has determined that there is potential for modification of CRLF designated critical habitat from the use of the chemical. A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat is presented in **Tables 1.1** and **1.2**. Use-specific determinations for the CRLF are provided in **Table 1.3**, which also includes a summary of LOC exceedances for direct effects to the CRLF for each modeled scenario and taxonomic group. A summary of indirect effect LOC exceedances for each modeled scenario and taxonomic group are provided in **Table 1.4**. Further information on the results of the effects determination is included as part of the Risk Description in **Section 5.2.** Given the LAA determination for the CRLF and potential modification of designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment 2**.

Table 1.1 Effects Determination Summary for Oxyfluorfen Use and the CRLF Impact Analysis

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Survival, growth, and/or reproduction of CRLF individuals	LAA[1]	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults): Freshwater fish data used as surrogate for CRLF. *Adult survival*: Acute LOC exceedances in several scenarios with LC_{50} attained under standard laboratory lighting = 203 µg a.i./L. Acute LOC exceedances in all scenarios with LC_{50} estimated under UV lighting from a calculated chronic:acute ratio. *Growth and reproduction:* Chronic LOC exceedances in many of the scenarios with NOAEC attained under UV lighting.
		Terrestrial-phase (Juveniles and Adults): Avian data used as surrogate for CRLF. *Survival:* No significant concerns based on acute studies. *Growth and reproduction*: Dietary-based chronic RQ values exceeded the LOC for liquid applications of oxyfluorfen at rates higher than two applications of 0.5 lb a.i./acre. Chronic granular exceedances were not observed.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity *Non-vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Vascular aquatic plants*: LOC exceedances in all but one modeled scenario. *Freshwater invertebrates, standard laboratory lighting*: Acute LOC was exceeded for several scenarios and chronic LOC exceeded for two scenarios. *Freshwater invertebrates, estimated UV lighting*: Acute LOC exceeded for all scenarios and chronic LOC exceeded for all but five scenarios.

Table 1.1 Effects Determination Summary for Oxyfluorfen Use and the CRLF Impact Analysis		
Assessment Endpoint	**Effects Determination [1]**	**Basis for Determination**
		Terrestrial prey items, riparian habitat *Terrestrial invertebrates*: For liquid and granular applications affecting small and large insects, the acute LOC was exceeded for all application rates. *Terrestrial-phase amphibians, acute toxicity*: No concerns based on acute avian studies. *Terrestrial-phase amphibians, growth and reproduction*: Dietary-based chronic RQ values exceeded the LOC for liquid applications of oxyfluorfen at rates higher than two applications of 0.5 lb a.i./acre. Chronic granular exceedances were not observed. *Small terrestrial mammals, acute toxicity:* No concerns based on acute studies. *Small terrestrial mammals, growth and reproduction:* For liquid applications of oxyfluorfen, chronic dose-based LOCs were exceeded for all application rates. Chronic dietary-based LOCs were exceeded for application rates greater than 1 lb a.i./acre. For granular applications at the rate of 2 lb a.i./acre, the chronic dose-based RQ exceeded the LOC for small mammals, but dietary-based exceedances were not observed. Dietary-based risk estimations were used for this effects determination. *Terrestrial plants*: LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen.
[1]No effect (NE); May affect, but not likely to adversely affect (NLAA); May affect, likely to adversely affect (LAA)		

Table 1.2 Effects Determination Summary for Oxyfluorfen Use and CRLF Critical Habitat Impact Analysis		
Assessment Endpoint	**Effects Determination [1]**	**Basis for Determination**
Modification of aquatic-phase PCE	HM[1]	*Terrestrial plants*: LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen. *Non vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Vascular aquatic plants*: LOC exceedances in all but one modeled scenario.
Modification of terrestrial-phase PCE		*Terrestrial plants*: LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen.
[1]Habitat modification (HM) or No effect (NE)		

Table 1.3 Oxyfluorfen Use-specific Effects Determinations (based on direct and indirect effects) and Direct Effect LOC Exceedance Summary for the CRLF						
Scenario	**Method[1]**	**Overall Effects Determination[2]**	**Direct Effect LOC Exceedance**			
			Aquatic Habitat		**Terrestrial Habitat**	
			Acute	**Chronic**	**Acute[3]**	**Chronic**
Orchard Uses						
CA Avocado RLF	G	LAA	No	Yes	No	Yes
CA Olive RLF	G	LAA	No	No	No	Yes
CA Almond STD	G	LAA	No	No	No	Yes
	A	LAA	No	No	No	No
CA Citrus STD	G	LAA	No	No	No	Yes
	A	LAA	No	No	No	Yes
CA Fruit STD	G	LAA	No	No	No	Yes
	A	LAA	No	No	No	Yes
CA Grapes STD	G	LAA	No	No	No	Yes
	A	LAA	No	No	No	Yes
CA Wine Grapes RLF	G	LAA	No	Yes	No	Yes
	A	LAA	No	Yes	No	Yes
Agricultural – Food Crop Uses						
CA Cole Crop RLF	G	LAA	No	No	No	No
	A	LAA	No	Yes	No	No
CA Garlic RLF	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Lettuce STD	G	LAA	No	Yes	No	No
	A	LAA	No	Yes	No	No
CA Melons RLF	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Onion STD	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Potato RLF	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Strawberry RLF	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Sugarbeet OP	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Tomato STD	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Wheat RLF	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
OR Mint	G	LAA	No	Yes	No	Yes
CA Row Crop RLF	G	LAA	No	Yes	No	Yes
	A	LAA	No	No	No	No
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	LAA	No	No	No	Yes
CA Cotton STD	G	LAA	No	No	No	No
	A	LAA	No	No	No	No
CA Rangeland Hay RLF	G	LAA	No	Yes	No	Yes

Table 1.3 Oxyfluorfen Use-specific Effects Determinations (based on direct and indirect effects) and Direct Effect LOC Exceedance Summary for the CRLF						
Scenario	**Method**[1]	**Overall Effects Determination**[2]	**Direct Effect LOC Exceedance**			
			Aquatic Habitat		**Terrestrial Habitat**	
			Acute	**Chronic**	**Acute**[3]	**Chronic**
	G	LAA	Yes	Yes	No	Yes
Non-agricultural Uses						
CA Nursery	G	LAA	Yes	Yes	No	Yes
CA Nursery (granular)	G	LAA	Yes	Yes	No	No
CA Forestry RLF	G	LAA	Yes	Yes	No	Yes
	G	LAA	Yes	Yes	No	Yes
	A	LAA	No	Yes	No	Yes
CA Residential RLF	G	LAA	No	No	No	Yes
	G	LAA	No	No	No	Yes
CA Right-of-Way RLF	G	LAA	No	Yes	No	Yes
	G	LAA	No	Yes	No	Yes
CA Turf RLF	G	LAA	No	No	No	Yes
	G	LAA	No	Yes	No	Yes

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[2] The Effects Determination call for each individual scenario is based on results from evaluation of direct effects (this table, last four columns) and indirect effects (**Table 1.4**).
[3]Because the acute LOC exceedances observed in the risk estimation were based on an LD_{10}, they were determined to be discountable and insignificant.
NE = No effect; NLAA = May effect, not likely to adversely effect; LAA = May effect, likely to adversely effect

Table 1.4 Oxyfluorfen Use-specific Indirect Effect LOC Exceedance Summary for the CRLF													
Scenario	**Method**[1]	**Aquatic Plants**		**Aquatic Invertebrates**		**Terrestrial Invertebrates (Acute)**	**Terrestrial Plants**	**Aquatic-phase Frogs and Fish**		**Terrestrial-phase Frogs**[2]		**Small Mammals**	
		Non-vascular	**Vascular**	**Acute**	**Chronic**			**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**[3]
Orchard Uses													
CA Avocado RLF	G	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes
CA Olive RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	Yes
CA Almond STD	G	Yes	Yes	Yes	No	Yes	Yes	No	No	No	Yes	No	Yes
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Citrus STD	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	No
CA Fruit STD	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	No
CA Grapes STD	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	No
CA Wine Grapes RLF	G	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes
	A	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	No	No
Agricultural – Food Crop Uses													
CA Cole Crop RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	No	No
CA Garlic RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Lettuce STD	G	Yes	Yes	No	No	Yes	Yes	No	Yes	No	No	No	No
	A	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No	No	No
CA Melons RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Onion STD	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Potato RLF	G	Yes	No	No	No	Yes	Yes	No	No	No	No	No	No

Table 1.4 Oxyfluorfen Use-specific Indirect Effect LOC Exceedance Summary for the CRLF

Scenario	Method[1]	Aquatic Plants		Aquatic Invertebrates		Terrestrial Invertebrates (Acute)	Terrestrial Plants	Aquatic-phase Frogs and Fish		Terrestrial-phase Frogs[2]		Small Mammals	
		Non-vascular	Vascular	Acute	Chronic			Acute	Chronic	Acute	Chronic	Acute	Chronic[3]
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Strawberry RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Sugarbeet OP	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Tomato STD	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Wheat RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
OR Mint	G	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	No	Yes
CA Row Crop RLF	G	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
Agricultural – Non-food Crop Uses													
CA Alfalfa OP	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	No
CA Cotton STD	G	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
	A	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
CA Rangeland Hay RLF	G	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes
	G	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Non-agricultural Uses													
CA Nursery	G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
CA Nursery (granular)	G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No
CA Forestry RLF	G	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	G	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	A	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	No
CA Residential RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes

Table 1.4 Oxyfluorfen Use-specific Indirect Effect LOC Exceedance Summary for the CRLF													
Scenario	**Method[1]**	**Aquatic Plants**		**Aquatic Invertebrates**		**Terrestrial Invertebrates (Acute)**	**Terrestrial Plants**	**Aquatic-phase Frogs and Fish**		**Terrestrial-phase Frogs[2]**		**Small Mammals**	
		Non-vascular	**Vascular**	**Acute**	**Chronic**			**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic[3]**
	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes
CA Right-of-Way RLF	G	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	No	Yes
	G	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes
CA Turf RLF	G	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes
	G	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	No	Yes

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[2]LOC exceedances based on T-HERPS refinement for small frogs.
[3]LOC exceedances based on dietary-based chronic risks to small mammals.

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. 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 to EPA. 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 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, would provide a more complete prediction of effects to individual frogs and potential modification to critical habitat.

2. 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 USEPA's *Guidance for Ecological Risk Assessment* (USEPA 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS 1998), and is consistent with procedures and methodology outlined in the Overview Document (USEPA 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 oxyfluorfen on cultivated fields for agricultural crops (*e.g.*, avocado, broccoli, garlic, melons, olives, potato, artichokes, strawberries, grapes, tree fruit, tree nuts, lettuce, onions, tomatoes, sugarbeets) and non-food commodities (*e.g.*, forest trees, nurseries, turf), residential uses, and other non-agricultural uses (*e.g*., industrial areas, right-of-ways). In addition, this assessment evaluates whether use on these crops is expected to result in modification of the species' designated critical habitat. This ecological risk assessment has been prepared to be consistent with a settlement agreement in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)) 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 (USEPA 2004). Screening level methods include use of standard models such as PRZM-EXAMS, T-REX, TerrPlant, and AgDRIFT, all of which are described at length in the Overview Document. Additional refinements include an analysis of the usage data, a spatial analysis, use of the T-HERPS model, and use of an earthworm fugacity model to predict concentrations of oxyfluorfen in soil as well as terrestrial invertebrates as food items for terrestrial-phase CRLFs. Use of such information is consistent with the methodology described in the Overview Document (USEPA 2004), 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 USEPA 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 oxyfluorfen is based on an action area. The action area is 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 oxyfluorfen 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 oxyfluorfen 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.

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 oxyfluorfen as it relates to this species and its designated critical habitat. If, however, potential direct or indirect effects to individual CRLFs are anticipated 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 oxyfluorfen.

If a determination is made that use of oxyfluorfen 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 oxyfluorfen use sites) and further evaluation of the potential impact of oxyfluorfen 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 not likely to adversely affect" from those actions that "may affect, and 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** 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 oxyfluorfen is expected to directly impact living organisms within the action area (defined in **Section 2.7**), critical habitat analysis for oxyfluorfen 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 oxyfluorfen 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

Oxyfluorfen is a diphenyl ether selective contact herbicide used on a wide variety of crops and other sites for the control of monocotyledonous and broadleaf weeds for both pre-emergent and post-emergent management (see **Table 2.3** for a complete list of labeled uses). Oxyfluorfen is registered for use in fallow or established fields of dormant or nonbearing food and feed crops including tree fruit and tree nut crops as well as an assortment of row crops. In some cases, oxyfluorfen may be applied to bearing crops when precautions are taken to avoid exposure to crop foliage. Oxyfluorfen can also be applied to Christmas tree plantations, forest trees, uncultivated areas, and ornamental plants in nurseries. Non-agricultural uses for oxyfluorfen include weed control in industrial sites, right-of-ways, paved areas and sidewalks, paths and patios, and other residential and commercial sites. Oxyfluorfen can be applied as a liquid formulation via ground sprayer, banded application, or aerial broadcast. It can also be applied as a granular formulation, which is common for ornamental nursery uses. Oxyfluorfen must not be incorporated into the soil for effective treatment. There are several ready-to-use products as well as a liquid concentrate available for residential use.

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 oxyfluorfen in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment.

Although current registrations of oxyfluorfen allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of oxyfluorfen 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**.

Several degradates have been reported for oxyfluorfen but only a few have been identified and quantified. The Agency does not have concerns for any degradates of oxyfluorfen relative to human health issues as the tolerance expression is only expressed in terms of oxyfluorfen *per se* (60 FR 62330, December 6, 1995). There is no evidence that any oxyfluorfen degradates are of toxicological concern, and none of them except

MW-332 [2-chloro-1-(3-ethoxy-4-hydroxyphenol)-4-(trifluoromethyl) benzene] (>10.0%), identified in the aqueous photolysis study, are found in significant amounts, and, therefore, this assessment is based on parent oxyfluorfen only.

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 (USEPA 2004; USFWS/NMFS 2004).

Oxyfluorfen 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**. Based on a review of the available studies on oxyfluorfen mixtures in ECOTOX, it appears that the information presented in the papers pertain to efficacy and phytotoxicity of the mixtures for weed control. The results of this analysis show that an assessment based on the toxicity of the single active ingredient of oxyfluorfen is appropriate.

2.3 Previous Assessments

Oxyfluorfen was first registered in the United States in 1979 to control pre-emergent and post-emergent broadleaf and monocotyledonous weeds in a variety of field, fruit, and vegetable crops, ornamentals, as well as non-crop sites. The technical ingredient is currently manufactured by Dow AgroSciences and Makhteshim-Agan under the trade names Goal and Galigan. The EPA issued the Re-registration Eligibility Decision (RED) in August 2002 on all oxyfluorfen products registered at that time. The results of EFED's 2002 ecological risk assessment for oxyfluorfen, which was conducted as part of the RED, suggests the potential for adverse effects to terrestrial and aquatic plants, acute effects to fish and aquatic invertebrates, chronic effects to aquatic invertebrates, and chronic effects to mammals and birds. To lessen the risks to wildlife posed by oxyfluorfen, EPA required several risk mitigation measures as a result of the RED, including rate reductions, vegetative buffer zones, and droplet size restrictions. These mitigation measures were implemented on some labels as of August 2008. Because this assessment modeled oxyfluorfen use by crop scenario rather than by each individual label, the effects determination assumes that the mitigation measures have not yet been implemented on any label. Therefore, when reviewing potential mitigation measures relative to the effects on listed species, those measures identified through the RED should be considered first to determine whether they reduce potential exposure to levels below the levels of concern for the CRLF and its critical habitat.

Following completion of the RED, additional environmental fate and ecotoxicity data on oxyfluorfen have been submitted to the Agency. These data have been reviewed and will be included in this assessment as appropriate.

The Agency also completed an effects determination for 26 threatened and endangered Pacific anadromous salmon and steelhead in April 2004 based on oxyfluorfen uses in a variety of field, fruit, and vegetable crops, ornamentals, and non-crop sites in the Pacific Northwest as part of the settlement for the petition filed against EPA by Washington Toxics Coalition (filed November 26, 2002). The results of that endangered species risk assessment showed that the use of oxyfluorfen will have no direct or indirect effect on loss of food supply or loss of cover in the 26 ESUs of Pacific salmon and steelhead when used according to labeled application directions.

2.4 Stressor Source and Distribution

2.4.1 Environmental Fate Properties

The major route of oxyfluorfen dissipation is aqueous photolysis. The chemical appears to have low mobility and is expected to persist in the environment for months following its application. Oxyfluorfen degrades very slowly in both soil and sediment and adsorbs strongly to soil containing sediment or organic matter. Adsorption/desorption studies suggest oxyfluorfen is slightly to hardly mobile, except perhaps when applied on very sandy soils of low organic carbon content.

The compound is readily degraded by sunlight when dissolved in water (half-lives = 2 and 7.5 days), moderately degraded by sunlight when on soil surfaces (half-life = 28 days, a minor route of dissipation), and is stable to hydrolysis (> 97% parent after 30 days at pH 4, 7, and 10). Other laboratory studies suggest that oxyfluorfen will persist in the environment weeks and months following its application. Its soil microbial degradation was slow with aerobic soil metabolism half-lives ranging from 69 to 596 days ($t_{1/2}$ = 77 days in a sandy loam soil from Switzerland, $t_{1/2}$ = 68 days in a loamy sand/sandy loam soil from Germany, and $t_{1/2}$ = 69 days in a clay loam soil from France (MRID 463731-03); $t_{1/2} \approx$ 290 days in a clay loam soil and $t_{1/2}$ = 575 days in a sandy loam soil (MRID 421423-09)). Anaerobic soil metabolism half-lives ranged between 554 and 603 days. The aerobic soil half-lives demonstrated a broad range, which could be attributed to decreased microbial population observed in one study (MRID 421423-09), the effect of the soil properties on the activity of soil microbial organisms, and variations in test conditions (*i.e.,* differences in temperature and soil moisture content). Open literature data suggest that the rate of oxyfluorfen dissipation in soil depends on both temperature and soil moisture content. In dark laboratory conditions, Yen *et al*. (2003) studied oxyfluorfen soil dissipation in six tea garden soils of Taiwan under different moisture content (30%, 60%, and 90% of soil field capacity) and soil temperature (10°C, 25°C, and 40°C). Oxyfluorfen half-lives ranged from 72 to 160 days for the six studied soils. The authors concluded that if the temperature is high, oxyfluorfen dissipation rate is rapid; however, at 10°C there is almost no dissipation, and microorganisms may play an important role in oxyfluorfen residues in soil (Yen *et al*. 2003).

Oxyfluorfen applied to water column dissipates by mineralization to CO_2 and minor transformation products and by incorporation into the organic matter of the suspended and bottom sediment. In water column, oxyfluorfen dissipated with half-lives of 4 and 5 days, in sediment with half-lives of 32 and 51 days, and in total water/sediment system with half-lives of 30 (pond water/silt loam sediment from Switzerland) and 40 days (river water/sandy loam sediment from Switzerland (MRID 463731-04). Adsorption/desorption studies suggest oxyfluorfen is slightly to hardly mobile, except perhaps when used on very sandy soils. Adsorption/desorption data also suggest that once the soil-bound oxyfluorfen reaches deep or turbid surface water, it will persist since it is stable to hydrolysis and light penetration would be limited; however, it may degrade by photolysis in clear, shallow surface water.

The major degradate found in the environmental fate studies was MW-332 [2-chloro-1-(3-ethoxy-4-hydroxyphenol)-4-(trifluoromethyl) benzene], which was identified in the aqueous photolysis study (MRID 421291-01) to be $\geq$ 10 % of the applied radioactivity. Other degradates identified in the aqueous photolysis study but not quantified include RH-3467, RH-34860, RH-34800, RH-45469, MW-327, and MW-180. In the hydrolysis study (MRID 134454), RH-34670 [(2-chloro-1-(3-hydroxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene] was identified at a maximum concentration of 1.2-1.7% of the applied radioactivity. In the soil photodegradation study, isolated volatile material was composed of two degradates, RH-34800 and RH-36329, the methyl ester of 3-Cl,4-OH benzoic acid. RH-34800 was the only degradate identified in the aerobic soil metabolism study (MRID 421423-09) at a maximum concentration of 2.9 % of the applied radioactivity. In a more recent aerobic soil study, oxyfluorfen mineralized to CO_2 ($\leq$ 21% of the applied) with the formation of multiple minor transformation products, which were isolated but not identified (each $\leq$ 2.1%, but one at 5.8% of the applied), and bound residues ($\leq$ 45% of the applied; MRID 463731-03). Oxyfluorfen applied to water dissipated by mineralization to CO_2 ($\leq$ 9.4% of applied) and minor transformation products, which were isolated but not identified (each $\leq$ 4.9%, but one at 9.6% of the applied), and by incorporation into the organic matter of the sediment (extractible residues $\leq$ 71%; nonextractible residues $\leq$ 59% of the applied; MRID 463731-03). There were no degradates isolated and identified in the anaerobic soil metabolism, aerobic aquatic metabolism, and leaching studies. Presently no fate and ecotoxicological data are available for oxyfluorfen degradates. Nomenclature and chemical structure of oxyfluorfen degradates are provided in **Figure 2.1**.

According to FAO soil classification (FAO 2000), the batch equilibrium data indicate that the compound is slightly mobile in sandy soils, sandy loam, and clay loam (K_{oc} = 2,891 L/kg, 8,076 L/kg, and 5,585 L/kg, respectively), and hardly mobile in silty clay loam soils (K_{oc} = 32,381 L/kg). In an unaged column leaching study, oxyfluorfen did not leach below four inches in any soil, except sand, where traces were found at nine inches. Likewise, open literature data concur with registrant-submitted laboratory studies' findings that oxyfluorfen is not very mobile in soil and is unlikely to contaminate groundwater under normal conditions. However, in course texture sandy soils of low organic matter content, oxyfluorfen has potential to leach into shallow groundwater less than three meters deep (Yen *et al*. 2003).

Oxyfluorfen dissipated from bare ground loamy sand and clay loam soil plots in California with half-lives of 53 and 58 days, respectively. The half lives for degradates RH-4672, RH-0671, and RH-2382 varied from 37 to 61 days. These half-lives were estimated based on the formation and decline curves from the field dissipation study (MRID 438401-01). The field dissipation study shows that oxyfluorfen dissipated with half-lives of 53 and 58 days; however, it has a potential to be more persistent under different environmental conditions. The dissipation half-lives for oxyfluorfen ranged from 30 to 103 days in Canadian muck soil (Frank *et al*. 1991). The study authors reported increased persistence of oxyfluorfen in colder climates. In another study conducted in Australian vineyards during a cool and damp season, the half-life was 119 days (Ying and Williams 2000).

Based on oxyfluorfen low vapor pressure (2.5×10^{-7} mm Hg at 25^{o}C) and Henry's Law Constant (8.21×10^{-7} atm·m^3/mol), volatilization loss of oxyfluorfen from soil and water systems is expected to be insignificant. Considering this low volatility along with high sensitivity to photolytic degradation, oxyfluorfen is not expected to continue long-range atmospheric transport in appreciable quantities.

Based on laboratory bioconcentration in bluegill fish, oxyfluorfen is expected to bioconcentrate in fish, which is in concurrence with oxyfluorfen's high K_{ow} value of 29,400 (log K_{ow} = 4.46). However, oxyfluorfen's potential for bioconcentration is expected to be closely linked to its concentration in water. The bioconcentration factors observed in a bluegill sunfish study (MRID 140477) were 450 and 605X in muscle, 3265 and 4360X in viscera, and 1075 and 2200X in whole fish. Elimination of accumulated residues by day fourteen of depuration was 82% in viscera and 91% in whole fish.

As demonstrated by the laboratory and field data, oxyfluorfen is expected to reach surface water via transport during runoff events and via spray drift during application events. The chemical is unlikely to leach into groundwater, although limited vertical movement through soils may be possible in sandy soils of low organic matter.

Tables 2.1.a and **2.1.b** list the environmental fate properties of oxyfluorfen, along with the major and minor degradates detected in the submitted environmental fate and transport studies. **Figure 2.1** provides nomenclature and chemical structures of oxyfluorfen degradates.

Table 2.1.a Summary of Oxyfluorfen Physical and Chemical Properties

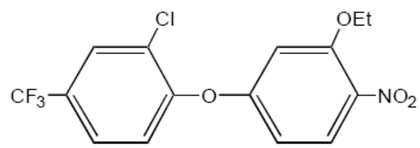
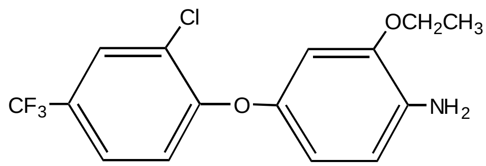
Physical/Chemical Property	Value (Unit)
Chemical Name	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene
Chemical Structure	
Molecular Formula	$C_{15}H_{11}ClF_3NO_4$
Molecular Weight	361.7 g/mol
Physical State	Orange Crystalline Solid
Melting Point	65-84^{o}C
Vapor Pressure (25^{o}C)	2.5 x 10^{-7} torr
Water Solubility (25^{o}C)	0.116 mg/L
Octanol/Water Partition Coefficient	2.94 x 10^{4} at 25 ^{o}C (log K_{ow} = 4.46)
Henry's Law Constant at 25^{o}C	8.21 x 10^{-7} atm m^{3} mol $^{-1}$

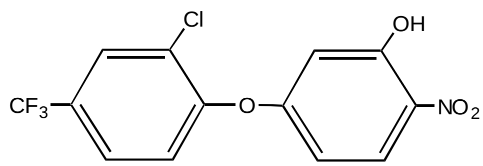
Table 2.1.b Summary of Oxyfluorfen Environmental Fate Properties

Physical/Chemical or Fate Property	Value & Unit	Major & Minor Degradates/Comment	MRID #	Status
Hydrolysis	Stable	RH-34670 at 1.2-1.7% of the applied	134454	Acceptable
Photodegradation in Water ($t_{½}$)	3.7 and 5.4 days 6.2 and 7.5 days	MW-332 ≥ 10% of the applied	421423-07 421423-08 421291-01	Supplemental Supplemental
Photodegradation on Soil ($t_{½}$)	28 days	6.5% methyl ester of 3-Cl,4-OH benzoic acid, and 6.5% 3-Cl,4-OH benzoic acid	419999-01	Acceptable

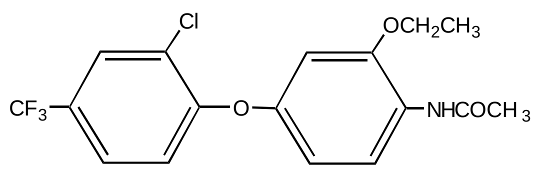
Table 2.1.b Summary of Oxyfluorfen Environmental Fate Properties				
Physical/Chemical or Fate Property	**Value & Unit**	**Major & Minor Degradates/Comment**	**MRID #**	**Status**
Aerobic Soil Metabolism ($t_{½}$)	556-596 days (sandy loam soil) 291-294 days (clay loam soil) European soils: 77 days-sandy loam, 68 days-loamy sand/sandy loam, 69 days-clay loam	Major: none Minor: RH-3480 (clay loam soil)	421423-09 463731-03	Acceptable Supplemental
Anaerobic Soil Metabolism ($t_{½}$)	554 and 603 days	None	421423-10	Supplemental
Anaerobic Aquatic Metabolism ($t_{½}$)			N/A	
Aerobic Aquatic Metabolism in Total System ($t_{½}$ in water/sediment system)	30 & 40 days (water: 4-5 days; sediment: 51-32 days)	Major: none Minor: not identified	463731-04	Supplemental
Leaching & Adsorption/Desorption	*sand soil*: K_d = 8.5 (K_{oc}=2891) *sandy loam*: K_d = 62 (K_{oc}=8076) *clay loam*: K_d = 99 (K_{oc}=5585) *silty clay loam*: K_d = 228 (K_{oc}=32381)	Parent did not leach below 4 inches except for in sand traces were found at 9 inches (MRID 110728)	110728 421423-11	Supplemental Supplemental
Terrestrial Field Dissipation ($t_{½}$) (CA bare ground loamy sand and clay loam soil plots)	Parent: 53 and 58 days Degradates (RH-4672, RH-0671 and RH-2382): 37 to 62 days.	RH-4672 was max of 0.379 ppm, RH-0671 was 0.044 ppm, and RH-2382 was 0.095 ppm immediately post treatment	438401-01	Supplemental
Bioconcentration in Fish (bluegill sunfish)	Muscle: 450 & 605X Viscera: 32265 & 4360X Whole fish: 1075 & 2200X	By day 14 of depuration, elimination of residues was 82% in viscera and 91% in whole tissue.	140477	Supplemental
Droplet Size Spectrum [a]			waived	
Drift Field Evaluation (using lettuce as bioassay)	Visible symptoms: 800 m downwind Quantifiable symptoms up to 100		144894	Supplemental
[a]Member of Spray Drift Task Force.				



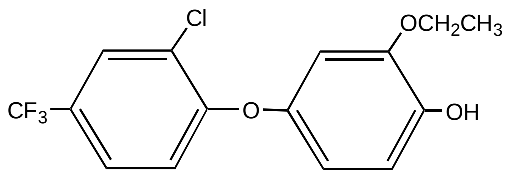
Amino-Goal: 2-chloro-1-(3-ethoxy-4-aminophenoxy)-4-(trifluoromethyl) benzene (RH-35451)



2-chloro-1-(3-hydroxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene (RH-34670)



Acyl-670 (RH-45469)



2-chloro-1-(3-ethoxy-4-hydroxy-phenoxy)-4-(trifluoromethyl) benzene (MW-332)

Figure 2.1 Degradate Structures

2.4.2 Environmental Transport Mechanisms

The mechanisms expected to be major routes of exposure for oxyfluorfen are surface water runoff and spray drift. Since oxyfluorfen is not expected to volatilize, secondary drift and long-range atmospheric transport are not expected.

As part of the California Environmental Protection Agency's Environmental Justice Action Plan, the Department of Pesticide Regulation (DPR) is conducting a pilot project focusing on pesticide air concentrations in Parlier (http://www.cdpr.ca.gov/docs/envjust/pilot_proj/interim/narrative.pdf). Parlier is a small agricultural community located in California's San Joaquin Valley, approximately 20 miles southeast of Fresno. Fruit orchards and grape vineyards are the predominant crops in the area. Oxyfluorfen was not detected in any of the samples (n = 297 collected from January 1 to August 16, 2006; LOQ (oxyfluorfen) = 46.3 ng/m^3), which confirms that long range aerial transport is expected to play an insignificant role in the overall oxyfluorfen environmental transport mechanism.

In general, deposition of drifting pesticides is expected to be greatest close to the site of application. Computer models of spray drift (AgDRIFT and AGDISP) can be used to determine potential exposures to aquatic and terrestrial organisms via spray drift.

2.4.3 Mechanism of Action

Oxyfluorfen is a diphenyl-ether, one of a class of herbicides sometimes referred to as light-dependent peroxidizing herbicides (LDPHs), which have enhanced toxicity in the presence of solar ultra-violet (UV) radiation. It disrupts the cell membrane of the plant by penetrating into the cytoplasm and causing formation of peroxides and free electrons. Oxyfluorfen inhibits the enzyme protoporphyrin-III oxidase, whose function is to catalyze the formation of protoporphyrin IX. Protoporphyrin IX is a precursor molecule common to both plants and animals. In plants, it is a step in chlorophyll biosynthesis, and in animals, it is a step in hemoglobin biosynthesis. Inhibition of protoporphyrin-III oxidase in plants leads to an accumulation of phototoxic chlorophyll precursors which, in the presence of light, produce activated oxygen species which rapidly disrupt cell membrane integrity. Some chemicals of this class have been associated with peroxisome proliferation, which can induce hepatocellular carcinomas in rodents. (Smith and Elcombe 1989, Ashby *et al*. as cited in Krijt *et al*. 1999). Other herbicides in this group include acifluorfen, lactofen, nitrofen, and fomesafen.

Oxyfluorfen is applied as a spray or granule that must contact plant foliage to cause effects. Oxyfluorfen is not translocated in plants, thus damage is normally limited to the areas it contacts. Visible signs of oxyfluorfen toxicity to plants include localized chlorosis (yellowing or whitening) and necrosis. Plants that are actively growing are most susceptible to oxyfluorfen. By forming a chemical barrier on the soil surface, oxyfluorfen affects plants at emergence. This barrier is formed with adequate spray coverage or irrigation following granule application (to partially dissolve granules and promote dispersion of oxyfluorfen over the soil surface). Because of the length of oxyfluorfen soil half-life, this barrier may last up to three months (for example see the Rout label, EPA Reg. # 58185-27). Some herbicidal effect may be observed for a longer period of time for some sensitive species as the treatment-planting interval may be restricted for up to ten months after application (for example, see the application instructions for fallow bed cereal grains on the EndZone Herbicide label, EPA Reg. # 34704-877). Many labels also recommend or require thorough tilling of soil before seeding or transplanting to break up the chemical barrier at the soil surface. All plants attempting to emerge through the soil surface prior to complete incorporation of the chemical will be affected through contact. Oxyfluorfen also affects plants through direct contact of spray or granules to exposed tissues. However, death may be avoided if the plant is able to recover from a partial injury to the contacted tissues.

2.4.4 Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for oxyfluorfen represents the FIFRA regulatory action; therefore, application rates and use methods 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.

There are three active technical and 26 active end-use products registered that contain oxyfluorfen as an active ingredient (**Table 2.2**). A total of fifteen companies hold active registrations.

Table 2.2 Active Registrations for Products Containing Oxyfluorfen

Product Name	Registration Number	Type of Formulation[a]	% a.i.	Other Ingredients (%)	Label Date [b]
Technical Products					
GALIGAN OXYFLUORFEN TECHNICAL	011603-00029	TECH	97.4		07/26/06
OXYFLUORFEN TGAI	042750-00135	TECH	97		11/03/06
GOAL TECHNICAL PURIFIED	062719-00399	TECH	99		06/01/04
End Use Products					
KLEENUP SUPER EDGER	000004-00432	RTU	0.25	Glyphosate-isopropylammonium (0.25)	04/15/02
ORTHO FENCE & GRASS EDGER FORMULA II	000239-02516	RTU	0.25	Glyphosate-isopropylammonium (0.25)	09/26/05
TRIOX VEGETATION KILLER FORMULA II	000239-02622	EC	0.7	Imazapyr, isopropylamine salt (0.08)	09/13/04
ORTHO SEASON-LONG GRASS & WEED KILLER	000239-02694	SC	1.5	Glyphosate (8.0) Diquat dibromide (0.1)	11/03/05
ORNAMENTAL HERBICIDE II	000538-00172	G	2	Pendimethalin (1.0)	10/06/06
CHEMSICO HERBICIDE CONCENTRATE 4A [d]	009688-00259	SC	1.92	Diquat dibromide (2.30) Fluazifop-p-butyl (1.15) Dicambia, dimethylamine salt (0.77)	11/08/07
CHEMSICO HERBICIDE RTU 4A [d]	009688-00264	RTU	0.1	Diquat dibromide (0.12) Fluazifop-p-butyl (0.06) Dicambia, dimethylamine salt (0.04)	12/03/07

Table 2.2 Active Registrations for Products Containing Oxyfluorfen					
Product Name	**Registration Number**	**Type of Formulation[a]**	**% a.i.**	**Other Ingredients (%)**	**Label Date [b]**
END ZONE HERBICIDE	034704-00877	EC	22.2		04/07/05
Oxyfluorfen 2EC	042750-00136	EC	22.3		11/14/07
REGAL O-O HERBICIDE	048234-00010	G	2	Oxadiazon (1.0)	02/24/04
WEEDFREE 75	052287-00015	G	2	Trifuralin (3.0)	02/04/05
WEEDFREE 63	052287-00016	G	2		09/28/04
ROUT ORNAMENTAL HERBICIDE	058185-00027	G	2	Oryzalin (1.0)	09/14/07
GOAL 2XL HERBICIDE	062719-00424	EC	22.3		08/08/06
GOALTENDER [c]	062719-00447	EC	40.0		02/16/05
RAWHIDE 4F HERBICIDE	062719-00448	SC	20.3	Glyphosate-isopropylammonium (20.3)	02/02/06
SHOWCASE	062719-00516	G	0.25	Isoxaben (0.25) trifluralin (2.0)	09/13/05
GALIGAN TM 2E	066222-00028	EC	22.2		01/08/08
CHIEF 3SC HERBICIDE	066222-00107	EC	21.1	Glyphosate-isopropylammonium (14.2)	09/22/06
Galigan H2O	066222-00140	L	41		03/22/07
ZOOMER HERBICIDE [e]	066222-00157	SC	3.75	Glyphosate-isopropylammonium (30.0)	12/07/07
Double O E-Pro Herbicide	079676-00020	G	2	Oryzalin (1.0)	06/09/06
Two OX E-Pro Herbicide	079676-00038	G	2	Oxadiazon (1.0)	01/19/07
ETI 105 1 H [d]	079676-00063	EC	22.3		11/01/07
OXYFLUORFEN 2 HERBICIDE	081391-00001	EC	22.3		01/09/08
Doubledown [d]	081943-00016	G	2.0	Oxadiazon (1.0)	10/25/07

[a] TECH = technical; SC = soluble concentrate; EC = emulsifiable concentrate; RTU = ready to use liquid; G = granular; L = liquid
[b] Date of product label used in the LUIS report to generate summarized crop uses, application rates, and application frequencies.
[c] As of the label dated 02/16/05, this product's name was changed from "Goal 4F" to "GoalTender."
[d] Labels for these products were not included in the LUIS report. It was verified that rates and applications restrictions on the relevant labels were not different than those on labels included in the LUIS report.
[e] Although rates on the Zoomer label for single applications are lower or the same as maximum rates on other labels, total seasonal application rates are higher on the Zoomer label than those modeled in the assessment. See **Table 2.3** for more detail.

Table 2.3 presents the uses and corresponding application rates and methods of application considered in this assessment. This application data was taken from current labels for active registrations. Because of the large number of labeled uses for oxyfluorfen, scenario groups were created for subsets of crops with similar growing conditions and application rates to make exposure modeling and the resulting analysis more feasible. Twenty-eight scenarios were used to estimate EECs and risk as surrogates for all of the uses included in a given scenario group. The highest application rates, maximum number of applications per year, and shortest application interval (see **Section 6.1.1** for explanation of application interval selection) are used for the scenario group modeling in order to ensure that the EECs and risk estimates for a given scenario group will be equal to or higher than that of each individual use.

In the label analysis, it was noted that several labels did not follow the mitigation measures established in the 2002 RED. The mitigation measures relevant to reduction of risks to wildlife posed by oxyfluorfen are as follows:

- "Lower the maximum rate to 1.5 lb a.i./broadcast acre/season for food crops and 2 lb a.i./acre/season for conifer seedlings.
- For liquid formulations and granulars applied to field-grown ornamentals, registrants have agreed to lower this seasonal maximum rate to 4.5 lb a.i./A (1.5 lb a.i./A/application). For granulars applied to containerized ornamentals, the rate will be lowered to a seasonal maximum of 6 lb a.i./A (2 lb a.i./A/application).
- Label language will be added to require 25-foot, no-spray, vegetative buffer zones around surface water bodies such as rivers, lakes, streams, and ponds.
- To minimize oxyfluorfen drift, only use of a coarse, very coarse, or extremely coarse spray will be allowed according to the ASAE 572 definitions for standard nozzles, or a volume median diameter (VMD) of 385 microns or larger for spinning atomizer nozzles.
- The maximum application rate on residential products will be reduced to 3 lb a.i./A or less unless efficacy data support the need for higher rates."

These mitigation measures were included on some labels at the time BEAD conducted its label analysis (April 15, 2008). However, some current labels do not yet reflect these mitigations. EFED will be using the highest current rate and least restrictive labels for assessing potential impacts to the CRLF. However, in developing risk mitigation measures relative to potential exposure of the CRLF to oxyfluorfen use, these changes in the registration parameters of oxyfluorfen should be considered first to determine whether they adequately mitigate exposure to the CRLF and its critical habitat.

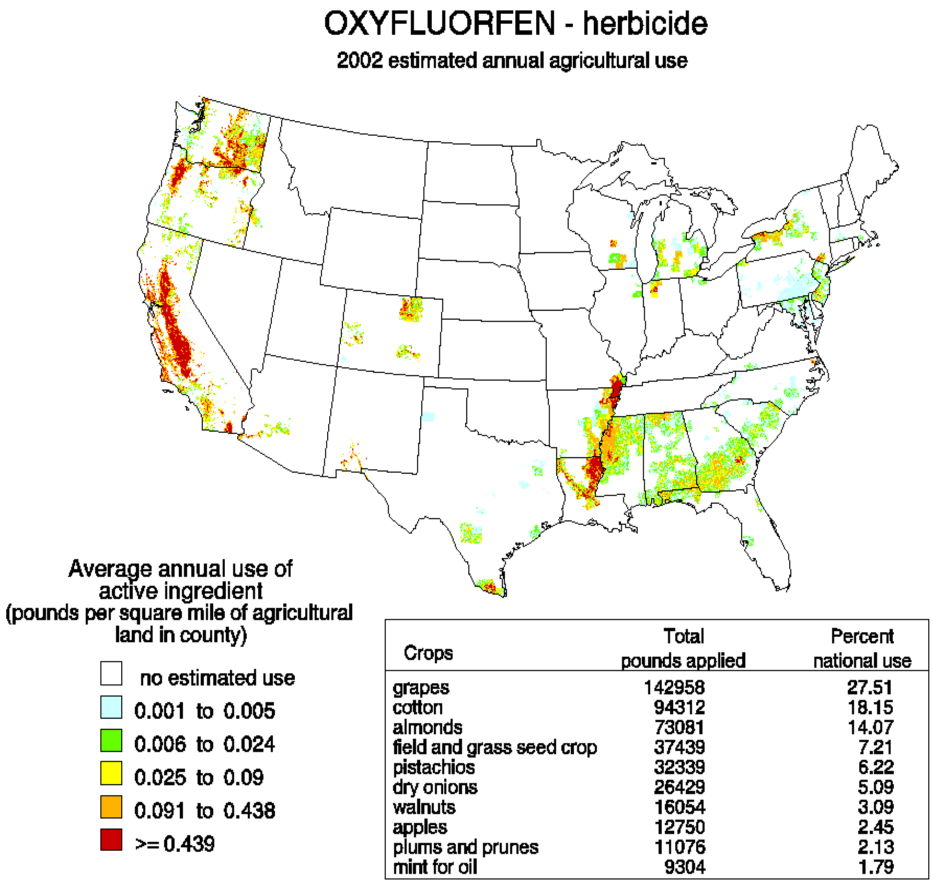
Table 2.3 Oxyfluorfen Uses Assessed for the CRLF			
Scenario (Label Uses)[1]	**Method[2]**	**Max. Single Application Rate (lb a.i./acre)**	**Max. Number of Applications per Year (Interval)[3]**
Orchard Uses [4]			
CA Avocado RLF_V2 (avocado) CA Olive RLF_V2 (olive)	G	2	1
CA Almond STD_Wirrig (almond, beechnut, Brazil nut, butternut, cashew, chestnut, chinquapin, filbert, hickory nut, jojoba, macadamia nut, pecan, pistachio, tree nuts, walnut)	G	2	1
	A	0.5	1
CA Citrus STD_Wirrig (calamondin, citron, citrus, citrus hybrids, grapefruit, kiwi fruit, kumquat, lemon, lime, orange, pummelo, tangelo, tangerines)	G	2	2 (NS - 30 days)
	A	0.5	3 (NS - 30 days)
CA Fruit STD_Wirrig (apple, apricot, cherry, crabapple, date, feijoa, fig, unspecified fruits, loquat, mayhaw, nectarine, peach, pear, persimmon, plum, pomegranate, prune, quince) CA Grapes STD (grapes) CA Wine Grapes RLF_V2 (grapes)	G	2	1
	A	0.5	NS - 3 (NS - 30 days)
Agricultural – Food Crop Uses [4]			
CA Cole Crop RLF_V2 (broccoli, cabbage, cauliflower, horseradish, leafy vegetables) CA Garlic RLF_V2 (garlic) CA Lettuce STD (lettuce) CA Melons RLF_V2 (cucurbit vegetables, cantaloupe, watermelons, squash) CA Onion STD_Wirrig (onion) CA Potato RLF_V2 (potato, root and tuber vegetables) CA Strawberry RLF_V2 (strawberry) CA Sugarbeet OP_Wirrig (sugarbeet) CA Tomato STD_Wirrig (tomato) CA Wheat RLF_V2 (safflower, cereal grains)	G	0.5	1
	A	0.5	1
OR Mint (peppermint, spearmint)	G	2	1
CA Row Crop RLF_V2 (artichoke, carrot, celery, fruiting vegetables, pepper, dried-type beans, legume vegetables)	G	2	1
	A	0.5	1
Agricultural – Non-food Crop Uses			
CA Alfalfa OP_Wirrig (clover)	G	1 (1st application) 0.25 (2nd application)	2 (NS - 30 days)
CA Cotton STD_Wirrig (cotton)	G	0.5	2 (NS - 30 days)
	A	0.5	1

Table 2.3 Oxyfluorfen Uses Assessed for the CRLF

Scenario (Label Uses)[1]	Method[2]	Max. Single Application Rate (lb a.i./acre)	Max. Number of Applications per Year (Interval)[3]
CA Rangeland Hay RLF_V2 (agricultural uncultivated areas)	G	2	NS - 1 (NS - 30 days)
	G	2	NS - 4 (NS - 30 days)
Non-agricultural Uses			
CA Nursery (deciduous fruit trees, nursery stock, conifers (seed orchard), ornamental and/or shade trees, ornamental ground cover, ornamental herbaceous plants, ornamental nonflowering plants, ornamental woody shrubs and vines)	G	2	4 (90 days)
	G (granular)	2	4 (90 days)
	A (granular)*	2	NS
CA Forestry RLF (Christmas tree plantations, conifers, cottonwood, forest trees)	G (basal)	1.5	3 (NS - 30 days)
	G (broadcast)	2	2 (NS - 30 days)
	A	0.5	4
CA Residential RLF (intermittently flooded areas/waters, mulch, paved areas (private roads/sidewalks), paths/patios, fencerows/hedgerows)	G	2	NS - 1 (NS - 30 days)
CA Right-of-Way RLF_V2 (commercial storages/warehouses premises, industrial areas (outdoors), nonagricultural uncultivated areas/soils, nonagricultural right-of-ways/fencerows/hedgerows, airports/landing fields) CA Turf RLF (airports/landing fields, ornamental lawns and turf)	G	2	NS – 4 (NS - 30 days)

[1]Description after scenario (*i.e.*, V2 or Wirrig) indicates file name for PRZM scenario.
[2]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[3]NS – Not specified. The value assumed for exposure modeling purposes is 30 days, which is based on EFED's knowledge of cultural practices for herbicides (see **Section 6.1.1**).
[4] The product label for Zoomer (EPA Reg. No. 66222-157, dated 12/7/2007) provides a single application rate of 0.4 lb a.i./acre and allows for two applications per year (total of 0.8 lb a.i./acre/year), with no restrictions on the re-application interval. Crops listed on the Zoomer label include many crops listed under 'Orchard' and 'Agricultural – Food Crop Uses'. These additional rates were not modeled in this assessment since there were already LOC exceedances for at least one taxonomic group for all modeled crops at the rates provided in the table above.
* The product label for Ornamental Herbicide II (EPA Reg. No. 538-172, dated 4/11/2007) indicated that the granular formulation of oxyfluorfen could be applied aerially. Granular formulations are not typically applied aerially, and the product label does not provide additional instructions for aerial applications. In addition, California DPR PUR data showed only five aerial nursery applications of oxyfluorfen for a total of 5.45 lb a.i. applied aerially in 2006. It is highly probable that these uses are the results of reporting errors. Therefore, aerial applications to nurseries were not modeled and were excluded from analysis in this effects determination.

A national map **(Figure 2.2)** showing the estimated poundage of oxyfluorfen uses across the United States is provided below. The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website (http://water.usgs.gov/nawqa/pnsp/usage/maps/).



Crops	Total pounds applied	Percent national use
grapes	142958	27.51
cotton	94312	18.15
almonds	73081	14.07
field and grass seed crop	37439	7.21
pistachios	32339	6.22
dry onions	26429	5.09
walnuts	16054	3.09
apples	12750	2.45
plums and prunes	11076	2.13
mint for oil	9304	1.79

Figure 2.2 Estimated Oxyfluorfen Use in 2002, Total Pounds Based on Data at the County Level

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Carter and Kaul 2006) using state-level usage data obtained from USDA-NASS[1], 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[2].

[1]United States Department 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.
[2]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.

CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases; thus, the usage data reported for oxyfluorfen by county in this California-specific assessment were generated using CDPR PUR data. Eight years (1999-2006) of usage data were included in this analysis. Data from CDPR PUR were obtained for every reported 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 area treated. Calculating county-level usage 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 (not included in **Tables 2.4** and **2.5**, and **Appendix C**), and average and maximum application rate across all eight years.

From 1999 to 2006, oxyfluorfen was used on 138 crops or sites in 55 counties in California. The herbicide was used in the greatest quantity on wine grapes with an average yearly application of ~102,900 lb a.i./year. Almonds, pistachios, cotton, and grapes followed with ~100,400 lb a.i./year, ~44,800 lb a.i./year, ~40,700 lb a.i./year, and ~40,300 lb a.i./year, respectively. The highest average application rate over the eight year period was 4.82 lb a.i./acre applied to spinach crop. The greatest quantity of oxyfluorfen was applied in Kern County with a yearly average application of ~83,100 lb a.i./year followed by Fresno, Tulare, Madera, and San Joaquin counties with ~71,600 lb a.i./year, ~41,800 lb a.i./year, ~35,800 lb a.i./year, and ~31,700 lb a.i./year, respectively. The highest average application rate over the eight year period was 3.09 lb a.i./acre applied in San Benito County.

Many of the highest single application rates (based on a single record in the data set) recorded in the 1999 to 2006 CDPR PUR data greatly exceed the maximum application rates permitted on oxyfluorfen labels and likely indicate data entry errors in the pounds applied or the acres treated data fields. Typically, the average application rate (based on many records from the data set) is far below the maximum label-permitted application rate. For instance, the average application rate for almonds (0.27 lb a.i./acre) was only 13.5% of the maximum labeled rate (2 lb a.i./acre). Although not often used and applied to small areas, there were a few instances where the average annual application rate for a given crop exceeded the maximum labeled rate. For example, the average application rate for squash (2.24 lb a.i./acre) was 448% greater than the maximum labeled rate (0.5 lb a.i./acre); however, only about 25 lb a.i./year was reportedly applied at this rate.

For almost all of the reported crops and uses in the CDPR PUR data, the 95th and 99th percentile estimations of application rates are also well below the maximum labeled rates. Again, the few exceptions to this likely occurred due to a few applications made to small areas or in the alternative, due to misreporting or misuse which is not part of the action being considered. Only maximum application rates as reported in the LUIS report were modeled for this assessment.

Evaluation of the usage data (aggregated by PRZM scenario) showed that oxyfluorfen was applied in the greatest quantity to crops included in the CA almond STD scenario with an average annual application of ~166,100 lb a.i./year. The CA wine grape RLF, CA fruit STD scenario, CA cotton STD scenario, and CA grapes STD scenario followed by ~102,900 lb a.i./year, ~46,200 lb a.i./year, ~40,700 lb a.i./year, and ~40,300 lb a.i./year, respectively. The CA nursery scenario had the highest average application rate at 1.11 lb a.i./acre, which is approximately 56% of the maximum labeled rate. All of the scenarios had average application rates lower than the maximum labeled rate with the exception of the CA cole crop RLF scenario. The average application rate for this scenario was 0.81 lb a.i/acre, which exceeds the maximum labeled rate (0.5 lb a.i./acre) by 62%. However, only two of nine crops actually exceeded the maximum labeled rates; the average application rate for spinach was 4.82 lb a.i./acre, and the average application for horseradish was 0.51 lb a.i./acre.

The 95th and 99th percentile estimations of application rates aggregated by PRZM scenario were, for the majority, less than the maximum labeled rates. There were a few exceptions to this, which were, again, the results of a few applications made to small areas.

There are a few limitations to the CDPR PUR data. There were several uses reported in the PUR data that were either not registered or were misuses according to labels; these accounted for ~7,100 lb a.i./year and are included in the non-categorized category. Because ground and aerial applications of oxyfluorfen in a given scenario often have different maximum labeled rates (aerial applications have lower rates), the aggregation of the application methods prevents aerial exceedances from being seen because the data was compared to the higher ground maximum labeled rate.

A summary of all oxyfluorfen uses in California based on the modeled scenarios is provided in **Table 2.4**. Scenarios with less than 5,000 lb a.i./year are grouped into the “Other Scenarios” category. **Figure 2.3** shows the scenarios with the highest usage as a fraction of the entire average annual usage. Use data for the 20 counties with the highest usage is provided in **Table 2.5**. Complete data tables can be found in **Appendix C**.

Table 2.4 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2006 for Currently Registered Oxyfluorfen Uses Based on Aggregated Scenario				
Scenario		Average Annual Application (lb a.i./year)	Application Rate (lb a.i./acre)	
			Average	Maximum
Scenarios with Usage > 5,000 lb a.i./year	CA almond STD	166,127.47	0.52	11.53
	CA wine grape RLF	102,854.07	0.62	90.01
	CA fruit STD	46,176.92	0.76	41.56
	CA cotton STD	40,731.26	0.22	4.53
	CA grapes STD	40,338.01	0.71	5.57
	CA right of way RLF	27,995.21	0.45	2.40
	CA cole crop RLF	12,006.60	0.81	9.50
	CA rangeland hay RLF	10,949.45	0.68	20.00
	CA onion STD	10,622.11	0.30	3.28
	Non-categorized	7,130.39	0.33	7.43
	CA row crop RLF	6,085.84	0.35	19.81
	CA garlic RLF	5,577.62	0.23	5.39
	CA nursery	5,349.99	1.11	60.00
Other Scenarios with Usage < 5,000 lb a.i./year	CA citrus STD	4,856.31	0.57	16.68
	CA tomato STD	4,749.85	0.20	5.10
	CA olive RLF	1,846.11	0.68	5.38
	CA melons RLF	1,704.65	0.42	8.64
	CA wheat RLF	306.37	0.24	1.57
	OR mint	261.01	0.24	1.20
	CA sugarbeet OP	220.05	0.20	3.22
	CA alfalfa OP	204.76	0.35	1.21
	CA impervious RLF	127.10	0.29	3.72
	CA avocado RLF	126.80	0.65	10.26
	CA strawberry RLF	78.83	0.40	1.59
	CA forestry RLF	64.26	0.94	2.75
	CA lettuce STD	39.90	0.18	0.96
	CA potato RLF	36.90	0.11	0.17
	CA turf RLF	9.72	0.73	3.08
	Total	14,632.61		
	TOTAL FOR ALL SCENARIOS	**496,577.57**		

Figure 2.3 Scenarios with Highest Oxyfluorfen Use Based on CDPR PUR Data from 1999-2006

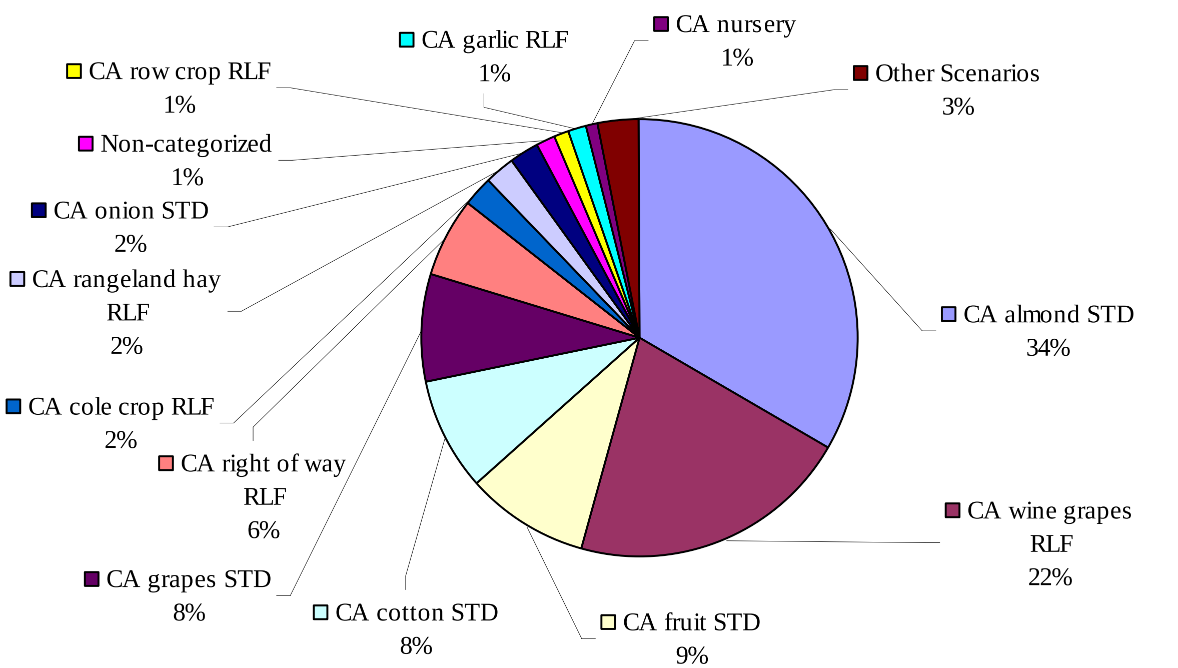


Table 2.5 Summary of California Department of Pesticide Registration (CDPR) Pesticide Usage Reporting (PUR) Data from 1999 to 2006 for 20 Counties with Highest Oxyfluorfen Usage			
County	**Average Annual Application (lb a.i./year)**	**Application Rate (lb a.i./acre)**	
		Average	**Maximum**
KERN	83,100.19	0.33	11.53
FRESNO	71,581.13	0.17	60.00
TULARE	41,761.59	0.99	20.00
MADERA	35,820.63	0.42	41.56
SAN JOAQUIN	31,676.82	0.27	8.64
MERCED	30,375.74	0.18	7.43
MONTEREY	28,456.30	0.23	19.81
STANISLAUS	23,398.53	0.24	8.36
KINGS	21,715.54	0.44	3.48
SAN LUIS OBISPO	15,547.89	0.24	9.84
SONOMA	15,110.81	0.55	90.01
SANTA BARBARA	14,398.70	0.39	15.15
YOLO	9,809.84	0.22	4.79
NAPA	8,463.76	0.47	16.25
SACRAMENTO	7,054.23	0.53	16.94
COLUSA	6,639.99	0.12	2.79
SUTTER	6,156.29	0.29	17.37

Table 2.5 Summary of California Department of Pesticide Registration (CDPR) Pesticide Usage Reporting (PUR) Data from 1999 to 2006 for 20 Counties with Highest Oxyfluorfen Usage			
County	**Average Annual Application (lb a.i./year)**	**Application Rate (lb a.i./acre)**	
		Average	**Maximum**
IMPERIAL	5,957.56	0.44	5.04
GLENN	5,955.73	0.20	6.97
BUTTE	5,934.38	0.41	16.68
All Other Counties	27,668.13		
TOTAL	**496,583.76**		

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 (4,921 feet) (Jennings and Hayes 1994); however, nearly all of the known CRLF populations have been documented below 1,050 meters (3,445 feet) (USFWS 2002).

Populations currently exist along the northern California coast, northern Transverse Ranges (USFWS 2002), foothills of the Sierra Nevada (five to six 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 2.4**). 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 2.6** and shown in **Figure 2.4**.

Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see **Figure 2.4**). **Table 2.6** 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. 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 2.6** (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**.

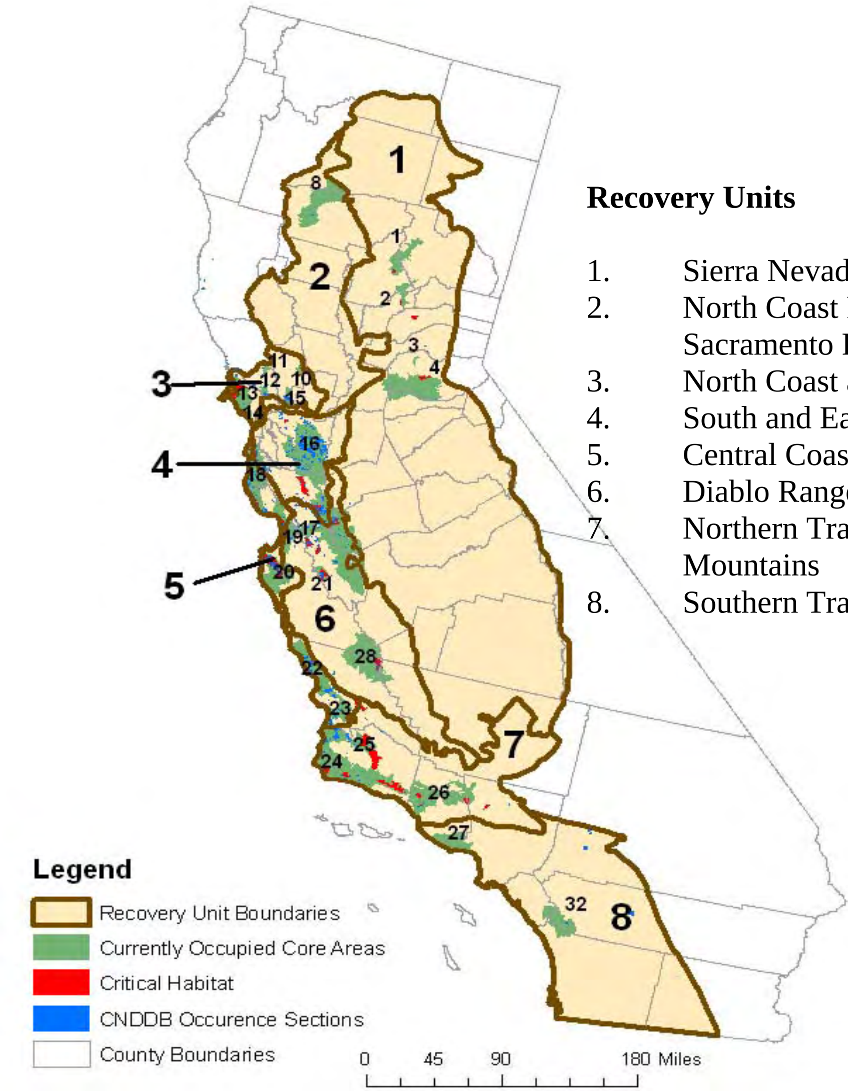
Table 2.6 California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat

Recovery Unit [1] (Figure 2.3)	Core Areas [2,7] (Figure 2.3)	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)	--	✓	
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	--	CCS-1A[6]		

Table 2.6 California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat				
Recovery Unit [1] (Figure 2.3)	**Core Areas [2,7] (Figure 2.3)**	**Critical Habitat Units [3]**	**Currently Occupied (post-1985)[4]**	**Historically Occupied [4]**
Francisco Bay (4)	**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	✓	
	--	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)	--		✓

Table 2.6 California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat				
Recovery Unit [1] (Figure 2.3)	**Core Areas [2,7] (Figure 2.3)**	**Critical Habitat Units [3]**	**Currently Occupied (post-1985)[4]**	**Historically Occupied [4]**

[1] Recovery units designated by the USFWS (USFWS 2002, pg 49).
[2] Core areas designated by the USFWS (USFWS 2002, 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.



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

Figure 2.4 Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

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

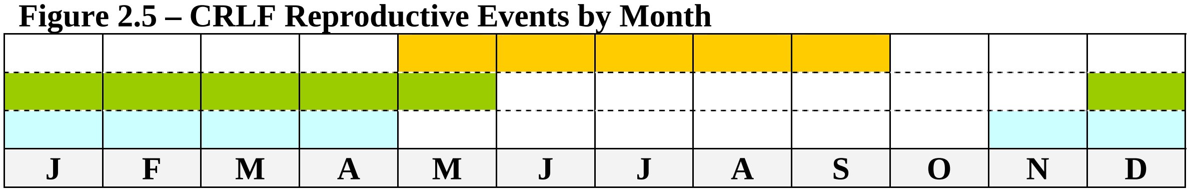
Other Known Occurrences from the CNDBB

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 2,000 to 6,000 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 2.5** depicts CRLF annual reproductive timing.

Figure 2.5 – CRLF Reproductive Events by Month



Light Blue = **Breeding/Egg Masses**
Green = **Tadpoles (except those that over-winter)**
Orange = **Young Juveniles**
Adults and juveniles can be present all year

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 inhabit dense, shrubby, or emergent vegetation closely associated with deep-water pools bordered with cattails and dense stands of overhanging vegetation (http://ecos.fws.gov/speciesProfile/SpeciesReport.do?spcode=D02D).

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 (USFWS 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 2.6**.

'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 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 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 modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of oxyfluorfen 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).
(7) Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

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 oxyfluorfen is expected to directly impact living organisms within the action area, critical habitat analysis for oxyfluorfen 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 oxyfluorfen is likely to encompass considerable portions of the United States based on the large array of 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. The Agency's approach to defining the action area under the provisions of the Overview Document (USEPA 2004) considers the results of the risk assessment process to establish boundaries for that action area with the understanding that exposures below the Agency's defined Levels of Concern (LOCs) constitute a no-effect threshold. For the purposes of this assessment, attention will be focused on the footprint of the action (*i.e.*, the area where pesticide application occurs), plus all areas where offsite transport (*i.e.*, spray drift, downstream dilution, etc.) may result in potential exposure within the state of California that exceeds the Agency's LOCs.

Deriving the geographical extent of this portion of the action area is based on consideration of the types of effects that oxyfluorfen may be expected to have on the environment, the exposure levels to oxyfluorfen that are associated with those effects, and the best available information concerning the use of oxyfluorfen and its fate and transport within the state of California. Specific measures of ecological effect for the CRLF that define the action area include any direct and indirect toxic effect to the CRLF and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature. Therefore, the action area extends to a point where environmental exposures are below any measured lethal or sublethal effect threshold for any biological entity at the whole organism, organ, tissue, and cellular level of organization. In situations where it is not possible to determine the threshold for an observed effect, the action area is not spatially limited and is assumed to be the entire 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 oxyfluorfen. An analysis of labeled uses and review of available product labels was completed. Several of the currently labeled uses are special local needs (SLN) uses or are restricted to specific states other than California and are excluded from this assessment. In addition, a distinction has been made between agricultural uses and those that are non-food/non-agricultural. An analysis of uses of oxyfluorfen results in our determination that those relevant to the CRLF, and considered part of the federal action evaluated in this assessment include the following agricultural uses: avocado, broccoli, cabbage, cauliflower, horseradish, leafy vegetables, garlic, cucurbit vegetables, cantaloupe, watermelons, squash, olive, potato, root and tuber vegetables, artichoke, carrot, celery, fruiting vegetables, pepper, dried-type beans, legume vegetables, strawberry, safflower, cereal grains, grapes, almond, beechnut, Brazil nut, butternut, cashew, chestnut, chinquapin, filbert, hickory nut, jojoba, macadamia nut, pecan, pistachio, tree nuts, walnut, calamondin, citron, citrus, citrus hybrids, grapefruit, kiwi fruit, kumquat, lemon, lime, orange, pummelo, tangelo, tangerines, cotton, apple, apricot, cherry, crabapple, date, feijoa, fig, unspecified fruits, loquat, mayhaw, nectarine, peach, pear, persimmon, plum, pomegranate, prune, quince, grapes, lettuce, onion, tomato, clover, sugarbeet, deciduous fruit trees, peppermint, and spearmint.

In addition, the following non-food and non-agricultural uses are considered: Christmas tree plantations, conifers, cottonwood, forest trees, commercial storage/warehouses/premises, industrial areas (outdoor), non-agricultural outdoor buildings/structures, agricultural uncultivated areas, intermittently flooded areas/waters, mulch, paved areas (private roads/sidewalks), paths/patios, fencerows/hedgerows, non-agricultural right-of-ways/fencerows/hedgerows, airports/landing fields, non-agricultural uncultivated areas/soils, ornamental lawns and turf, nursery stock, conifers (seed orchard), ornamental and/or shade trees, ornamental ground cover, ornamental herbaceous plants, ornamental nonflowering plants, and ornamental woody shrubs and vines.

Following a determination of the uses to assess, an evaluation of the potential "footprint" of oxyfluorfen use patterns (*i.e.*, the area where pesticide application occurs) 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 defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. A map representing all the land cover types that make up the initial area of concern for oxyfluorfen is presented in **Figure 2.6**. Land cover types depicted in the map are:

- <u>Agricultural uses</u>:
    - Cultivated crop
    - Orchard/vineyard
- <u>Non-agricultural uses:</u>
    - Cultivated crop: Christmas tree plantations; ornamentals (all), nursery stock
    - Forest: conifers, cottonwood, forest trees
    - Pasture: agricultural uncultivated areas
    - Turf: ornamental lawns/turf
    - Right-of-ways: non-agricultural right-of-ways/fencerows/hedgerows

- Developed (open space, low density, medium density, high density): mostly urban and residential, to encompass all 'no match' uses below:
  - Commercial storage/warehouse/premises, industrial areas (outdoor), non-agricultural outdoor buildings/structures, intermittently flooded areas/waters, mulch, paved areas (private roads/sidewalks), paths/patios, fencerows/hedgerows, non-agricultural uncultivated areas/soils

More information regarding which specific uses are represented for each land cover types can be found in **Appendix D**.

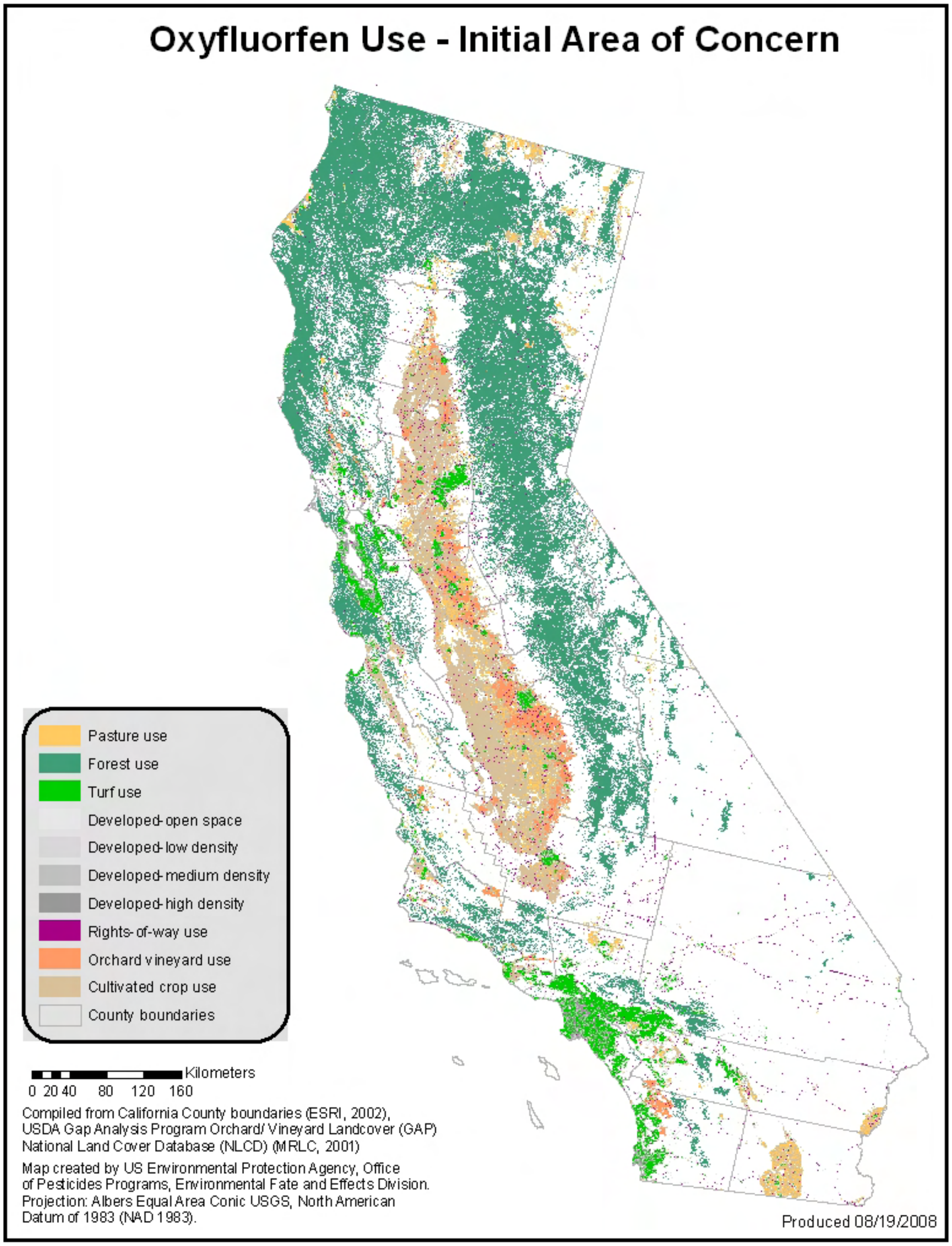


Figure 2.6 Initial Area of Concern, or "Footprint" of Potential Use, for Oxyfluorfen

Once the initial area of concern is defined, the next step is to define the potential boundaries of the action area by determining the extent of offsite transport via spray drift and runoff where exposure of one or more taxonomic groups to the pesticide exceeds the listed species LOCs.

As previously discussed, the action area is defined by the most sensitive measure of direct and indirect ecological toxic effects including reduction in survival, growth, reproduction, and the entire suite of sublethal effects from valid, peer-reviewed studies.

Because oxyfluorfen has been recognized as a possible human carcinogen (HED's Human Health Risk Assessment for Reregistration Eligibility Decision (RED), April 29, 2002, D281831; **Appendix E**), the spatial extent of the action area (*i.e.*, the boundary where exposures and potential effects are less than the Agency's LOC) for oxyfluorfen cannot be determined. Therefore, it is assumed that the action area encompasses the entire state of California, regardless of the spatial extent (*i.e.*, initial area of concern or footprint) of the pesticide use(s). In addition, it is reasonable to assume that the action area encompasses the entire state of California given the broad range of labeled uses and the large geographic coverage of the state for those uses.

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."[3] 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.*, water bodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of oxyfluorfen (*e.g.*, runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to oxyfluorfen *(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 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. It should be noted that assessment endpoints are limited to direct and indirect effects associated with survival, growth, and fecundity, and do not include the full suite of sublethal effects used to define the action area. According to the Overview Document (USEPA 2004), the Agency relies on acute and chronic effects endpoints that are either direct measures of impairment of survival, growth, or fecundity or endpoints for which there is a scientifically robust, peer-reviewed relationship that can quantify the impact of the measured effect endpoint on the assessment endpoints of survival, growth, and fecundity.

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

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** of this document. A summary of the assessment endpoints and measures of ecological effect selected to quantify and characterize potential assessed direct and indirect CRLF risks associated with exposure to oxyfluorfen is provided in **Table 2.7**.

Table 2.7 Assessment Endpoints and Measures of Ecological Effects

Assessment Endpoint	Measures of Ecological Effects[1]
Aquatic-Phase CRLF (Eggs, larvae, juveniles, and adults)[a]	
Direct Effects	
1. Survival, growth, and reproduction of CRLF	1a. Bluegill sunfish, acute LC_{50} 1b. Fathead minnow chronic NOAEC (from early-life stage study)
Indirect Effects and Critical Habitat Effects	
2. Survival, growth, and reproduction of CRLF individuals via indirect effects on aquatic prey food supply (*i.e.*, fish, freshwater invertebrates, non-vascular plants)	2a. *Selenastrum capricornutum* EC_{50} 2b. Fathead minnow chronic NOAEC (from early-life stage study)
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	3a. *Lemna gibba* EC_{50} 3b. *Selenastrum capricornutum* EC_{50}
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation	4a. Monocot EC_{25}: ryegrass (seedling emergence) and oats (vegetative vigor) 4b. Dicot EC_{25}: lettuce (seedling emergence and vegetative vigor)
Terrestrial-Phase CRLF (Juveniles and adults)	
Direct Effects	
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Northern bobwhite quail[b] acute LD_{50} 5b. Northern bobwhite quail[b] chronic NOAEC
Indirect Effects and Critical Habitat Effects	
6. Survival, growth, and reproduction of CRLF individuals via effects on terrestrial prey (*i.e.,*terrestrial invertebrates, small mammals, and frogs)	6a. Earthworm acute LC_{50}[c] 6b. Laboratory rat acute LD_{50} 6c. Laboratory rat chronic NOAEL 6d. Northern bobwhite quail[b] acute LD_{50} 6e. Northern bobwhite quail[b] chronic NOAEC
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian and upland vegetation)	7a. Monocot EC_{25}: ryegrass (seedling emergence) and oats (vegetative vigor) 7b. Dicot $EC_{25:}$ lettuce (seedling emergence and vegetative vigor)

Table 2.7 Assessment Endpoints and Measures of Ecological Effects
[1]All registrant-submitted and open literature toxicity data reviewed for this assessment are included in **Appendix F** and **Appendix G**. [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 that exposure pathways on land. [b]Birds are used as surrogates for terrestrial phase amphibians. [c]The earthworm study was the only terrestrial invertebrate study providing a definitive LC50. Other terrestrial invertebrate (honey bee and other beneficial insect) studies were used to qualitatively characterize risk as definitive toxicity values could not be obtained from these submitted studies.

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 oxyfluorfen 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 and jeopardize the continued existence of the CRLF. 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 oxyfluorfen effects data are available.

Modification to the critical habitat of the CRLF as specified by USFWS (2006) is detailed in **Section 2.6**. Measures of such possible effects by labeled use of oxyfluorfen on critical habitat of the CRLF are described in **Table 2.8**. 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 modification standard established by USFWS (2006).

<table>
<tr><th colspan="2">Table 2.8 Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat[a]</th></tr>
<tr><th>Assessment Endpoint</th><th>Measures of Ecological Effect</th></tr>
<tr><td colspan="2">Aquatic-Phase CRLF PCEs
(Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)</td></tr>
<tr><td>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.</td><td>a. Selenastrum capricornutum EC_{50}
b. Terrestrial Monocot EC_{25}: ryegrass (seedling emergence) and oats (vegetative vigor)
c. Terrestrial Dicot EC_{25}: lettuce (seedling emergence, vegetative vigor)</td></tr>
<tr><td>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.</td><td>a. Selenastrum capricornutum EC_{50}
b. Terrestrial Monocot EC_{25}: ryegrass (seedling emergence) and oats (vegetative vigor)
c. Terrestrial Dicot EC_{25}: lettuce (seedling emergence, vegetative vigor)</td></tr>
<tr><td>Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.</td><td>a. Daphnia magna EC_{50}
b. Fathead minnow chronic NOAEC (from early-life stage study)</td></tr>
<tr><td>Reduction and/or modification of aquatic-based food sources for pre-metamorphs (e.g., algae).</td><td>a. Selenastrum capricornutum EC_{50}</td></tr>
<tr><td colspan="2">Terrestrial-Phase CRLF PCEs
(Upland Habitat and Dispersal Habitat)</td></tr>
<tr><td>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="4">a. Monocot EC_{25}: ryegrass (seedling emergence) and oats (vegetative vigor)
b. Dicot EC_{25}: lettuce (seedling emergence and vegetative vigor)
c. Earthworm acute LC_{50}[b]
d. Rat acute LD_{50}
e. Rat chronic NOAEL
f. Northern bobwhite quail acute LD_{50}
g. Northern bobwhite quail chronic NOAEC</td></tr>
<tr><td>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></tr>
<tr><td>Reduction and/or modification of food sources for terrestrial phase juveniles and adults.</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>
<tr><td colspan="2">[a] 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.
[b] The earthworm study was the only terrestrial invertebrate study providing a definitive LC50. Other terrestrial invertebrate (honey bee and other beneficial insect) studies were used to qualitatively characterize risk as definitive toxicity values could not be obtained from these submitted studies.</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 (USEPA 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of oxyfluorfen to the environment. The following risk hypotheses are presumed for this endangered species assessment:

The labeled use of oxyfluorfen within the action area may:

- directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect the CRLF by reducing or changing the composition of food supply;
- 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 and/or cover;
- 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;
- 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);
- modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- 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.
- 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.
- 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 oxyfluorfen 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 **Figures 2.7** and **2.8**, respectively, and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in **Figures**

2.9 and **2.10**, respectively. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the CRLF and modification to designated critical habitat is expected to be negligible.

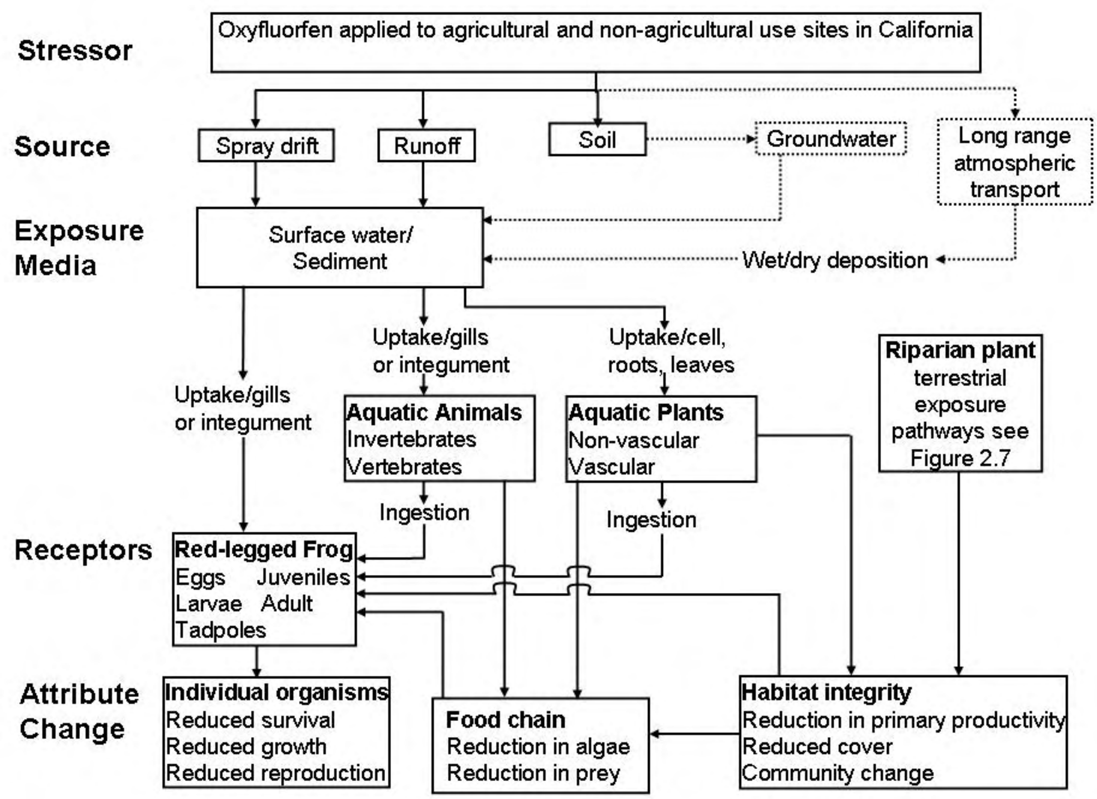


Figure 2.7 Conceptual Model for Aquatic-Phase CRLF

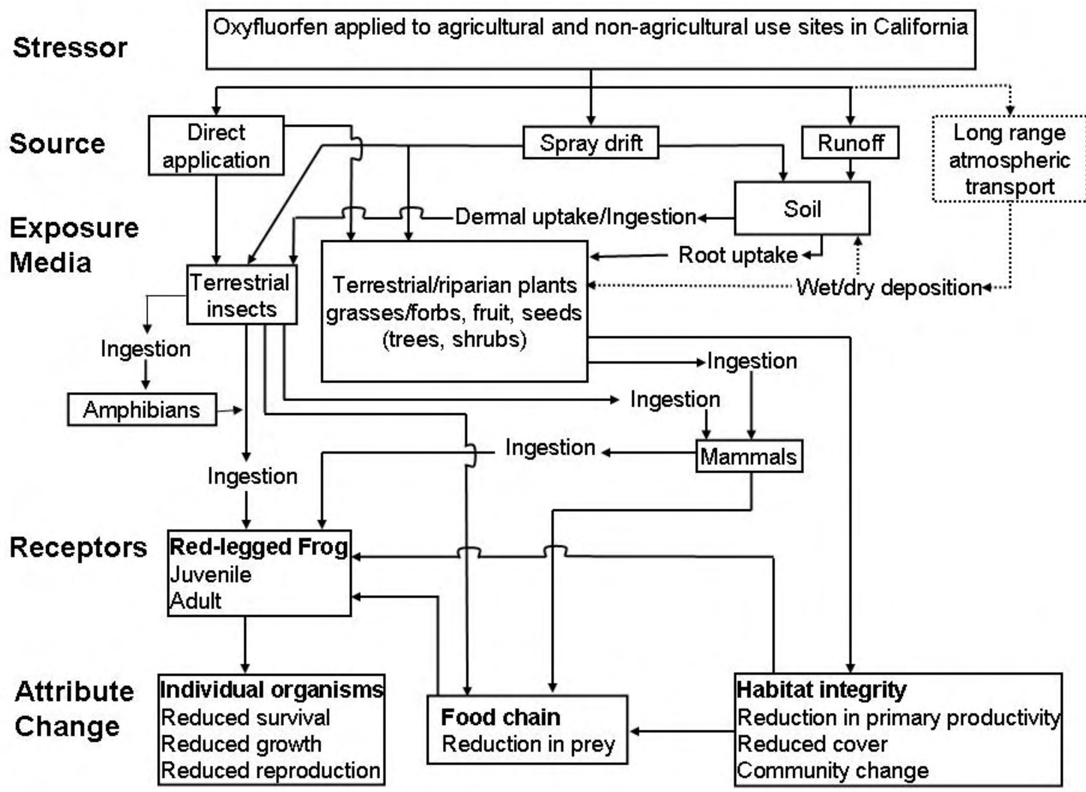


Figure 2.8 Conceptual Model for Terrestrial-Phase CRLF

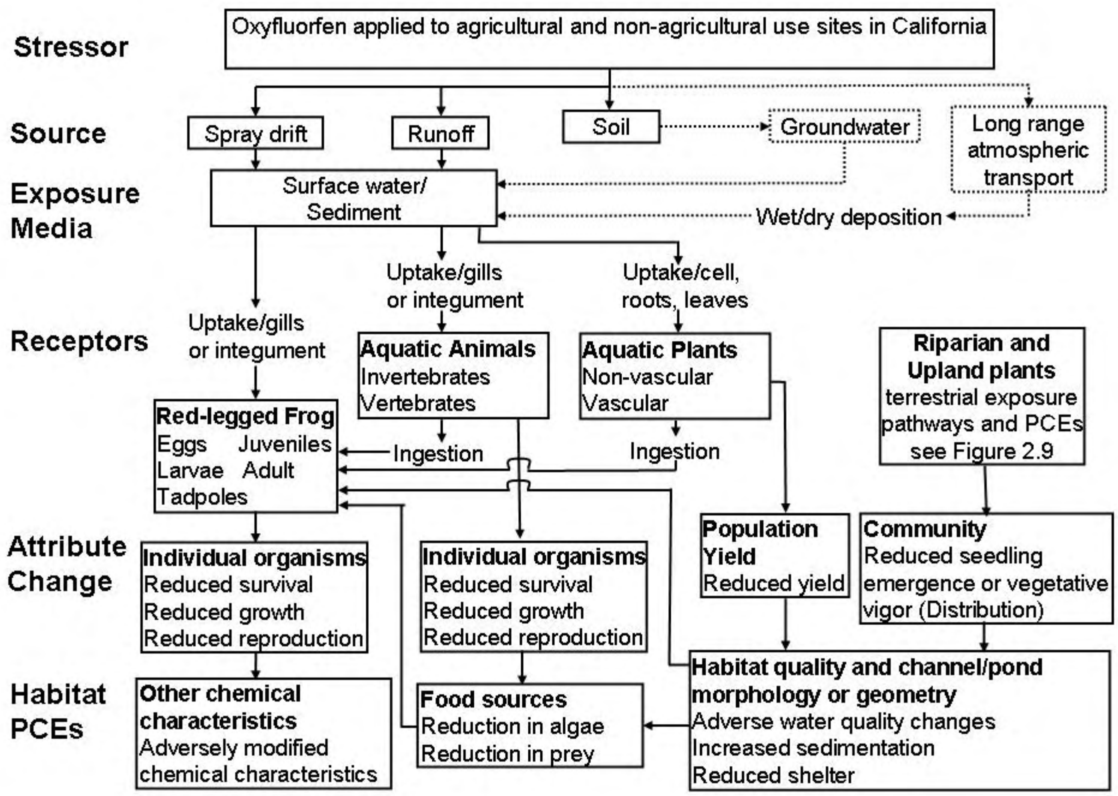


Figure 2.9 Conceptual Model for Pesticide Effects on Aquatic Component of CRLF Critical Habitat

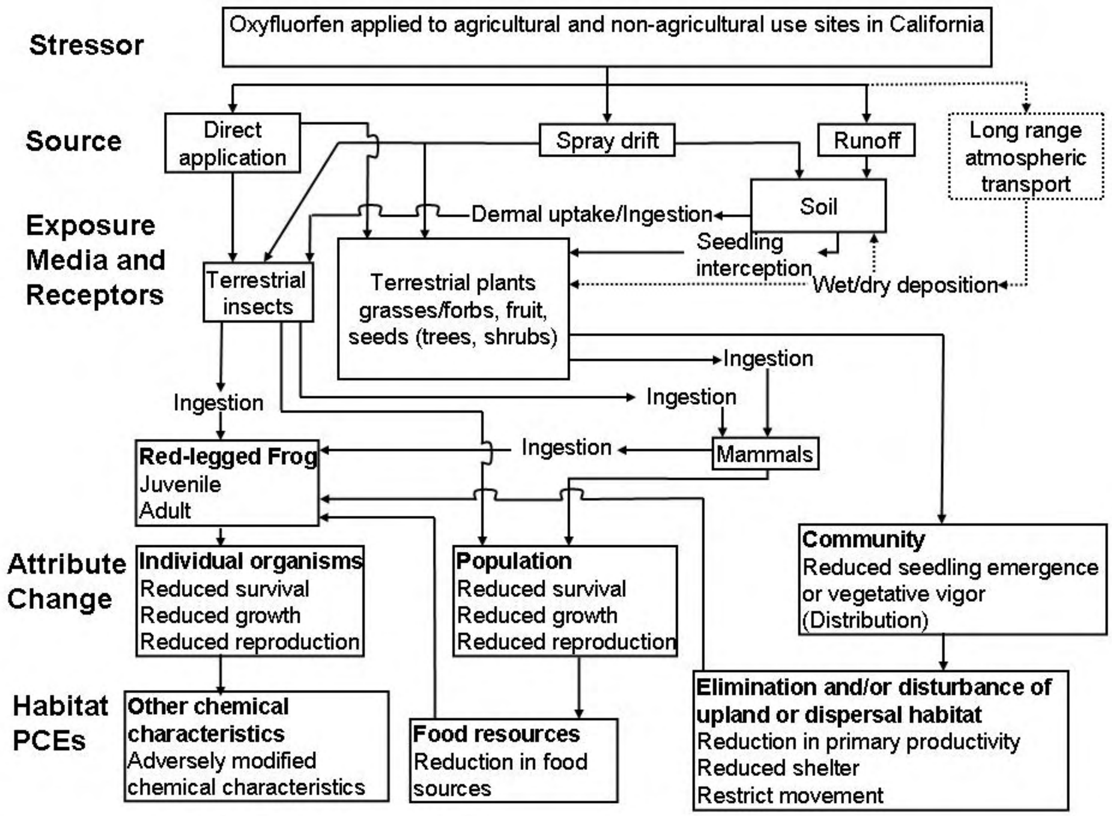


Figure 2.10 Conceptual Model for Pesticide Effects on Terrestrial Component of CRLF Critical Habitat

2.10 Analysis Plan

In order to address the risk hypothesis, 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 oxyfluorfen 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 (USEPA 2004), the likelihood of effects to individual organisms from particular uses of oxyfluorfen 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 Hypothesis and Conceptual Model

2.10.1.1 Measures of Exposure

The environmental fate properties of oxyfluorfen along with available monitoring data indicate that runoff and spray drift are the principle potential transport mechanisms of oxyfluorfen to the aquatic and terrestrial habitats of the CRLF. In this assessment, transport of oxyfluorfen through runoff and spray drift is considered in deriving quantitative estimates of oxyfluorfen 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 oxyfluorfen using maximum labeled application rates and least restrictive 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. The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data.

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 (August 2007) to generate daily exposures and 1-in-10 year EECs of oxyfluorfen that may occur in surface water bodies adjacent to application sites receiving oxyfluorfen 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 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 oxyfluorfen. 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.

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, December 7, 2006). This model incorporates the Kenaga 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 represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenaga 1972). For modeling purposes, direct exposures of the CRLF to oxyfluorfen through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey (small mammals) are assessed using the small mammal (15 g) which consumes short grass. The small bird (20 g) consuming small insects and the small mammal (15 g) 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. Estimated exposures of terrestrial insects to oxyfluorfen are bound by using the dietary-based EECs for small insects and large insects. In addition, terrestrial exposures from granular applications (mg a.i./square foot) for the CRLF are also estimated using T-REX and an earthworm fugacity model.

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 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.

EECs for terrestrial plants inhabiting dry and wetland areas are derived using TerrPlant (version 1.2.2, December 26, 2006). This model uses estimates of pesticides in runoff and in spray drift to calculate EECs. EECs are based on solubility, application rate, and minimum incorporation depth.

AgDRIFT is the spray drift model used to assess exposures of terrestrial phase CRLF and its prey to oxyfluorfen deposited on terrestrial habitats by spray drift. In addition to the buffered area from the spray drift analysis, the downstream extent of oxyfluorfen that exceeds the LOC for the effects determination is also considered.

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 oxyfluorfen 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).

It is important to note that the measures of effect for direct and indirect effects to the CRLF and its designated critical habitat are associated with impacts to survival, growth, and fecundity, and do not include the full suite of sublethal effects used to define the action area. According to the Overview Document (USEPA 2004), the Agency relies on effects endpoints that are either direct measures of impairment of survival, growth, or fecundity or endpoints for which there is a scientifically robust, peer reviewed relationship that can quantify the impact of the measured effect endpoint on the assessment endpoints of survival, growth, and fecundity.

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 oxyfluorfen, 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 oxyfluorfen 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 I**).

For this endangered species assessment, listed species LOCs are used for comparing RQ values for acute and chronic exposures of oxyfluorfen directly to the CRLF. If estimated exposures directly to the CRLF of oxyfluorfen 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 oxyfluorfen 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 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 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 I**.

2.10.2 Data Gaps

2.10.2.1 Fate and Transport Data

The registrant-submitted fate and transport data (classified as either Acceptable or Supplemental) provide sufficient information for EFED to identify oxyfluorfen routes of dissipation in surface soils and water, and therefore, were sufficient to conduct the risk assessment. No apparent data gaps were identified in the fate and transport database. The shortcomings of fate and transport studies are provided in their summaries in **Appendix B**.

2.10.2.2 Ecotoxicity Data

No registrant-submitted studies or studies identified in the open literature document the acute or chronic exposure effects of oxyfluorfen on amphibians. Therefore, acute and chronic toxicity data on fish and birds (which served as surrogate species for aquatic and terrestrial phase amphibians, respectively) were used.

There is a lack of toxicity testing conducted under natural lighting conditions.. Because toxicity of the LDPHs is affected by the presence of ultraviolet (UV) radiation, most toxicity tests used in this assessment, which were conducted under standard laboratory lighting conditions, may underestimate the toxicity of oxyfluorfen to some taxa under natural sunlight conditions. Fish early life-cycle studies on oxyfluorfen conducted under UV light indicate larval fish LD_{50}'s are approximately an order of magnitude lower than LD_{50}'s based on standard lighting conditions (MRID 465851-04). The extent to which UV light enhances the toxicity of oxyfluorfen to other taxa is unknown; existing studies conducted under standard laboratory lighting may underestimate the toxicity. It is also unknown whether enhanced toxic effects would be observed in acute fish testing.

3. Exposure Assessment

Oxyfluorfen is formulated as a liquid, an emulsifiable concentrate, a granule, and ready-to-use products. Oxyfluorfen may be aerially applied or ground applied in band treatment or broadcast using various sprayers and spreaders. Risks from ground boom and aerial applications are expected to result in the highest off-target levels of oxyfluorfen. Ground boom and aerial applications tend to use lower volumes of chemical applied in finer sprays than applications with coincident use of sprayers and spreaders and thus have a higher potential for off-target movement via spray drift.

3.1 Label Application Rates and Intervals

Oxyfluorfen labels may be categorized into two types: labels for manufacturing uses (including technical grade oxyfluorfen and its formulated products) and end-use products. While technical products, which contain oxyfluorfen 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 pre- and post-emergent broadleaf and monocot weeds. The formulated product labels legally limit oxyfluorfen's use to only those sites that are specified on the labels. These products, their use sites, rates, and mitigation measures are discussed in **Section 2.4.4**. Additionally, an explanation for the selection of specific application intervals used in modeling exposure is located in **Section 6.1.1**.

3.2 Aquatic Exposure Assessment

3.2.1 Modeling Approach

Aquatic exposures are quantitatively estimated for all assessed uses using scenarios that represent high exposure sites for oxyfluorfen 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 larger 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 same 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.

Crop-specific management practices for all of the assessed uses of oxyfluorfen were used for modeling These parameters included 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. For example, the distribution of pounds of oxyfluorfen applied per day to grapes from the CDPR PUR data for 2006 used to pick a

February 1 initial application date is shown in **Figure 3.1**. More detail on the crop profiles and the previous assessments may be found at:
http://pestdata.ncsu.edu/cropprofiles/cropprofiles.cfm

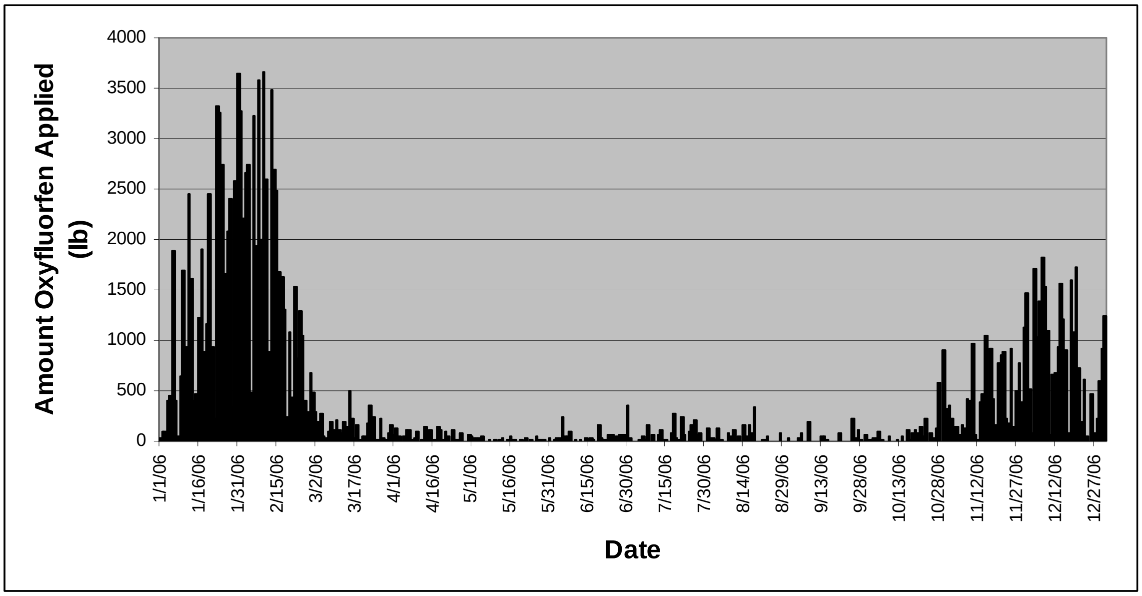


Figure 3.1 Summary of Oxyfluorfen Applications (total pounds per day) to Grapes (all types) in 2006 from CDPR PUR Data

3.2.2 Model Inputs

Oxyfluorfen is an herbicide used on a wide variety of food and non-food crops. Oxyfluorfen environmental fate data used for generating model parameters are listed in **Tables 2.1.a and 2.1.b**. The input parameters for PRZM and EXAMS are in **Table 3.2**.

Table 3.2 Summary of PRZM/EXAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Oxyfluorfen Endangered Species Assessment for the CRLF

Model Parameter	Value	Comment	Data Source
Maximum Single Application Rate	Depends on scenario	See **Table 2.3** for values for each scenario	Product labels
Number of Applications	Depends on scenario	See **Table 2.3** for values for each scenario	Product labels
Anaerobic Soil Metabolism Rate ($t_{½}$)	654 days	Upper confidence bound on the mean of metabolism $t_{½}$ of 554 and 603 days[1]	MRID 921361-11
Aerobic Aquatic Degradation Rate ($t_{½}$)	50 days	Upper confidence bound on the mean of metabolism $t_{½}$ of 30 and 40 days[1]	MRID 463731-04

Table 3.2 Summary of PRZM/EXAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Oxyfluorfen Endangered Species Assessment for the CRLF			
Model Parameter	**Value**	**Comment**	**Data Source**
Anaerobic Aquatic Degradation Rate ($t_{1/2}$)	1308 days	Twice the anaerobic soil metabolism input parameter[1]	MRID 921361-11
Aqueous Photolysis Rate ($t_{1/2}$)	7.5 days	The longest $t_{1/2}$ value of all available (3.7, 5.4, 6.2, and 7.5 days) [1]	MRID 421291-01
Hydrolysis ($t_{1/2}$)	Stable		MRID 134454
K_{OC}	12233 L/kg	Mean of 4 Koc values (2891, 8076, 5585, and 32381 L/kg)[1]	MRID 921361-12, 921360-99
Molecular Weight	361.7 g/mole		Product chemistry
Water Solubility	1.16 mg/l	10 x solubility[1]	Product chemistry
Vapor Pressure	2.5 E-7 torr		Product chemistry
Henry's Law Constant	8.21E-7 atm·m^3/mole		Experimental database EPI Suite
Application Method (CAM)	1	Soil application	Product labels
Application Efficiency	0.99 ground spray 0.95 aerial spray 1.00 granular	SDTF application efficiency data	Product label
Spray Drift Fraction	0.01 ground spray 0.05 aerial spray 0.0 granular	SDTF application efficiency data	Product labels

[1]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

3.2.2.1 Post-processing of PRZM/EXAMS outputs to develop EECs for non-cropland areas

Available data from California DPR indicate that use of oxyfluorfen on rights-of-way represents a significant portion of the past (1999-2006) use of oxyfluorfen (6% of total use). Of uses of oxyfluorfen on non-cropland areas, 82% was applied to rights-of-way.

Rights-of-way include roads, highways, railroads, utilities, and pipelines. These areas contain both impervious (*i.e.*, cement, asphalt, metal surfaces) and pervious surfaces. It is assumed that oxyfluorfen will be applied to the pervious surfaces where weeds are expected to grow. It is also assumed that oxyfluorfen is not applied to impervious surfaces in rights-of way, but that there is a 1% incidental spray onto impervious surfaces surrounding rights-of-way. Further details on how these values were derived as well as characterization of alternative assumptions are provided in the Barton Springs salamander endangered species risk assessment for atrazine (USEPA 2006).

In a standard PRZM scenario, it is assumed that an entire 10-hectare field is composed only of the identified crop and that the field has uniform surface properties throughout the field. In a right-of-way, this is not a reasonable assumption, since a right-of-way generally contains both impervious and pervious surfaces. Since the two surfaces have different properties (especially different curve numbers influencing the runoff from the surfaces) and different amounts of oxyfluorfen applied, the standard approach for deriving aquatic EECs is revised using the following approach:

1) Aquatic EECs are derived for the pervious portion of the right-of-way, using the maximum use rate of oxyfluorfen on the CA right-of-way scenario. At this point, it is assumed that 100% of the right-of-way is composed of pervious surface. Specific inputs for this modeling are defined below.
2) Aquatic EECs are derived for the impervious portion of the right-of-way using 1% for liquid formulation of the maximum use rate of oxyfluorfen on the CA impervious scenario. At this point, it is assumed that 100% of the right-of-way is composed of impervious surface.
3) The daily aquatic EECs (contained in the PRZM/EXAMS output file with the suffix "TS") are input into a Microsoft® Excel® worksheet.
4) Daily aquatic EECs for the impervious surface are multiplied by 50%. Daily aquatic EECs for the pervious surface are multiplied by 50%. The resulting EECs for impervious and pervious surfaces are added together to get an adjusted EEC for each day of the 30-year simulation period (**Equation 3.1**).

   Equation 3.1

   Revised EEC = (*impervious EEC* * 50%) + (*pervious EEC* * 50%)

5) Rolling averages for the relevant durations of exposure (21-day and 60-day averages) are calculated. The 1-in-10 year peak, 21-day, and 60-day values are used to define the acute and chronic EECs for the aquatic habitat.

In this modeling approach, it is assumed that rights-of-way are composed of equal parts pervious and impervious surfaces (*i.e.*, in step 4, the EECs of both surfaces are multiplied by 50%). However, in reality, it is likely that rights-of-way contain different ratios of the two surfaces. In general, incorporation of impervious surfaces into the exposure assessment results in increasing runoff volume in the watershed, which tends to reduce overall pesticide exposure (when assuming 1% overspray to the impervious surface).

Residential EECs were post-processed in the same manner as rights-of way uses because residential scenarios are often composed of both impervious and pervious surfaces as well (a 50/50 ratio was assumed).

3.2.3 Results

The aquatic 1-in-10-year EECs for the 28 scenarios (ground and aerial applications) are listed in **Table 3.3.a.** The peak EECs range from 0.347 µg/L (ground application to potato) to 46.40 µg/L (liquid ground application in nurseries), with an average of 5.14 µg/L, and median of 2.08 µg/L. The 21-day average EECs range from 0.149 µg/L (for ground application to potato) to 24.40 µg/L (liquid ground application in nurseries), with an average value of 2.79 µg/L and median of 1.27 µg/L for all scenarios modeled. The predicted 60-day average EECs range from 0.117 µg/L (ground application to potato) to 21.03 µg/L (liquid ground application in nurseries), with an average value of 2.36 µg/L and median of 1.04 µg/L for all scenarios modeled.

Table 3.3.a Aquatic EECs (µg/L) for Oxyfluorfen Uses in California

Scenario	Method[1]	Application Rate*	1st App. Date[4]	Peak EEC	21-day Average EEC	60-day Average EEC
Orchard Uses						
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	Dec 1	5.57	2.14	1.63
CA Olive RLF	G	1 app @ 2 lb a.i./acre	Dec 1	1.67	0.907	0.784
CA Almond STD	G	1 app @ 2 lb a.i./acre	Dec 1	3.69	1.69	1.28
	A	1 app @ 0.5 lb a.i./acre	Apr 1	1.78	0.761	0.586
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	Jan 1	1.83	0.983	0.891
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	2.08	1.08	0.948
CA Fruit STD	G	1 app @ 2 lb a.i./acre	Jan 1	1.82	1.02	0.765
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	2.34	1.29	1.15
CA Grapes STD	G	1 app @ 2 lb a.i./acre	Feb 1	1.57	0.814	0.593
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Feb 1	2.27	1.18	1.07
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	Feb 1	6.81	3.50	2.85
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Feb 1	3.47	2.36	2.24
Agricultural – Food Crop Uses						
CA Cole Crop RLF	G	1 app @ 0.5 lb a.i./acre	Dec 1	2.04	1.40	1.11
	A	1 app @ 0.5 lb a.i./acre	Dec 1	2.53	1.56	1.31
CA Garlic RLF	G	1 app @ 0.5 lb a.i./acre	Mar 1	1.60	0.759	0.581
	A	1 app @ 0.5 lb a.i./acre	Sep 1	1.81	0.792	0.620
CA Lettuce STD	G	1 app @ 0.5 lb a.i./acre	Nov 1	3.53	2.15	1.83
	A	1 app @ 0.5 lb a.i./acre	Sep 1	3.60	2.05	1.83
CA Melons RLF	G	1 app @ 0.5 lb a.i./acre	Dec 1	1.27	0.651	0.541
	A	1 app @ 0.5 lb a.i./acre	Dec 1	1.83	0.908	0.724
CA Onion STD	G	1 app @ 0.5 lb a.i./acre	Jan 1	0.398	0.220	0.166
	A	1 app @ 0.5 lb a.i./acre	Jan 1	1.59	0.611	0.434
CA Potato RLF	G	1 app @ 0.5 lb a.i./acre	Apr 1	0.347	0.149	0.117
	A	1 app @ 0.5 lb a.i./acre	Apr 1	1.55	0.549	0.371
CA Strawberry RLF	G	1 app @ 0.5 lb a.i./acre	Jan 1	2.02	1.29	1.02

Table 3.3.a Aquatic EECs (µg/L) for Oxyfluorfen Uses in California						
Scenario	Method[1]	Application Rate*	1st App. Date[4]	Peak EEC	21-day Average EEC	60-day Average EEC
	A	1 app @ 0.5 lb a.i./acre	Jan 1	2.68	1.51	1.23
CA Sugarbeet OP	G	1 app @ 0.5 lb a.i./acre	Mar 1	0.532	0.253	0.215
	A	1 app @ 0.5 lb a.i./acre	Mar 1	1.69	0.652	0.475
CA Tomato STD	G	1 app @ 0.5 lb a.i./acre	Dec 1	0.820	0.431	0.349
	A	1 app @ 0.5 lb a.i./acre	Jan 1	1.71	0.718	0.531
CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	Feb 1	2.36	1.28	1.07
	A	1 app @ 0.5 lb a.i./acre	Feb 1	2.58	1.44	1.27
OR Mint	G	1 app @ 2 lb a.i./acre	Mar 1	3.06	2.00	1.85
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	Dec 1	5.25	2.93	2.40
	A	1 app @ 0.5 lb a.i./acre	Mar 1	1.93	0.923	0.715
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	May 1	1.01	0.587	0.535
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	2.66	1.27	1.04
	A	1 app @ 0.5 lb a.i./acre	Jan 1	1.91	1.02	0.847
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	Mar 1	3.98	2.25	1.69
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Mar 1	17.43	8.69	6.72
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	Jan 1	46.40	24.40	21.03
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	Jan 1	46.19	23.97	20.48
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	Jan 1	18.49	10.50	9.25
	G	2 apps @ 2 lb a.i./acre (30 day interval)	Jan 1	15.55	8.82	8.07
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	7.89	5.31	4.84
CA Residential RLF[2]	G	1 app @ 2 lb a.i./acre	Mar 1	1.04	0.430	0.302
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Mar 1	1.54	0.891	0.821
CA Right-of-Way RLF[3]	G	1 app @ 2 lb a.i./acre	Mar 1	2.88	1.63	1.41
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Mar 1	8.89	6.45	5.24
CA Turf RLF	G	1 app @ 2 lb a.i./acre	Mar 1	1.54	0.74	0.58
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Mar 1	3.39	2.29	2.07

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[2]Modeled with 1% overspray using Impervious Scenario, post-processed with Residential scenario with 50/50 ratio.
[3]Modeled with 1% overspray using Impervious Scenario, post-processed with Right-of-Way scenario with 50/50 ratio.
[4]See **Section 3.2.1** for explanation of initial application date selection.
*All scenarios with multiple applications modeled with an assumed interval of 30 days (based on EFED's knowledge of herbicide cultural practices) except for the Nursery scenario, which was modeled with a 90 day interval based on instructions on a product label. See **Section 6.1.1** for explanation of application interval selection.

The benthic 1-in-10-year EECs for the selected scenarios by ground and aerial application practices are listed in **Table 3.4** below. The EECs for pore water were provided for selected uses only: those that had the greatest usage in California in 1999 to 2006 and a range of scenarios that represented the high, middle, and low predicted water column EECs. The peak benthic EECs range from 0.085µg/L (ground application to potato) to 16.88 µg/L (liquid ground application in nurseries). The 21-day average EECs range from 0.085 µg/L (for ground application to potato) to 16.84 µg/L (liquid ground application in nurseries). The predicted 60-day average EECs range from 0.084 µg/L (ground application to potato) to 16.67 µg/L (liquid ground application in nurseries).

Table 3.4 Benthic Pore Water EECs (µg/L) for Selected Oxyfluorfen Uses in California

Scenario	Method[1]	Application Rate*	1st App. Date	Peak EEC	21-day Average EEC	60-day Average EEC
Orchard Uses						
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	Dec 1	1.18	1.18	1.17
CA Almond STD	G	1 app @ 2 lb a.i./acre	Dec 1	1.04	1.03	1.02
	A	1 app @ 0.5 lb a.i./acre	Apr 1	0.452	0.451	0.448
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	Jan 1	0.710	0.708	0.702
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	0.737	0.735	0.727
CA Fruit STD	G	1 app @ 2 lb a.i./acre	Jan 1	0.544	0.543	0.539
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	0.881	0.880	0.872
CA Grapes STD	G	1 app @ 2 lb a.i./acre	Feb 1	0.430	0.428	0.423
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Feb 1	0.839	0.837	0.825
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	Feb 1	2.40	2.39	2.38
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Feb 1	1.80	1.79	1.77
Agricultural – Food Crop Uses						
CA Potato RLF	G	1 app @ 0.5 lb a.i./acre	Apr 1	0.085	0.085	0.084
	A	1 app @ 0.5 lb a.i./acre	Apr 1	0.256	0.255	0.252
CA Strawberry RLF	G	1 app @ 0.5 lb a.i./acre	Jan 1	0.777	0.776	0.769
	A	1 app @ 0.5 lb a.i./acre	Jan 1	0.982	0.980	0.971
Agricultural – Non-food Crop Uses						
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	Jan 1	0.780	0.777	0.768
	A	1 app @ 0.5 lb a.i./acre	Jan 1	0.610	0.609	0.606
CA Rangeland Hay RLF	G	4 apps @ 2 lb a.i./acre (30 day interval)	Mar 1	5.71	5.70	5.65
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	Jan 1	16.88	16.84	16.67
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	Jan 1	16.38	16.34	16.17
CA Turf RLF	G	1 app @ 2 lb a.i./acre	Mar 1	0.472	0.471	0.465
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Mar 1	1.81	1.81	1.79

Table 3.4 Benthic Pore Water EECs (µg/L) for Selected Oxyfluorfen Uses in California						
Scenario	Method[1]	Application Rate*	1[st] App. Date	Peak EEC	21-day Average EEC	60-day Average EEC
[1]G = ground application. Aerial = aerial application. All applications are liquid unless otherwise specified. *All scenarios with multiple applications modeled with an assumed interval of 30 days (based on EFED's knowledge of herbicide cultural practices) except for the Nursery scenario, which was modeled with a 90 day interval based on instructions on a product label.						

The PRZM-EXAMS modeling results in oxyfluorfen accumulation from year to year. This observation is not unexpected due to the persistence of oxyfluorfen in aquatic and soil environments as well as the static nature of the PRZM/EXAMS 'standard pond' scenario. The 1-in-10 year concentrations, as routinely reported for Tier II aquatic exposure modeling, may or may not be conservative for actual aquatic environments depending on how water bodies depart from assumptions in PRZM/EXAMS. For example, if flow conditions that result in the removal of pesticide mass are present in the actual water body, then the modeled concentrations may be higher than any measured concentrations. In addition, the probabilistic interpretation of the 1-in-10 year concentrations as a return frequency may not be defensible because of temporal auto-correlation in the modeled concentrations.

3.2.4 Existing Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. An evaluation of the surface water monitoring data was conducted to assess the occurrence of oxyfluorfen in California surface and ground waters. Most of this data, however, is non-targeted (*i.e.*, study was not specifically designed to capture oxyfluorfen concentrations in high-use areas). Included in this assessment are surface and ground water data obtained from the USGS NAWQA data warehouse (http://water.usgs.gov/nawqa/data). Typically, sampling frequencies employed in these monitoring studies are insufficient to document peak exposure values. This, coupled with the fact that these data are not temporally or spatially correlated with pesticide applications, limits the utility of these data for estimating exposure concentrations for risk assessment purposes. These monitoring data are characterized in terms of general statistics including number of samples, frequency of detection, maximum concentration, and mean value of all detections, where that level of detail is available. Surface water data were not available for oxyfluorfen at the California Department of Pesticide Regulation (CDPR) web (http://www.cdpr.ca.gov/docs/sw/surfdata.htm). No STORET data (http://www.epa.gov/storet/) were available for California. In addition to the available water monitoring data, air monitoring data from the Environmental Justice Pilot Study conducted in Parlier, a small agricultural community located in California's San Joaquin Valley, was evaluated.

Field monitoring studies addressing oxyfluorfen were conducted in North Carolina and Missouri and Iowa. In 1981, six sites were monitored (four in North Carolina, one in

Missouri, and one in Iowa) for the presence of oxyfluorfen in the soil in the field, soil in the runoff path, and in the associated pond (water and hydrosoil) [MRID 94749]. In 1982, two different sites were monitored (one in North Carolina, and one in Missouri) for the presence of oxyfluorfen in the soil in the field, soil in the runoff path, and in the associated pond (water and hydrosoil) [MRID 127936]. Application rates of oxyfluorfen during the sampling year ranged from 0.38 to 1.25 lb a.i./acre (note: the application rate was unreported for one test site), and history of oxyfluorfen usage varied among sites. All sites had detectable quantities of oxyfluorfen in the soil sampled from the field. Oxyfluorfen was not detected in the pond water at any of the sampling times (LOD = 2.0 µg/L in 1981 and 2.5 µg/L in 1982). Five of the eight sites had no detections of oxyfluorfen in the hydrosoil (sediment sampled at the edge or center of the pond) at any sampling time (LOD = 10 ppb). Oxyfluorfen was detected once in hydrosoil sampling at two sites (20 ppb in each sample). In the final site, oxyfluorfen concentrations ranged from non-detect to 690 ppb in the sampled hydrosoil; this site also demonstrated an erratic pattern of residues in the field soil samples. The study authors stated that this particular site was subject to acute runoff slopes, excessive field drainage rates, and poor land management techniques.

These field study submissions indicate that under the specific field and environmental conditions described therein with good management practices, oxyfluorfen is not expected to accumulate in the runoff pond water or hydrosoil. However, the selected sampling sites do not reflect the highest labeled application rates for oxyfluorfen, nor do they reflect the range of soil and climatic conditions expected for oxyfluorfen usage. Most notably, no test sites were located in the region of interest for the CRLF assessment and application methods were not described. In addition, the erosion component of the oxyfluorfen runoff may not have been adequately captured based on the sampling and analytical methodologies described in the two field studies. Pond sediment samples were not collected at all of the sampling times, water samples were filtered through cotton plugs which would likely remove suspended sediments (to which oxyfluorfen may be bound), and the sediment/soil extraction methods were mild (e.g., no heat and no acid) and the bound residues may not have been extracted. It is important to note that even with these limitations; oxyfluorfen was detected in the pond sediment.

3.2.4.1 USGS NAWQA Surface Water Data

Surface water monitoring data from the United States Geological Survey (USGS) NAWQA program was accessed on July 10, 2008, and all data for the state of California were downloaded. The USGS surface water data set contains oxyfluorfen data from filtered surface water samples (192 samples from six sites in California collected between October 9, 2001 and September 27, 2007). Because these samples were filtered, the implication is that the oxyfluorfen measured in these samples is dissolved rather than bound to suspended soil and sediment particles and, therefore, is likely to be more biologically available to water column organisms than if it were bound to soil or sediment particles.

In filtered surface water, USGS monitoring data detected oxyfluorfen at concentrations of up to 0.0875 µg/L. The maximum concentration was detected in an agricultural area of Orestimba Creek at River Road near Crows Landing, California. Of those 192 samples analyzed, 35 (18.2%) had positive detections of oxyfluorfen, and the mean concentrations of all detects was 0.0208 µg/L. Reported detection limits were either 0.0073 or 0.017 µg/L with the exception of one sample's detection limit being 0.01 µg/L. Oxyfluorfen was detected in the San Joaquin River near Vernalis, California, in thirteen samples with concentrations ranging from 0.0045 -0.0267 µg/L (mixed land use). Near the Orestimba Creek at River Road near Crows Landing, California, oxyfluorfen was detected in 20 samples with concentrations ranging from 0.0055 -0.0875 µg/L (agricultural land use). Oxyfluorfen was also detected in mixed land use area of the Merced River Road Bridge near Newman, California (two samples with concentrations of 0.0074 and 0.0403 µg/L). In conclusion, oxyfluorfen was detected in a number of different agricultural and mixed use site types of watersheds and was not detected in urban use sites (total of fourteen urban samples collected) as classified by the USGS land use information. The lack of detection of oxyfluorfen in urban areas may be due to the small number of urban samples collected rather than the lack of presence of the chemical in surface water.

3.2.4.2 USGS NAWQA Groundwater Data

The USGS NAWQA data set contained ground water data for oxyfluorfen from 171 samples from fifteen counties in California (collected between July 24, 2001 and September 14, 2006). Reported detection limits varied by sample and were either 0.0073 or 0.017 µg/L. None of the ground water samples had oxyfluorfen concentrations measured above their respective sample's reported detection limits. The registrant-submitted mobility data indicate that oxyfluorfen is slightly to hardly mobile in soil. The lack of detectable concentrations of oxyfluorfen in California ground water agrees with the submitted fate and transport data that indicates that oxyfluorfen has, in general, limited leaching potential.

3.2.4.3 Monitoring Data: Open Literature

The presence of oxyfluorfen in pond water from a nursery after a realistic application in a nursery field has been documented (Keese *et al.* 1994). Rout, a granular formulation, was applied to an ornamental nursery plot which drained into a 0.5 hectare containment pond at a rate of 2 lb oxyfluorfen/acre and 1.0 lb oryzalin/acre. Following application, the area was irrigated for 2.75 hours with 13 mm of water. Oxyfluorfen concentrations in the runoff water were below 1000 µg/L for 3.5 hours after Rout was applied; runoff sampling ceased at 3.5 hours after herbicide application. Concentrations in the pond water were highest (147 µg/L) one day after treatment, decreased to less than 40 µg/L three days after treatment, and remained at detectable levels fourteen days after treatment. Oxyfluorfen concentrations were highest in the pond sediment three days after treatment (0.35 mg/kg). Within seven days of treatment, the concentrations in sampled pond sediment decreased to below the detection limit. The concentrations of oxyfluorfen discussed above were averages based on multiple sampling sites within the pond. Measurement of oxyfluorfen at concentrations higher than solubility may be due to colloidal material (to which oxyfluorfen may have sorbed) passing through the laboratory filter; in addition, the formulation may have altered the solubility of oxyfluorfen. The pond used in this study was not a stagnant body of water; overflow water exits the pond at the opposite side of runoff water entering the pond. If a PRZM/EXAMS scenario was conducted for this situation (*i.e.*, the pond in this study was similar to the 'standard pond' used in PRZM/EXAMS in all aspects except for the overflow exiting the pond), the water concentrations predicted by PRZM/EXAMS would be higher than the water concentrations observed in the pond because of the outflow. No other pond measurements (*e.g.,* depth, suspended sediments, organic carbon) were provided in the paper to facilitate a stronger comparative analysis between the sampled pond and the 'standard pond' in PRZM/EXAMS.

Based on sampling during February 1992 in the San Joaquin River (at Vernalis, California), oxyfluorfen concentrations in suspended sediment ranged from 11.8 to 82.2 µg/L (Bergamaschi *et al*. 1997). Using a partitioning factor of 100 (average K_d = 100), dissolved water concentrations are estimated to be between 0.12 and 0.82 µg/L. Long term sampling at four sites in the San Joaquin River had estimated average concentrations in water ranging from 0.01 to 0.27 µg/L (Bergamaschi *et al*. 1997).

3.2.4.1.1 Atmospheric Monitoring Data

Based on its low vapor pressure (2.5×10^{-7} mm Hg at 25°C) and Henry's Law Constant (8.21×10^{-7} atm·m^3/mol), volatilization loss of oxyfluorfen from soil and water systems is expected to be insignificant. Based on relatively low volatility and high sensitivity to photolytic degradation, oxyfluorfen is not expected to subject to long-range transport.

The Environmental Justice Pilot project conducted by the California Department of Pesticide Regulation (DPR), the Air Resources Board (ARB), and the San Joaquin Air Pollution Control District (SJVAPCD) focused their air monitoring in Parlier, California, on 40 pesticides including oxyfluorfen (CalEPA 2006, http://www.cdpr.ca.gov/docs/envjust/pilot_proj/interim/narrative.pdf). Parlier is a small agricultural community located in California's San Joaquin Valley, approximately 20 miles southeast of Fresno. The predominant crops in the area are fruit orchards and grape vineyards. For oxyfluorfen and other pesticides, DPR collected 297 air samples from January 1 to August 16, 2006. Oxyfluorfen was not detected in any of the collected samples. The quantitation limit for oxyfluorfen was 46.3 ng/m^3. However, DPR has not determined the location and dates of oxyfluorfen and other pesticides' applications relative to the monitoring.

3.2.5 Downstream Dilution Analysis

The final step in defining the action area is to determine the downstream extent of exposure in streams and rivers where the EEC could potentially be above levels that would exceed the most sensitive LOC. To complete this assessment, the greatest ratio of aquatic RQ to LOC was estimated. Using an assumption of uniform runoff across the landscape, it is assumed that streams flowing through treated areas (*i.e.*, the initial area of concern) are represented by the modeled EECs; as those waters move downstream, it is assumed that the influx of non-impacted water will dilute the concentrations of oxyfluorfen present.

Based on oxyfluorfen use patterns, the entire state of California is considered to be the initial area of concern. As stated previously, oxyfluorfen was recognized as a possible human carcinogen by HED, therefore the spatial extent of the action area cannot be determined. Therefore, it is assumed that the action area encompasses the entire state of California, regardless of the spatial extent (*i.e.*, initial area of concern or footprint) of the pesticide use(s). In addition, it is reasonable to assume that the action area encompasses the entire state of California given the broad range of labeled uses and the large geographic coverage of the state for those uses.

Given the broad scope of labeled uses, and since there are no areas within the state of California where oxyfluorfen use is restricted, and it is not unlikely that multiple uses for (and applications of) oxyfluorfen will occur simultaneously within the same areas, there are no areas where potential effects from oxyfluorfen use can be categorically discounted. Thus, there is no need to consider such potentially mitigating effects as 'downstream dilution' or 'drift attenuation' (to areas where oxyfluorfen is not used), as no region lies outside the bounds of potential oxyfluorfen use. Therefore, no credible watershed dilution can be done. For that reason, a downstream dilution analysis was not conducted.

3.3 Terrestrial Animal Exposure Assessment

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

Terrestrial EECs for foliar formulations of oxyfluorfen were derived for the uses summarized in **Table 2.3**. Given that no adequate data on interception and subsequent dissipation from foliar surfaces is available for oxyfluorfen, a default foliar dissipation half-life of 35 days is used based on the work of Willis and McDowell (1987). A dislodgeable foliar residue study of oxyfluorfen applied to conifer seedlings (MRID 420983-01) was submitted to the Agency that concluded oxyfluorfen had a very short half-life of < 24 hours. The review by HED indicated that this study had serious deficiencies, which include very low recovery, very high fortification levels, lack of method validation data, and use of a non-standard dislodging solution; therefore, the default foliar dissipation half-life of 35 days was used. Use-specific input values, including number of applications, application rate, and application interval are provided in **Table 2.3**. An example output from T-REX is available in **Appendix J**.

For modeling purposes, exposures of the CRLF to oxyfluorfen through contaminated food items are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey are assessed using the small mammal (15 g) which consumes short grass. Upper-bound Kenaga nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential prey (**Table 3.5.a**). Exposure calculated as mg a.i./sq ft is provided for the granular application on nursery crops (**Table 3.5.b**).

Table 3.5.a Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of the Terrestrial-phase CRLF and its Prey to Liquid Applications of Oxyfluorfen

Scenario	Method[1]	Application Rate	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)
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
CA Almond STD	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
	A	1 app @ 0.5 lb a.i./acre	67.50	76.88	120.00	114.41
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	419.05	477.26	744.98	710.28
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	125.33	142.74	222.82	212.44
CA Fruit STD** CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	125.33	142.74	222.82	212.44
Agricultural – Food Crop Uses						
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	67.50	76.88	120.00	114.41
	A	1 app @ 0.5 lb a.i./acre	67.50	76.88	120.00	114.41
OR Mint	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
	A	1 app @ 0.5 lb a.i./acre	67.50	76.88	120.00	114.41
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	135.00	153.75	240.00	228.82
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	104.76	119.31	186.25	177.57
	A	1 app @ 0.5 lb a.i./acre	67.50	76.88	120.00	114.41
CA Rangeland Hay RLF*	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
	G	4 apps @ 2 lb a.i./acre (30 day interval)	546.76	622.70	972.02	926.74

Table 3.5.a Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of the Terrestrial-phase CRLF and its Prey to Liquid Applications of Oxyfluorfen						
Scenario	Method[1]	Application Rate	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)
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	324.35	369.40	576.63	549.77
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	376.00	428.23	668.45	637.31
	G	2 apps @ 2 lb a.i./acre (30 day interval)	419.05	477.26	744.98	710.28
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	136.69	155.68	243.00	231.69
CA Residential RLF* CA Right-of-Way RLF* CA Turf RLF*	G	1 app @ 2 lb a.i./acre	270.00	307.50	480.00	457.64
	G	4 apps @ 2 lb a.i./acre (30 day interval)	546.76	622.70	972.02	926.74

[1]G = ground application. A = aerial application.
*Number of applications and/or maximum annual application rate were not specified (NS). The first row of EECs models 1 application; the second row models 4 applications.
**Number of applications and/or maximum annual application rate for aerial application to fruits were not specified (NS). The second row of EECs models 3 applications.

Table 3.5.b EECs for Exposures of the CRLF and its Prey to Granular Applications of Oxyfluorfen		
Scenario	Application Rate	EEC[2] (mg a.i./ft^2)
Non-agricultural Uses		
CA Nursery (granular)[1]	4 apps @ 2 lb a.i./acre (90 day interval)	20.83

[1] Scenario based on ground application of oxyfluorfen.

T-REX is also used to calculate EECs for terrestrial insects exposed to oxyfluorfen. Dietary-based EECs calculated by T-REX for small and large insects are used to bound an estimate of exposure to bees or another more sensitive species. The EECs for the surrogate are later compared to the acute contact toxicity data in order to derive RQs. Dietary-based EECs for small and large insects reported by T-REX are available in **Table 3.6** for liquid applications; granular applications are discussed in **Appendix K**.

Table 3.6 Upper-bound Kenaga Nomogram EECs for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items Based on Liquid Applications of Oxyfluorfen				
Scenario	**Method[1]**	**Application Rate**	**Small Insect (ppm)**	**Large Insect (ppm)**
Orchard Uses				
CA Avocado RLF CA Olive RLF	G	1 app @ 2 lb a.i./acre	270.00	30.00
CA Almond STD	G	1 app @ 2 lb a.i./acre	270.00	30.00
	A	1 app @ 0.5 lb a.i./acre	67.50	7.50
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	419.05	46.56
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	125.33	13.93
CA Fruit STD** CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	270.00	30.00
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	125.33	13.93
Agricultural – Food Crop Uses				
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	67.50	7.50
	A	1 app @ 0.5 lb a.i./acre	67.50	7.50
OR Mint	G	1 app @ 2 lb a.i./acre	270.00	30.00
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	270.00	30.00
	A	1 app @ 0.5 lb a.i./acre	67.50	7.50
Agricultural – Non-food Crop Uses				
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	135.00	15.00
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	104.76	11.64
	A	1 app @ 0.5 lb a.i./acre	67.50	7.50
CA Rangeland Hay RLF*	G	1 app @ 2 lb a.i./acre	270.00	30.00
	G	4 apps @ 2 lb a.i./acre (30 day interval)	546.76	60.75
Non-agricultural Uses				
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	324.35	36.04
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	376.00	41.78
	G	2 apps @ 2 lb a.i./acre	419.05	46.56

Table 3.6 Upper-bound Kenaga Nomogram EECs for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items Based on Liquid Applications of Oxyfluorfen				
Scenario	**Method[1]**	**Application Rate**	**Small Insect (ppm)**	**Large Insect (ppm)**
		(30 day interval)		
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	136.69	15.19
CA Residential RLF* CA Right-of-Way RLF* CA Turf RLF*	G	1 app @ 2 lb a.i./acre	270.00	30.00
	G	4 apps @ 2 lb a.i./acre (30 day interval)	546.76	60.75
[1]G = ground application. A = aerial application. *Number of applications and/or maximum annual application rate were not specified (NS). The first row of EECs models 1 application; the second row models 4 applications. **Number of applications and/or maximum annual application rate for aerial application to fruits were not specified (NS). The second row of EECs models 3 applications.				

3.4 Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.1.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameters for application rate (based on a single application), drift assumption, and incorporation depth are based upon the use and related application method (**Table 3.7**). A runoff value of 0.01 is utilized in TerrPlant based on oxyfluorfen's solubility, which is 0.116 mg/L. For aerial and ground application methods, drift is assumed to be 5% and 1%, respectively. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 3.7**. An example of output from TerrPlant v.1.2.2 is available in **Appendix J.**

Table 3.7 TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Oxyfluorfen via Runoff and Drift						
Scenario	**Method[1]**	**Application Rate (lb a.i./acre)**	**Drift Value (%)**	**Dry Area EEC (lb a.i./acre)**	**Semi-aquatic Area EEC (lb a.i./acre)**	**Spray Drift EEC (lb a.i./acre)**
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	2	1	0.04	0.22	0.02
CA Almond STD CA Citrus STD CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	2	1	0.04	0.22	0.02
	A	0.5	5	0.03	0.075	0.025
Agricultural – Food Crop Uses						

Table 3.7 TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Oxyfluorfen via Runoff and Drift						
Scenario	**Method[1]**	**Application Rate (lb a.i./acre)**	**Drift Value (%)**	**Dry Area EEC (lb a.i./acre)**	**Semi-aquatic Area EEC (lb a.i./acre)**	**Spray Drift EEC (lb a.i./acre)**
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	0.5	1	0.01	0.055	0.005
	A	0.5	5	0.03	0.075	0.025
OR Mint	G	2	1	0.04	0.22	0.02
CA Row Crop RLF	G	2	1	0.04	0.22	0.02
	A	0.5	5	0.03	0.075	0.025
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1	1	0.02	0.11	0.01
CA Cotton STD	G	0.5	1	0.01	0.055	0.005
	A	0.5	5	0.03	0.075	0.025
CA Rangeland Hay RLF	G	2	1	0.04	0.22	0.02
Non-Agricultural Uses						
CA Nursery CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	2	1	0.04	0.22	0.02
CA Nursery (granular)	G	2	0	0.02	0.20	0
CA Forestry RLF	G	1.5	1	0.03	0.165	0.015
	G	2	1	0.04	0.22	0.02
	A	0.5	5	0.03	0.075	0.025
[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.						

3.5 Exposure to Spray Drift Alone

An analysis of spray drift distance is crucial to determine the areas of concerns for the CRLF. In order to determine aquatic and terrestrial habitats of concern due to oxyfluorfen exposures through spray drift, it is necessary to estimate the distance that spray applications can drift from the treated area and still be present at concentrations that exceed levels of concern. AgDRIFT 2.01 (developed by the Spray Drift Task Force, SDTF) was used to estimate these distances. During model development, results from the SDTF field studies were used to confirm the model results at each of the different levels of analysis. The methodology includes a “screening” or Tier I level, designed to yield conservative exposure estimates for downwind deposition values less than the assessment value, and “detailed” or Tier II and Tier III levels, requiring more knowledge of spraying conditions and information related to the specific spray material anticipated, spray system, and meteorological conditions. Tier I is designed as a preliminary screen for aerial, ground, and orchard airblast spraying; Tier II and Tier III permit increasing access to more model details for aerial spraying only. All input values other than the defaults used in AgDRIFT are provided in text and/or tables.

4. Effects Assessment

This assessment evaluates the potential for oxyfluorfen to directly or indirectly affect the CRLF or modify its designated critical habitat. As previously discussed in **Section 2.7**, assessment endpoints for the CRLF effects determination include direct toxic effects on the survival, reproduction, and growth of CRLF, 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. Acute (short-term) and chronic (long-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on oxyfluorfen.

As described in the Agency's Overview Document (USEPA 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include aquatic-phase amphibians, freshwater fish, freshwater invertebrates, aquatic plants, birds (surrogate for terrestrial-phase amphibians), mammals, terrestrial invertebrates, and terrestrial plants.

Toxicity endpoints are established based on 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) (USEPA 2004). Open literature data presented in this assessment were obtained from ECOTOX information obtained on February 2, 2008. 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 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 that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, maintenance of CRLF survival, reproduction, and growth) identified in **Section 2.8**. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because quantitative relationships between modifications and reduction in species survival, reproduction, and/or growth are not available. Although the effects determination relies on endpoints that are relevant to the assessment endpoints of survival, growth, or reproduction, it is important to note that the full suite of sublethal endpoints potentially available in the effects literature (regardless of their significance to the assessment endpoints) are considered to define the action area for oxyfluorfen.

Citations of all open literature, including studies that were 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), are included in **Appendix G. Appendix G** 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. **Appendix E** includes a summary of the human health effects data for oxyfluorfen.

In addition to registrant-submitted and open literature toxicity information, other sources of information, including use of the acute probit dose-response relationship to establish the probability of an individual effect and reviews of the Ecological Incident Information System (EIIS), are conducted to further refine the characterization of potential ecological effects associated with exposure to oxyfluorfen. A summary of the available aquatic and terrestrial ecotoxicity information, use of the probit dose-response relationship, and the incident information for oxyfluorfen are provided in **Sections 4.1** through **4.4**.

No studies were identified that evaluate the toxicity of oxyfluorfen degradates to aquatic or terrestrial taxa. The Agency does not have concerns for any degradates of oxyfluorfen relative to human health issues as the tolerance expression is only expressed in terms of oxyfluorfen *per se* (60 FR 62330, December 6, 1995). There is no evidence that any oxyfluorfen degradates are of toxicological concern as well. Several degradates are formed in various oxyfluorfen degradation pathways, and all but one (2-chloro-1-(3-ethoxy-4-hydroxy-phenoxy)-4-(trifluoromethyl) benzene (MW-332); MRID 421423-07 and 421423-08) are minor degradates formed in small quantities; many of these minor degradates were isolated but not identified in the submitted environmental fate studies. Therefore, degradates were not evaluated in this assessment.

A detailed summary of the available ecotoxicity information for all oxyfluorfen technical and formulated products is presented below. Further information on toxicity of products containing multiple active ingredients is presented in **Appendix A**.

4.1 Specific Toxicological Concerns Associated with Oxyfluorfen

4.1.1 Enhanced Toxicity in Natural Sunlight

Oxyfluorfen is a diphenyl-ether, one of a class of herbicides sometimes referred to as light-dependent peroxidizing herbicides (LDPHs) that have enhanced toxicity in the presence of solar ultra-violet radiation. Because toxicity of the LDPHs is affected by the presence of ultraviolet (UV) radiation, most toxicity tests used in this assessment, which were conducted under standard laboratory lighting conditions, may underestimate the toxicity of oxyfluorfen to some taxa under natural sunlight conditions. The Agency and the LDPH Task Force are currently in the process of developing a protocol for aquatic studies that evaluate the effect of UV light on the toxicity of these herbicides, but at the time of this assessment, it had not been finalized (EFED 2007). Preliminary studies have been submitted for some chemicals, including oxyfluorfen. Fish early life-cycle studies on oxyfluorfen conducted under UV light indicate larval fish LD_{50}'s are approximately an order of magnitude lower than LD_{50}'s based on standard lighting conditions (MRID 465851-04). In this study, the larval fish appeared to hatch prematurely compared to the controls and then died. Based on the mode of action, it is possible that disruption of the egg cell membrane caused the premature hatch.

The extent to which UV light enhances the toxicity of oxyfluorfen to other taxa or other life stages is unknown; existing studies conducted under standard laboratory lighting may underestimate the toxicity. The potential for phototoxic effects is a serious concern for this chemical. Anemia and other hematologic consequences were observed in the developmental studies in mammals. In wild mammal populations, hematologic effects have the potential to magnify since the lack of natural sunlight in the laboratory reduces the likelihood of activating the phototoxic effects of oxyfluorfen. Potential impacts of this underestimation are discussed in the Risk Description (**Section 5.2**).

4.1.2 Changes in Purity of Technical

Several oxyfluorfen toxicity studies recently have been submitted to the Agency using a technical grade of the chemical with purity ranging from 95-99%, as opposed to older studies using a technical grade with purity ranging from 71-85%. The newer technical material has similar profiles of impurities when compared to the older material, but in reduced concentrations. HED noted a reduced toxicity with the current 98% product (see RED), and utilized newer studies with the 98% product to identify toxicological endpoints when studies with newer and older technical material were available. Based on conclusions from HED, it is possible that the newer technical material will have a reduced toxic effect on species evaluated in the environmental assessment; however, no data have been submitted to the Agency to confirm that extrapolation. Within the suite of environmental toxicology studies reviewed by EFED, limited comparisons could be made due to lack of data for both the 'old' and 'new' technicals. When available, EFED utilized toxicity data for the 'new' technical, as it would better represent the material currently used in the environment.

4.2 Toxicity of Oxyfluorfen to Aquatic Organisms

Table 4.1 summarizes the most sensitive aquatic toxicity endpoints for the CRLF, 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 for the CRLF is presented below. Additional information is provided in **Appendix F** and **Appendix G.**

Table 4.1 Freshwater Aquatic Toxicity Profile for Oxyfluorfen

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment[a]	MRID (Author & Date)	Status/Comment
Acute Direct Toxicity to Aquatic-Phase CRLF	Bluegill (*Lepomis macrochirus*)	LC_{50} = 203 µg a.i./L	38574 (Bentley 1976)	Acceptable
Chronic Direct Toxicity to Aquatic-Phase CRLF	Fathead minnow (*Pimephales promelas*)	NOAEC = 1.3 µg a.i./L	465851-04 (Palmer *et al.* 2005)	Supplemental, study conduced under enhanced UV light conditions. LOAEC = 2.4 µg a.i./L, based on larval survival
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Freshwater Invertebrates (*i.e.*, prey items)	*Daphnia magna*	EC_{50} = 80 µg a.i./L	452713-01 (Sutherland *et al.* 2000)	Supplemental, study conducted with end-use product, Goal 2XL.
Indirect Toxicity to Aquatic-Phase CRLF via Chronic Toxicity to Freshwater Invertebrates (*i.e.*, prey items)	*Daphnia magna*	NOAEC = 13 µg a.i./L	421423-05 (Forbis *et al.* 1986) 455502-01 (Forbis and Frazier 2001; raw data)	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Non-vascular Aquatic Plants	*Selenastrum capricornutum*	EC_{50} = 0.29 µg a.i./L	452713-02 (Sutherland *et al.* 2000)	Acceptable, study conducted with end-use product, Goal 2XL
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Vascular Aquatic Plants	*Lemna gibba*	EC_{50} = 0.35 µg a.i./L	458611-03 (Roshon 2002)	Supplemental (poor recovery of test chemical, typically < 60%)

[a] Confidence intervals and slopes (if calculated) are reported in the corresponding table in **Appendix F**.

Toxicity to aquatic fish and invertebrates is categorized using the system shown in **Table 4.2** (USEPA 2004). Toxicity categories for aquatic plants have not been defined.

Table 4.2 Categories of Acute Toxicity for Aquatic Organisms	
LC_{50} (ppm)	**Toxicity Category**
< 0.1	Very highly toxic
> 0.1 - 1	Highly toxic
> 1 - 10	Moderately toxic
> 10 - 100	Slightly toxic
> 100	Practically nontoxic

4.2.1 Toxicity to Freshwater Fish

Given that no oxyfluorfen toxicity data are available for aquatic-phase amphibians, freshwater fish data were used as a surrogate to estimate direct acute and chronic risks to the CRLF. Freshwater fish toxicity data were also used to assess potential indirect effects of oxyfluorfen to the CRLF. Effects to freshwater fish resulting from exposure to oxyfluorfen have the potential to indirectly affect the CRLF via reduction in available food. As discussed in **Section 2.5.3**, over 50% of the prey mass of the CRLF may consist of vertebrates such as mice, frogs, and fish (Hayes and Tennant 1985).

A summary of acute and chronic freshwater fish data, including data from the open literature, is provided below in **Sections 4.2.1.1** through **4.2.1.3**.

4.2.1.1 Freshwater Fish: Acute Exposure (Mortality) Studies

The LC_{50}'s for three species of freshwater fish (bluegill sunfish, rainbow trout, and channel catfish) ranged from 203 µg/L to 410 µg/L, classifying oxyfluorfen as "highly toxic" on an acute basis. All five guideline studies that were submitted to the Agency were classified as Acceptable (**Table F-1**).

The most sensitive LC_{50} (203 µg a.i./L, bluegill, MRID 38574) was selected as the surrogate acute freshwater fish toxicity endpoint and used to assess direct acute effects of oxyfluorfen to the CRLF.

4.2.1.2 Freshwater Fish: Chronic Exposure (Growth/Reproduction) Studies

One fish early life-stage toxicity study was conducted for oxyfluorfen. The study on fathead minnows (MRID 921360-57, also reviewed as MRID 30249, Acceptable) resulted in a NOAEC of 38 µg/L and a LOAEC of 74 µg/L. Survival, total length, and average weight were the most sensitive parameters (**Table F-2**).

A 33-day fish early-life study was conducted with oxyfluorfen (MRID 465851-04) in which fathead minnow embryos were exposed to mean-measured oxyfluorfen concentrations ranging from 0.55 to 8.0 µg a.i./L. This study was conducted under UV light conditions. Fluorescent tubes that emit light spectra from UVA (320 to 400 nm) and

UVB (285 to 320 nm) were used. Based on weekly measurements, UV light irradiance was from 22 to 44 µW/cm^2 for UVA and from 5 to 12 µW/cm^2 for UVB. Lighting intensity ranged from 371 to 660 lux. The study was conducted under this lighting regime to meet an Agency request for presumed LDPH chemicals.

The EC_{50}, NOAEC, and LOAEC for hatching success (determined on day 5) were 7.3 [with 95%CI(6.0, 8.7)] µg a.i./L,1.3 µg a.i./L, and 2.4 µg a.i./L, respectively. Embryos in the higher concentrations also tended to hatch earlier then embryos in the controls and lower concentrations. The LC_{50}, NOAEC, and LOAEC for larval survival (determined on day 33, day 28 post-hatch) were 2.9 [with 95%CI(2.6, 3.3)] µg a.i./L,1.3 µg a.i./L, and 2.4 µg a.i./L, respectively. Most mortalities occurred within 96-hrs of the "post-hatch" period; therefore, the LC_{50}, NOAEC, and LOAEC for larval survival calculated at 96-hrs were similar to the endpoints calculated at study conclusion. Length, wet weight, and dry weight were measured on day 33; the NOAEC and LOAEC for all three parameters was 1.3 µg a.i./L and 2.4 µg a.i./L. Sublethal effects (curled spine, reduced size, weakness) were noted in a large percentage of individuals in the 2.4 and 4.7 µg a.i./L test concentrations. All larvae that hatched in the 8.0 µg a.i./L test group died immediately; sublethal effects could not be noted.

Because of the large differential in study endpoints between the early-life study conducted in 1980 (MRID 921360-57) under standard lighting and the study conducted under UV light conditions, an abbreviated, confirmatory side-by-side early life cycle study was conducted (also under MRID 465851-04). This study was conducted exactly as above, with the following exceptions:

- Study terminated seven days post-hatch (total study length 12 days)
- Typical laboratory lighting and UV lighting described above were used in two separate chambers, conducted concurrently.
- Nominal test concentrations ranged from 0 (control) to 20 µg a.i./L.
- Terminal growth measurements not recorded.

In the standard lighting study, hatching success ranged from 95-100% with no statistically-significant differences, and larval survival ranged from 81-96%. In the enhanced UV lighting study, hatching success ranged from 0 to 99% with statistically significant reductions in the 10 and 20 µg a.i./L test groups, and larval survival ranged from 0 to 98% with statistically significant reductions in all test groups (NOAEC <1.3 µg a.i./L). Results of this short term test generally confirmed the results of the 33-day early-life stage test conducted under UV lighting conditions.

The NOAEC (1.3 µg a.i./L) determined at the completion of the full-length early-life study will be used for chronic RQ calculations. The results of the abbreviated study indicate that there is the potential for significant effects at lower concentrations; however, there is less certainty in those results be cause of the short length of the study.

4.2.1.3 Freshwater Fish: Sublethal Effects and Additional Open Literature Information

Peixoto *et al*. (2006, E95831) evaluated the effect of two concentrations of oxyfluorfen on stress enzymes in tilapia (*Oreochromis niloticus*). Most fish survived the whole period of exposure to oxyfluorfen at 300 µg/L, but only about 60% of the fish exposed to 600 µg/L were still alive at the end of the experiment. The mortality that occurred for both concentrations was observed during the last days of the 21-day experiment. Sampling occurred on days 7, 14, and 21. The total liver protein concentration in tilapia exposed to oxyfluorfen increased at all sampling times, although the levels appeared to be highest in fish exposed to the lowest concentration. The authors hypothesized that the increase of the protein content could be the result of an elevated liver metabolic activity induced by oxyfluorfen. The enzymes included in this study also differ in their responses to oxyfluorfen. CAT (enzymes that remove the hydrogen peroxide which is metabolized to oxygen and water) levels tended to increase relative to the control. SOD (metalloenzymes that plays a crucial antioxidant role and constitutes the primary defense against the toxic effect of oxygen in aerobic organisms) levels decreased relative to the control. GR (maintains the GSH/GSSG homeostasis under stress conditions) activity was high at both tested concentrations at all the sampling days.

4.2.2 Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data were used to assess potential indirect effects of oxyfluorfen to the CRLF. Effects to freshwater invertebrates resulting from exposure to oxyfluorfen have the potential to indirectly affect the CRLF via reduction in available food items. As discussed in **Section 2.5.3**, the main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic invertebrates found along the shoreline and on the water surface, including aquatic sowbugs, larval alderflies and water striders.

A summary of acute and chronic freshwater invertebrate data, including data published in the open literature, is provided below in **Sections 4.1.2.1** through **4.1.2.3**.

4.2.2.1 Freshwater Invertebrates: Acute Exposure Studies

For freshwater invertebrates, the toxicity endpoints (LC_{50} or EC_{50}) range between 80 µg a.i./L and 1500 µg a.i./L, classifying oxyfluorfen as “very highly toxic” to “moderately toxic” (**Table F-3**). The lowest LC_{50} (80 µg a.i./L) was obtained in a toxicity test using Goal 2XL on daphnids. In the study with the highest values for the toxicity endpoints, 48-hr LC_{50} = 1500 µg/L for daphnids (MRID 134449), oxyfluorfen concentration was recorded as nominal levels. The actual exposure concentrations experienced by these invertebrates are likely to have been much less because these nominal levels were well in excess of the compound solubility limit (oxyfluorfen solubility = 100 µg/L).

A toxicity study submitted to the Agency (MRID 420480-01, supplemental) evaluated the acute toxicity of Goal 1.6E (a TEP of oxyfluorfen, 19.5% a.i.) to a sediment-dwelling midge larvae (*Chironomus tentans*) in a sediment-spiked test system. The 96-hr LC_{50} was

> 5.1 mg a.i./kg-soil (dry weight). Percent survival in the three tested concentrations ranged from 83 to 93%. After addition of “flood” water (which did not contain oxyfluorfen) to the test system, there was a decline in the concentrations of oxyfluorfen in the soil, and small amounts of oxyfluorfen (<50 µg/L) were detected in the flood water at the test concentrations of 1.28 and 5.1 mg a.i./kg-soil (dry weight). Concentrations of oxyfluorfen in pore water were not measured, and this study was not conducted following the current draft guidelines (OPPTS 850.1735).

A study submitted to the Agency (MRID 465851-02, supplemental) evaluated the acute toxicity of oxyfluorfen technical to a sediment-dwelling midge larvae (*Chironomus tentans*) in a sediment-spiked test system. The 10-day LC_{50} was > 97.6 mg a.i./kg-soil (dry weight). Percent survival in the tested concentrations ranged from 64 (in the highest test concentration, 97.6 mg a.i./kg-soil) to 98%. The NOAEC was established at 55.7 µg a.i./L due to mortality at the highest test concentration. No significant effect of oxyfluorfen on average midge dry weight was identified. Concentration measurements of oxyfluorfen sorbed to the sediment were close to the nominal concentrations. Oxyfluorfen was detected in the pore water, average concentrations ranged from 16.4 to 498.5 µg a.i./L in the 6.3 and 100 mg a.i./kg-sediment nominal test groups. Oxyfluorfen in the overlying water was not detected in the three lowest test groups (6.3, 13, 25 µg a.i./L), and small concentrations (< 30 µg a.i./L) were detected in one of each of the two higher test groups (50 and 100 µg a.i./L).

The most sensitive EC_{50} (80 µg a.i./L, MRID 452713-01) was selected as the endpoint to access the acute risk of oxyfluorfen to the aquatic invertebrate prey of the CRLF.

4.2.2.2 Freshwater Invertebrates: Chronic Exposure Studies

One invertebrate life-cycle toxicity study was conducted for oxyfluorfen (**Table F-4**). The life-cycle study on *Daphnia magna* (reviewed under MRID 921361-06 and under MRID 421423-05, raw data submitted under MRID 455502-01) indicated a NOAEC of 13 µg/L and a LOAEC of 28 µg/L. This study is classified as Acceptable under Guideline 72-4(b).

4.2.2.3 Freshwater Invertebrates: Open Literature Data

No data for oxyfluorfen toxicity to freshwater invertebrates were identified in the open literature.

4.2.3 Toxicity to Aquatic Plants

Aquatic plant toxicity studies were used as one of the measures of effect to evaluate whether oxyfluorfen has the potential to affect primary production and the availability of aquatic plants as food for CRLF tadpoles. Primary productivity is essential for indirectly supporting the growth and abundance of the CRLF.

A summary of the laboratory data and freshwater field studies for aquatic plants is provided in **Sections 4.2.3.1** and **4.2.4**.

4.2.3.1 Aquatic Plants: Laboratory Data

An Acceptable aquatic plant toxicity study was conducted for one species (**Table F-5**). The plant growth study on *Selenastrum capricornutum* (MRID 452713-02) with Goal 2XL indicated a 96-hr EC_{50} of 0.29 µg/L and a NOAEC of 0.10 µg/L.

A second toxicity study on *Pseudokirchneriella subcapitata* (formerly *Selenastrum capricornutum*) was submitted to the Agency (MRID 449462-32). This study was classified as Supplemental (scientifically valid, non-guideline). The 96-hr EC_{50} > 2.9 µg a.i./L and the NOAEC was 1.4 µg a.i./L with the most sensitive endpoints being cell density, growth rate, and biomass. In this study, artificial sediment (mixture of industrial sand, kaolin clay, and sphagnum peat moss) and humic acid (extracted from the Suwannee River in southern Georgia) were introduced into the test system. The results indicate a reduced toxicity of oxyfluorfen to *Selenastrum* in the presence of artificial sediment and humic acid relative to the reference test system (*Selenastrum* exposed to oxyfluorfen without artificial sediment and humic acid) utilized in this study. Presence of sediment and humic acid also appears to have reduced toxicity relative to a previously submitted study (MRID 452713-02); however, that comparison is confounded with the fact that different test substances were used (oxyfluorfen technical in this naturalized test system and an end-use product, Goal 2XL, in MRID 452713-02).

4.2.4 Freshwater Field/Mesocosm Studies

No freshwater field or mesocosm studies evaluating oxyfluorfen toxicity were submitted to the Agency or identified in the open literature.

4.3 Toxicity of Oxyfluorfen to Terrestrial Organisms

Table 4.3 summarizes the most sensitive terrestrial toxicity endpoints used for determining the direct and indirect effects of oxyfluorfen to the terrestrial-phase CRLF. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the CRLF is presented below. Additional information is provided in **Appendix F.**

Table 4.3 Terrestrial Toxicity Profile for Oxyfluorfen				
Endpoint	**Species**	**Toxicity Value Used in Risk Assessment (Endpoint)[a]**	**MRID (Author & Date)**	**Status**
Acute Direct Toxicity to Terrestrial-Phase CRLF (LD_{50})	Northern bobwhite (*Colinus virginianus)*	LD_{50} > 2150 mg a.i./kg-bw, practically non-toxic	921361-02 (Fletcher 1987)	Acceptable
Acute Direct Toxicity to Terrestrial-Phase CRLF (LC_{50})	Northern bobwhite (*Colinus virginianus*) Mallard duck (*Anas platyrhynchos*)	LC_{50} > 5000 mg a.i./kg-diet, practically non-toxic	921361-03 (Fletcher 1987) 921361-04 (Fletcher 1987)	Acceptable Acceptable
Chronic Direct Toxicity to Terrestrial-Phase CRLF	Northern bobwhite (*Colinus virginianus*) Mallard duck (*Anas platyrhynchos*)	NOAEC = 124 mg a.i./kg-diet (Reduced survivor weight) NOAEC = 506 mg a.i./kg-diet (Egg production, embryo development, hatchability)	460701-02 (Frey *et al*. 2003) 460701-01 (Frey *et al*. 2003)	Acceptable Acceptable
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to mammalian prey items)	Laboratory rat	Acute Oral LD_{50} > 5000 mg a.i./kg-bw, practically non-toxic	447120-10 (Dreher 1995) 448289-03 (Lampe *et al.* 1988)	Acceptable Acceptable
Indirect Toxicity to Terrestrial-Phase CRLF (via chronic toxicity to mammalian prey items)	Laboratory rat	NOAEC = 400 mg a.i/kg-diet (Parental effects included mortality, decreased body weight, liver and kidney histopathology)	420149-01 (Solomon *et al.* 1991)	Acceptable
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to terrestrial invertebrate prey items)	Earthworm	LC_{50} = 89 mg/kg-dry soil NOAEC = 29 mg/kg-dry soil (growth)	459060-07 (Nienstedt 1999)	Supplemental
Indirect Toxicity to Terrestrial- and Aquatic-Phase CRLF (via toxicity to terrestrial plants)	<u>Seedling Emergence</u> Monocots (Ryegrass)	EC_{25} = 0.0062 lb a.i./acre (Shoot dry weight)	458611-01 (Aufderheide 2002)	Acceptable
	<u>Seedling Emergence</u> Dicots (Lettuce)	EC_{25} = 0.0072 lb a.i./acre (Shoot dry weight)	458611-01 (Aufderheide 2002)	Acceptable
	<u>Vegetative Vigor</u> Monocots (Oat)	EC_{25} = 0.267 lb a.i./acre (Shoot dry weight)	458611-02 (Aufderheide 2002)	Acceptable
	<u>Vegetative Vigor</u> Dicots (Lettuce)	EC_{25} = 0.0077 lb a.i./acre (Shoot dry weight)	458611-02 (Aufderheide 2002)	Acceptable

[a] Confidence intervals and slopes (if calculated) are reported in the corresponding table in **Appendix F**.

Acute toxicity to terrestrial animals is categorized using the classification system shown in **Table 4.4** (USEPA 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4.4 Categories of Acute Toxicity for Terrestrial Organisms		
Categories of Acute Toxicity for Birds and Mammals		
Toxicity Category	**Oral LD_{50}**	**Dietary LC_{50}**
Very highly toxic	< 10 mg/kg	< 50 ppm
Highly toxic	10 – 50 mg/kg	50 - 500 ppm
Moderately toxic	51 – 500 mg/kg	501 - 1000 ppm
Slightly toxic	501 - 2000 mg/kg	1001 - 5000 ppm
Practically non-toxic	> 2000 mg/kg	> 5000 ppm
Categories of Acute Toxicity for Non-Target Insects		
Toxicity Category	**LC_{50}**	
Highly toxic	< 2 µg/bee	
Moderately toxic	2-11 µg/bee	
Practically nontoxic	>11 µg/bee	

4.3.1 Toxicity to Birds

As specified in the Overview Document, the Agency uses birds as a surrogate for terrestrial-phase amphibians when amphibian toxicity data are not available (USEPA 2004). No terrestrial-phase amphibian data are available for oxyfluorfen; therefore, acute and chronic avian toxicity data are used to assess the potential direct effects of oxyfluorfen to terrestrial-phase CRLFs.

4.3.1.1 Birds: Acute Exposure (Mortality) Studies

The acute toxicity of the old technical grade oxyfluorfen (~70% purity) to birds was established with the following guideline tests: one avian single-dose oral (LD_{50}) study on the bobwhite quail; two sub-acute dietary studies (LC_{50}) on the mallard duck and the bobwhite quail.

Avian acute and sub-acute toxicity summary data for oxyfluorfen are presented in **Table F-6**. A non-definitive LD_{50} for bobwhite quail was estimated at > 2150 mg a.i./kg-bw (reviewed under MRID 921361-02 and 422559-01). One death occurred at the highest dose tested, but it was unclear whether the death was incidental or treatment-related. For the purposes of risk estimation (**Section 5.1.2.1**), upper bound acute RQ values were determined based on an LD_{10} = 2150 mg a.i./kg-bw. The LC_{50}'s for both bobwhite quail and mallard duck were > 5000 mg a.i./kg-diet (MRID 921361-03 and 921361-04, respectively). Based on these studies, acute exposure of oxyfluorfen to birds was classified as “practically non-toxic”.

4.3.1.2 Birds: Chronic Exposure (Growth, Reproduction) Studies

Avian chronic exposure reproduction effects studies were performed for oxyfluorfen using two species, bobwhite quail and mallard duck (**Table F-7**). In an older quail study using 72.5% technical (MRID 4153012-06), a NOAEC was not established, as body weights of 14-d chicks were reduced at both dose concentrations (50 and 100 mg a.i/kg-diet). For mallards (MRID 4153012-05, supplemental), no negative effects were observed at the only test concentration (100 mg a.i./kg-diet) using 72.5% technical; therefore, a conservative NOAEC was set at 100 mg a.i./kg-diet.

Two newer studies submitted after the RED were classified as acceptable using 99.3% technical oxyfluorfen. In the quail study (MRID 460701-02), the NOAEC was established at 124 mg a.i./kg-diet with the most sensitive endpoint being reduced survivor weight. Other endpoints included ratio of hatchling survival to number of hatchlings, viable embryos, live embryos, number of hatchlings, ratio of eggs set to eggs laid, ratio of number of hatchlings to eggs laid, and ratio of hatchling survival to eggs set. In the mallard study (MRID 460701-01), the NOAEC was determined to be 506 mg a.i./kg-diet with endpoints including eggs laid, eggs set, viable embryos, the ratio of viable embryos to eggs set, live embryos, number of hatchlings, the ratios of normal hatchlings to eggs laid and to eggs set, and hatchling survival. Any of these effects would have an effect on the fitness of individuals and may have an effect on the overall fitness of wild bird populations exposed to oxyfluorfen. Since birds are used as a surrogate for the CRLF, these effects have the potential to result in direct effects to the frog by affecting reproductive fitness or in indirect effects to the frog by affecting the prey population.

4.3.1.3 Birds: Open Literature Studies

Hoffman *et al.* conducted a developmental toxicity study (E097949) in 1991 to determine the American kestrel's response to diphenyl ether herbicides including oxyfluorfen, nitrofen, and bifenox. Nestlings were orally dosed daily for ten days at a rate of 500 mg a.i./kg-bw in a preliminary range-finding test. Nitrofen caused complete mortality among the nestlings, while bifenox caused 66% mortality. Oxyfluorfen (98.5% purity) did not cause any mortalities in the test; because of this, oxyfluorfen was not further evaluated in this study. The study results are limited by the lack of reported sub-lethal effects, the inclusion of only three birds in the range-finding test, and lack of a definitive LD_{50}.

4.3.2 Toxicity to Mammals

Mammalian toxicity data are used to assess potential indirect effects of oxyfluorfen to the terrestrial-phase CRLF. Effects to small mammals resulting from exposure to oxyfluorfen have the potential to indirectly affect the CRLF via reduction in available food. As discussed in **Section 2.5.3**, over 50% of the prey mass of the CRLF may consist of vertebrates such as mice, frogs, and fish (Hayes and Tennant 1985).

In most cases, mammalian toxicity data are used to approximate toxicity to mammals. However, wild mammal toxicity tests may be required on a case-by-case basis, depending on the results of the lower tier studies such as acute and sub-acute testing, intended use pattern, and pertinent environmental fate characteristics. No studies evaluating toxicity testing on wild mammal species have been submitted by registrants. For the purposes of this risk assessment, EFED used the available mammalian toxicity data on laboratory rodents as surrogates for mammalian wildlife (**Tables F-8**, **F-9**, and **F-10**).

Based on male mice combined hepatocellular adenoma and carcinoma tumor rates of 7.32×10^{-2} mg/kg/day in human equivalents, oxyfluorfen (87.5%) was classified as a possible human carcinogen (HED's Human Health Risk Assessment for Reregistration Eligibility Decision (RED), April 29, 2002, D281831; **Appendix E**). In mutagenicity tests, oxyfluorfen (96%) showed a positive result in an Ames assay at high, insoluble levels. Another study at the same purity by a different laboratory showed a negative result in an Ames assay also at high, insoluble levels. Although the studies using the newer technical ingredient are the relevant ones, the older technical material (72.7% purity) showed a positive result in an Ames assay and the mouse lymphoma assay. Due to these results, it is plausible that any mutagenic properties may be caused by impurities in the technical material rather than oxyfluorfen itself.

4.3.2.1 Mammals: Acute Exposure (Mortality) Studies

There are two registrant submitted acceptable rat acute oral toxicity studies (**Table F-8**). No deaths or signs of systemic toxicity were reported; based on a laboratory rat LD_{50} value greater than 5000 mg a.i./kg-bw, oxyfluorfen is practically non-toxic to small mammals on an acute oral basis (MRID 447120-10, 448289-03).

4.3.2.2 Mammals: Chronic Exposure (Growth, Reproduction) Studies

Chronic toxic effects may be manifested as reproductive, developmental, and hemolytic consequences. In the 2-generation rat reproduction study (MRID 420149-01, 71.4% purity), toxic effects in adults were mortality, decreased body weight, and liver and kidney histopathology (**Table F-10**). Toxic effects observed in the pups included decreased body weight and a decreased number of live pups per litter. Both parental and reproductive NOAECs were 400 mg a.i./kg-diet. Any of these effects would have an effect on the fitness of individuals and may have an effect on the overall fitness of wild mammal populations exposed to oxyfluorfen. Since CRLFs may consume mammals, these effects have the potential to result in indirect effects to the frog by affecting its prey population.

Toxic effects of oxyfluorfen were observed in three of the four prenatal developmental toxicity studies (**Table F-10**) involving rats and rabbits (MRID 449331-03, 418065-01, 449331-02, 94052). Of these studies, the lowest maternal NOAEL was 10 mg/kg-bw/day for rabbits, based on decreased bodyweight gain and clinical signs (MRID 94052). However, this study used a formulation of oxyfluorfen rather than the technical material. The lowest developmental NOAEL was 18 mg/kg-bw/day for rats, based on decreased fetal body weight, vascular deformities, and bone deformities (MRID 418065-01). This study used the old technical material (71.4% purity). There is some evidence to suggest that the removal of impurities in the technical grade of oxyfluorfen (currently approximately 98% a.i.) has reduced the toxic effects relative to the older technical grade of oxyfluorfen (approximately 72% a.i.). In the rabbit study using 98% oxyfluorfen (MRID 449331-02), NOAELs were established at 30 mg/kg-bw/day for both maternal and developmental endpoints. In the rat study that used 98% oxyfluorfen (MRID 449331-

03), no adverse effects were observed at the highest doses tested. The apparent reduction in toxicity may also be due to variability between and within laboratories, changes in laboratory methods and procedures over time, and different tolerances in strains of test animals.

A similar trend was also observed in sub-chronic studies (**Table F-9**). With an increased purity of oxyfluorfen in the technical grade (98% a.i.) the NOAEC in a sub-chronic rat study was 1500 mg a.i./kg-diet (MRID 449331-01). In sub-chronic rat studies with a less pure technical grade of oxyfluorfen (72-72.5% a.i.), the NOAECs were 200 mg a.i./kg-diet, and 800 mg a.i./kg-diet (MRID 117603 and 117601, respectively). In a sub-chronic 90-day oral-feeding mice study (MRID 117602), effects of oxyfluorfen (72.5% purity) including anemia, increased serum glutamate pyruvate transaminase enzyme, increased liver weight, and liver hisopathology were observed at a LOAEC of less than or equal to 200 mg a.i./kg-diet.

4.3.2.3 Mammals: Open Literature Studies

Krijt *et al*. conducted three studies evaluating the effects of oxyfluorfen on mice and rat liver and kidney components. In the 1993 study (E095026), male mice were fed a diet containing 2500 ppm oxyfluorfen for ten days. Significant effects included decreased body weight, increased relative liver weight, increased liver porphyrins, increased fecal porphyrins, increased EROD and PROD activity, and increased peroxisomal β-oxidation activity. In the 1994 study (E095589), ICR male mice were fed a diet containing 2500 ppm oxyfluorfen and experienced increased liver, bile, and fecal porphyrin content. C57B1/6J male mice were fed a diet containing 2500 ppm oxyfluorfen for three months, which resulted in increased PROD activity. In Krijt's 1997 study, male BALB/c mice were administered oxyfluorfen (99.4% purity) (and oxadiazon in separate trials) in the diet at 125, 200, or 1000 ppm for nine days. At 1000 ppm in the diet, oxyfluorfen resulted in experimental porphyria, which resembles the acute phase of human variegate porphyria (VP). The most sensitive significant effects included liver and kidney increase in porphyrin content, increase in urinary porphyrins, increase in liver and kidney PPO, and increase in liver PROD activity (LOAEC = 200 ppm, NOAEC = 125 ppm). Other effects included increase in relative liver weight, increase in serum alanine aminotransferase activity, and increase in urinary porphobilinogen (LOAEC = 1000 ppm, NOAEC = 200 ppm).

4.3.3 Toxicity to Terrestrial Invertebrates

Effects to terrestrial invertebrates resulting from exposure to oxyfluorfen may also indirectly affect the CRLF via reduction in available food.

4.3.3.1 Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

Based on an LD_{50} of >100 µg/bee, oxyfluorfen (71.4% a.i.) appears to be "practically non-toxic" to honeybees (MRID 423681-01).

A registrant also submitted a non-guideline, supplemental study evaluating the toxicity of acute contact of oxyfluorfen on a predatory mite [*Typhlodromus pyri* Schueten (acari: Phytoseiidae)] (MRID 452713-03). The formulation used in this test was Goal 4F (aka Goal 480SC, 42.09% a.i. measured), and the rate was 1.44 kg a.i./hectare (1.28 lb a.i./acre), which is less than the maximum labeled application rate of 2 lb a.i/acre. Seven-day mortality of the treated predatory mites was 98%, compared to a 7-day mortality rate of 5% in the control group. A more recent study involving predatory mites (MRID 459060-06) using Goal 2XL (22.26% a.i. measured) formulation at a rate of 5.8 lb Goal 2XL/acre (1.29 lb a.i./acre) caused 100% mortality by day seven of the test.

Non-guideline, supplemental studies evaluating the acute toxicity to parasitic wasps, ground beetles, and spiders were also submitted (MRID 459060-03, 459060-04, 459060-05). Parasitic wasps [*Aphidus rhopalosiphi* (Hymenoptera: Aphidiidae)] were evaluated at an application rate of 5.8 lb Goal 2XL/acre (1.29 lb a.i./acre), which caused the death of 100% of organisms within 24 hours. Spiders [*Paradosa* sp. (Araneae: Lycosidae)] were evaluated at an application rate of 4.86 lb Goal 2XL/acre (1.08 lb a.i./acre), which also caused the death of 100% of organisms within 24 hours. It is important to note that both of these application rates are less than the maximum labeled rate of 2 lb a.i./acre. For ground beetles [*Poecilus cupreus* L. (Coleoptera: Carabidae)], application of 5.8 lb Goal 2XL/acre (1.29 lb a.i./acre) resulted in no significant reduction of survival or feeding rates relative to the control.

In comparing the results of the six insect studies, there appears to be a wide range of sensitivity to the toxic effects of oxyfluorfen on beneficial insects. Oxyfluorfen was practically non-toxic to honey bees and ground beetles, but highly toxic to predatory mites, parasitic wasps, and spiders. It is not possible to determine which species, if any, is most representative of the level of sensitivity to oxyfluorfen across the insect class. The honey bee study was the only one that tested the effects of the technical. In addition, since the ground beetle was the only organism that did not experience mortality among those that were tested with the formulation, it is possible that the ground beetle was protected from exposure to the chemical due to its hard carapace.

A non-guideline, supplemental study was submitted to evaluate the acute toxicity of Goal 2XL to earthworms [*Eisenia foetida* (Andrei: Bouche)] (MRID 459060-07). The LC_{50} was 89 mg a.i./kg-dry soil and the NOAEC, based on growth, was 29 mg a.i./kg-dry soil. At the highest test concentration, 223 mg a.i./kg-dry soil, there was 100% mortality of earthworms by day 14 of the test. Because this test organism provides the only definitive LC_{50}, it will be used as a surrogate for quantifying the indirect effects to the terrestrial-phase CRLF through reduction of the terrestrial invertebrate prey base. The other beneficial insect studies will be used to qualitatively characterize the indirect effects to the terrestrial-phase CRLF.

Summaries of the seven submitted studies regarding effects of oxyfluorfen exposure to terrestrial invertebrates are located in **Table F-11**.

4.3.3.2 Terrestrial Invertebrates: Open Literature Studies

No studies evaluating toxicity of oxyfluorfen to terrestrial invertebrates were identified in the open literature.

4.3.4 Toxicity to Terrestrial Plants

Terrestrial plant toxicity data are used to evaluate the potential for oxyfluorfen to affect riparian zone and upland vegetation within the action area for the CRLF. Impacts to riparian and upland (*i.e.,* grassland, woodland) vegetation may result in indirect effects to both aquatic- and terrestrial-phase CRLFs, as well as modification to designated critical habitat PCEs via increased sedimentation, alteration in water quality, and reduction in of upland and riparian habitat that provides shelter, foraging, predator avoidance and dispersal for juvenile and adult CRLFs.

Plant toxicity data from both registrant-submitted studies and studies in the scientific literature were reviewed for this assessment. Registrant-submitted studies are conducted under conditions and with species defined in EPA toxicity test guidelines. Sub-lethal endpoints such as plant growth, dry weight, and biomass are evaluated for both monocots and dicots, and effects are evaluated at both seedling emergence and vegetative life stages. Guideline studies generally evaluate toxicity to ten crop species. A drawback to these tests is that they are conducted on herbaceous crop species only, and extrapolation of effects to other species, such as the woody shrubs and trees and wild herbaceous species, contributes uncertainty to risk conclusions.

Commercial crop species have been selectively bred, and may be more or less resistant to particular stressors than wild herbs and forbs. The direction of this uncertainty for specific plants and stressors, including oxyfluorfen, is largely unknown. Homogenous test plant seed lots also lack the genetic variation that occurs in natural populations, so the range of effects seen from tests is likely to be smaller than would be expected from wild populations.

4.3.4.1 Terrestrial Plants: Registrant-submitted Studies

In general, toxicity tests demonstrate that oxyfluorfen negatively impacts seedling emergence and vegetative vigor of terrestrial plants (MRID 416440-01, 458611-01). Results of Tier II toxicity testing on the technical material and the end-use product are summarized in **Tables F-12** and **F-13**.

In the study with technical oxyfluorfen (71.4% purity, MRID 416440-01), both seedling emergence and vegetative vigor were adversely affected. Shoot length was the most sensitive parameter in the seedling emergence study; ryegrass was the most sensitive monocot (EC_{25} = 0.0058 lb a.i./acre), and cabbage was the most sensitive dicot (EC_{25} = 0.0026 lb a.i./acre). For the vegetative vigor test, the most sensitive monocot was onion (EC_{25} = 0.0062 lb a.i./acre, shoot weight), and the most sensitive dicot was tomato (EC_{25} = 0.00043 lb a.i./acre, shoot weight). The results of this study were reported and used in EFED's 2002 RED chapter.

Following the RED, Tier II studies were submitted that evaluated the effects of the formulation product Goal 2XL on non-target terrestrial plant seedling emergence and vegetative vigor (MRID 458611-01, 458611-02). In general, the seedling monocots were more sensitive than the seedling dicots, and the emerged dicots were more sensitive than emerged monocots based on EC_{25} comparisons. Shoot dry weight was the most sensitive parameter in both studies. In the seedling emergence study; ryegrass was the most sensitive monocot (EC_{25} = 0.0062 lb a.i./acre), and lettuce was the most sensitive dicot (EC_{25} = 0.0072 lb a.i./acre). For the vegetative vigor test, the most sensitive monocot was oat (EC_{25} = 0.267 lb a.i./acre, shoot weight) and the most sensitive dicot was lettuce (EC_{25} = 0.0077 lb a.i./acre). Radish (vegetative vigor, dicot) did have a lower EC_{25} (= 0.0055 lb a.i./acre); however, this was not chosen as the most sensitive species since the fit to the probit curve was poor and confidence in the estimated EC_{25} was low.

For the purposes of this risk assessment, the data from the toxicity test using the formulation (Goal 2XL) were used for risk calculation and characterization. Generally, EFED prefers terrestrial plant toxicity tests to be conducted using end-use products as this better represents the exposure of non-target plants in the environment. In addition, the study conducted with the technical grade oxyfluorfen was done using a material produced from an older manufacturing process that has a purity of only 71.5%. All currently produced technical product has a purity of approximately 95-99%. Impurities in the older technical may have caused differences in toxicity. For this risk assessment, EFED is using toxicity testing results that were conducted with the higher purity (more recently produced) technical if available.

4.3.4.2 Terrestrial Plants: Open Literature Studies

A 1991 study (E073249) conducted by Warren *et al*. examined the effects of an oxyfluorfen formulation product on the growth and survival of newly seeded deciduous woody plants. Ornamental Herbicide II was applied immediately after planting to eight species of woody tree species at two application rates (due to poor germination of red maple, results were not reported). At the lower rate (2 lb oxyfluorfen and 1 lb pendimethalin), five of seven tested species were affected: river birch (survival), sweet gum (height), pin oak (diameter), flowering dogwood (height, diameter, and survival), and sugar maple (height, diameter, and survival). At the higher rate (4 lb oxyfluorfen and 2 lb pendimethalin), five of seven species were affected: red bud (height, diameter), river birch (height, diameter, and survival), sweet gum (height, diameter, and survival), flowering dogwood (100% mortality), and sugar maple (100% mortality). The lower rate is a typical labeled rate for Ornamental Herbicide II, but the higher rate exceeds the maximum labeled rate. There are a few limitations to this study. First, because Ornamental Herbicide II has two active ingredients, it is not possible to attribute the observed toxicity solely to oxyfluorfen. Second, IC_{50}'s could not be determined for this study.

4.4 Use of Probit Slope Dose-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 individual listed species and aquatic animals that may indirectly affect the listed species of concern (USEPA 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 or immobilization) should exposure at the EEC actually occur for a species with sensitivity to oxyfluorfen 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 USEPA, 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. The relevant probabilities are reported in **Section 5.1**.

4.5 Incident Database Review

A review of the EIIS database for ecological incidents involving oxyfluorfen was completed on May 29, 2008. The results of this review for terrestrial, plant, and aquatic incidents are discussed below in **Sections 4.4.1**, **4.4.2**, and **4.4.3**, respectively. A complete list of the incidents involving oxyfluorfen including associated uncertainties is included **Table H-1**.

4.5.1 Terrestrial Animal Incidents

There are currently no reported incidents involving terrestrial animals and the use of oxyfluorfen.

4.5.2 Plant Incidents

There are several reported incidents in the Environmental Incident Information System (EIIS) database with terrestrial plant effects, although none of these involves an adverse effect to a wild plant. Agricultural drift was the route of exposure for three of fifteen incidents where crops experienced adverse toxicological effects, and two of these incidents were the results of accidental misuse. The other twelve incidents resulted in adverse effects to directly treated crops or ornamentals, and five of these incidents were the results of accidental misuse. **Table 4.5** summarizes the fifteen incidents; detailed descriptions can be found in **Table H-2**.

Table 4.5 Summary of Oxyfluorfen Plant Incidents in EIIS Database

EIIS Incident # (Date)	Location	Crop Damaged	Type of Damage	Certainty	Acres Damaged (Value)	Misuse?	Spray Drift?	Other Chemicals?
I003377-003 (3/7/1996)	Madera Co., CA	plums, almonds	NR	Probable	130-140 ($500,000-$760,000)	Yes	Yes	glyphosate
I013636-029 (5/1/1996)	Union Co., OR	peppermint	NR	Possible	181	No	No	paraquat
I013563-002 (11/25/1997)	Huron Co., CA	garbanzo beans	NR	Probable	78	Yes	No	
I013563-007 (12/4/1997)	Monterey Co., CA	lettuce	necrotic spotting	Probable	50	Yes	Yes	
I013563-008 (4/21/1998)	San Joaquin Co., CA	grapes	burnt leaves and shoots	Probable	NR	No	No	
I013563-003 (5/3/1999)	Fresno Co., CA	onion	stunting, necrosis, death	Possible	NR	Yes	No	bromoxynil octanoate
I013563-004 (12/1/1999)	Sonoma Co., CA	grape vines	curling, necrosis, speckling	Probable	10	No	No	
I016102-001 (5/2000)	MI	blueberries	yield declines, leaf damage	Possible	20	No	Yes	prodiamine
I013563-009 (6/16/2000)	Fresno Co., CA	muscat grapes	burnt leaves and berries	Probable	20	No	No	sulfur, fenarimol
I013563-005 (11/20/2000)	Madera Co., CA	almond	lack of bloom	Possible	332	No	No	glyphosate
I013563-006 (1/24/2001)	San Joaquin Co., CA	garbanzo beans	NR	Possible	110	No	No	metribuzin, flufenacet
I012366-049 (9/26/2001)	CA	onion	NR	Probable	33 ($124,000)	Yes	No	bromoxynil octanoate, atrazine
I016962-027 (9/8/2004)	Yamhill Co., OR	ryegrass	NR	Probable	38	Yes	No	metribuzin, flufenacet
I013563-001 (NR)	CA	onion	yellowing	Possible	NR	No	No	

Table 4.5 Summary of Oxyfluorfen Plant Incidents in EIIS Database								
EIIS Incident # (Date)	**Location**	**Crop Damaged**	**Type of Damage**	**Certainty**	**Acres Damaged (Value)**	**Misuse?**	**Spray Drift?**	**Other Chemicals?**
I001734-001 (NR)	WA	fir trees	death, necrosis, loss of turgidity, stem brittleness	Unlikely	8	Yes	No	
NR – Not reported.								

4.5.3 Aquatic Incidents

There is one reported incident in the EIIS database with an aquatic organism effect. On 22 August 2000, Fifteen Mile Creek, near the Dalles Dam in Oregon, was the site of an oxyfluorfen spill (# I010844-001, I010949-001). A truck carrying formulated oxyfluorfen (Goal 2XL, 21-24% oxyfluorfen) crashed on a bridge spilling an unknown amount of herbicide into the creek yards from where the creek enters the Columbia River. Following the spill, 2616 gallons of Goal 2XL (628 gallons of oxyfluorfen) were missing; however, less than this amount entered the creek, as a fire burned an indeterminable amount of the herbicide. Two weeks after the spill, samples of filtered (8-micron filter) and unfiltered water near the spill site contained an average of 37 μg/L and 340 μg/L, respectively. This spill was estimated to cause a 35% decrease in the numbers of adult Chinook salmon and a 26% decrease in the numbers of steelhead passing over the Dalles Dam the day immediately following the spill, relative to the day prior to the spill. The spill reportedly killed fish and other aquatic organisms in Fifteen Mile Creek, but fish mortality was not reported in the Columbia River. Over a period of 26 days following the spill, an extensive cleanup operation (removal of water and sediment) removed 270 gallons of oxyfluorfen, and the estimated quantity of the chemical not recovered was less than 358 gallons. Due to the aforementioned fire, it is unlikely that the entire amount of unrecovered oxyfluorfen was spilled into the river.

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to the CRLF or for modification to its designated critical habitat from the use of oxyfluorfen in CA. The risk characterization provides an estimation (**Section 5.1**) and a description (**Section 5.2**) of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of adverse 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 I**). 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, mammals, and other terrestrial-phase amphibians, the LOC is 0.10. 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 oxyfluorfen 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 oxyfluorfen (**Tables 3.5** and **3.6**) and the appropriate toxicity endpoint from **Table 4.3**. 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 oxyfluorfen use within the action area.

5.1.1 Exposures in the Aquatic Habitat

5.1.1.1 Direct Effects to Aquatic-Phase CRLF

Direct effects to the aquatic-phase CRLF are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60-day EECs and the lowest chronic toxicity value for freshwater fish are used. Acute and chronic RQ values exceeded the acute LOC (0.05) and the chronic LOC (1.0) in several of the modeled scenarios (**Table 5.1.a**).

The RQs in the **Table 5.1.a** are based on an acute fish study done under standard laboratory lighting (LC_{50} = 203 μg/L) and a fish early-life cycle test conducted under enhanced UV lighting (NOAEC = 1.3 μg/L). The objective of the enhanced UV lighting was to more closely approximate natural sunlight as oxyfluorfen's toxicity is enhanced by natural sunlight (especially in the 400 nm wavelength range). In order to better estimate acute fish toxicity, a 'standard lighting: enhanced UV lighting" ratio was used. The ratio was calculated as 29.2 (ratio of NOAECs from the standard lighting test to the enhanced lighting test for fish early-life, NOAECs = 38 and 1.3 µg/L, respectively). Therefore, the estimated LC_{50} under enhanced UV lighting was calculated as 7.0 µg/L, and the acute RQs ranged from 0.05 to 6.63 resulting in exceedances of the Listed Species LOC for all modeled scenarios (results not presented in **Table 5.1.a**).

Table 5.1.a Summary of Direct Effect RQs for the Aquatic-phase CRLF[1]

Scenario	Method[2]	Application Rate	Peak EEC (µg/L)	60-day EEC (µg/L)	Direct Effects Acute RQ (standard lab lighting)	Direct Effects Chronic RQ (enhanced UV lighting)
Orchard Uses						
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	5.57	1.63	0.03	**1.25**[+]
CA Olive RLF	G	1 app @ 2 lb a.i./acre	1.67	0.784	0.01	0.60
CA Almond STD	G	1 app @ 2 lb a.i./acre	3.69	1.28	0.02	0.98
	A	1 app @ 0.5 lb a.i./acre	1.78	0.586	0.01	0.45
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	1.83	0.891	0.01	0.69
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.08	0.948	0.01	0.73
CA Fruit STD	G	1 app @ 2 lb a.i./acre	1.82	0.765	0.01	0.59
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.34	1.15	0.01	0.88
CA Grapes STD	G	1 app @ 2 lb a.i./acre	1.57	0.593	0.01	0.46
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.27	1.07	0.01	0.82
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	6.81	2.85	0.03	**2.19**[+]
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	3.47	2.24	0.02	**1.72**[+]
Agricultural – Food Crop Uses						
CA Cole Crop RLF	G	1 app @ 0.5 lb a.i./acre	2.04	1.11	0.01	0.85
	A	1 app @ 0.5 lb a.i./acre	2.53	1.31	0.01	**1.01**[+]
CA Garlic RLF	G	1 app @ 0.5 lb a.i./acre	1.60	0.581	0.01	0.45
	A	1 app @ 0.5 lb a.i./acre	1.81	0.620	0.01	0.48
CA Lettuce STD	G	1 app @ 0.5 lb a.i./acre	3.53	1.83	0.02	**1.41**[+]
	A	1 app @ 0.5 lb a.i./acre	3.60	1.83	0.02	**1.41**[+]
CA Melons RLF	G	1 app @ 0.5 lb a.i./acre	1.27	0.541	0.01	0.42
	A	1 app @ 0.5 lb a.i./acre	1.83	0.724	0.01	0.56
CA Onion STD	G	1 app @ 0.5 lb a.i./acre	0.398	0.166	<0.01	0.13
	A	1 app @ 0.5 lb a.i./acre	1.59	0.434	0.01	0.33
CA Potato RLF	G	1 app @ 0.5 lb a.i./acre	0.347	0.117	<0.01	0.09
	A	1 app @ 0.5 lb a.i./acre	1.55	0.371	0.01	0.29
CA Strawberry RLF	G	1 app @ 0.5 lb a.i./acre	2.02	1.02	0.01	0.78
	A	1 app @ 0.5 lb a.i./acre	2.68	1.23	0.01	0.95
CA Sugarbeet OP	G	1 app @ 0.5 lb a.i./acre	0.532	0.215	<0.01	0.17
	A	1 app @ 0.5 lb a.i./acre	1.69	0.475	0.01	0.37
CA Tomato STD	G	1 app @ 0.5 lb a.i./acre	0.820	0.349	<0.01	0.27
	A	1 app @ 0.5 lb a.i./acre	1.71	0.531	0.01	0.41
CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	2.36	1.07	0.01	0.82
	A	1 app @ 0.5 lb a.i./acre	2.58	1.27	0.01	0.98
OR Mint	G	1 app @ 2 lb a.i./acre	3.06	1.85	0.02	**1.42**[+]
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	5.25	2.40	0.03	**1.85**[+]
	A	1 app @ 0.5 lb a.i./acre	1.93	0.715	0.01	0.55

Table 5.1.a Summary of Direct Effect RQs for the Aquatic-phase CRLF[1]						
Scenario	**Method[2]**	**Application Rate**	**Peak EEC (µg/L)**	**60-day EEC (µg/L)**	**Direct Effects Acute RQ (standard lab lighting)**	**Direct Effects Chronic RQ (enhanced UV lighting)**
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	1.01	0.535	<0.01	0.41
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	2.66	1.04	0.01	0.80
	A	1 app @ 0.5 lb a.i./acre	1.91	0.847	0.01	0.65
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	3.98	1.69	0.02	**1.30**+
	G	4 apps @ 2 lb a.i./acre (30 day interval)	17.43	6.72	**0.09***	**5.17**+
Non-Agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.40	21.03	**0.23***	**16.18**+
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.19	20.48	**0.23***	**15.75**+
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	18.49	9.25	**0.09***	**7.12**+
	G	2 apps @ 2 lb a.i./acre (30 day interval)	15.55	8.07	**0.08***	**6.21**+
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	7.89	4.84	0.04	**3.72**+
CA Residential RLF	G	1 app @ 2 lb a.i./acre	1.04	0.302	0.01	0.23
	G	4 apps @ 2 lb a.i./acre (30 day interval)	1.54	0.821	0.01	0.63
CA Right-of-Way RLF	G	1 app @ 2 lb a.i./acre	2.88	1.41	0.01	**1.08**+
	G	4 apps @ 2 lb a.i./acre (30 day interval)	8.89	5.24	0.04	**4.03**+
CA Turf RLF	G	1 app @ 2 lb a.i./acre	1.54	0.58	0.01	0.45
	G	4 apps @ 2 lb a.i./acre (30 day interval)	3.39	2.07	0.02	**1.59**+

[1]RQs associated with acute and chronic direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items.
[2]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
*,+ = LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0) are bolded. Acute RQ = use-specific peak EEC / 203 µg a.i./L (MRID 38574). Chronic RQ = use-specific 60-day EEC / 1.3 µg a.i./L (MRID 465851-04).

Table 5.1.b Summary of Direct Effect RQs for the Aquatic-phase CRLF [a], Individual Effect Probabilities				
Scenario	**Method[1]**	**Application Rate**	**Direct Effects Acute RQ***	**Probability of Individual Effect at RQ[b] (Confidence Interval)**
Agricultural – Non-food Crop Uses				
CA Rangeland Hay RLF	G	4 apps @ 2 lb a.i./acre (30 day interval)	**0.09**	4.31E05 (3.19E03, 2.26E08)
Non-Agricultural Uses				
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	**0.23**	3.86E02 (5.42E01, 4.47E03)
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	**0.23**	3.86E02 (5.42E01, 4.47E03)
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	**0.09**	4.31E05 (3.19E03, 2.26E08)
	G	2 apps @ 2 lb a.i./acre (30 day interval)	**0.08**	1.29E06 (5.98E03, 1.24E09)
All other scenarios (If there was no LOC exceedance, the probability of individual effect is evaluated at the Listed Species LOC.)				1.65E08 (9.54E04, 2.40E12)

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[a]RQs associated with acute and chronic direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items
[b] A probit slope value and 95% confidence interval for the acute bluegill toxicity test was available; therefore, the effect probability was calculated based on slope of 4.38 with a 95% confidence interval of (3.27, 5.50). Probabilities should be read as 1 in 4.31×10^5 for California forestry, ground basal application, for example.
* = LOC exceedances (acute RQ $\geq$ 0.05) are bolded. Acute RQ = use-specific peak EEC / 203 µg a.i./L (MRID 38574).

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

5.1.1.2.1 Non-vascular Aquatic Plants

Indirect effects of oxyfluorfen to the aquatic-phase CRLF (tadpoles) via reduction in non-vascular aquatic plants in its diet are based on peak EECs from the standard pond and the lowest toxicity value (EC_{50}) for aquatic non-vascular plants (**Table 5.2**). All modeled scenarios resulted in RQ values that exceeded LOCs for aquatic non-vascular plants.

Table 5.2 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Non-Vascular Aquatic Plants (diet of CRLF in tadpole life stage and habitat of aquatic-phase CRLF)				
Scenario	**Method[1]**	**Application Rate**	**Peak EEC**	**RQ***
Orchard Uses				
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	5.57	**19.21**
CA Olive RLF	G	1 app @ 2 lb a.i./acre	1.67	**5.76**
CA Almond STD	G	1 app @ 2 lb a.i./acre	3.69	**12.72**
	A	1 app @ 0.5 lb a.i./acre	1.78	**6.14**
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	1.83	**6.31**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.08	**7.17**
CA Fruit STD	G	1 app @ 2 lb a.i./acre	1.82	**6.28**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.34	**8.07**
CA Grapes STD	G	1 app @ 2 lb a.i./acre	1.57	**5.41**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.27	**7.83**
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	6.81	**23.48**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	3.47	**11.97**
Agricultural – Food Crop Uses				
CA Cole Crop RLF	G	1 app @ 0.5 lb a.i./acre	2.04	**7.03**
	A	1 app @ 0.5 lb a.i./acre	2.53	**8.72**
CA Garlic RLF	G	1 app @ 0.5 lb a.i./acre	1.60	**5.52**
	A	1 app @ 0.5 lb a.i./acre	1.81	**6.24**
CA Lettuce STD	G	1 app @ 0.5 lb a.i./acre	3.53	**12.17**
	A	1 app @ 0.5 lb a.i./acre	3.60	**12.41**
CA Melons RLF	G	1 app @ 0.5 lb a.i./acre	1.27	**4.38**
	A	1 app @ 0.5 lb a.i./acre	1.83	**6.31**
CA Onion STD	G	1 app @ 0.5 lb a.i./acre	0.398	**1.37**
	A	1 app @ 0.5 lb a.i./acre	1.59	**5.48**
CA Potato RLF	G	1 app @ 0.5 lb a.i./acre	0.347	**1.20**
	A	1 app @ 0.5 lb a.i./acre	1.55	**5.34**
CA Strawberry RLF	G	1 app @ 0.5 lb a.i./acre	2.02	**6.97**
	A	1 app @ 0.5 lb a.i./acre	2.68	**9.24**
CA Sugarbeet OP	G	1 app @ 0.5 lb a.i./acre	0.532	**1.83**
	A	1 app @ 0.5 lb a.i./acre	1.69	**5.83**
CA Tomato STD	G	1 app @ 0.5 lb a.i./acre	0.820	**2.83**
	A	1 app @ 0.5 lb a.i./acre	1.71	**5.90**
CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	2.36	**8.14**
	A	1 app @ 0.5 lb a.i./acre	2.58	**8.90**
OR Mint	G	1 app @ 2 lb a.i./acre	3.06	**10.55**
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	5.25	**18.10**
	A	1 app @ 0.5 lb a.i./acre	1.93	**6.66**
Agricultural – Non-food Crop Uses				
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre &	1.01	**3.48**

Table 5.2 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Non-Vascular Aquatic Plants (diet of CRLF in tadpole life stage and habitat of aquatic-phase CRLF)				
Scenario	**Method[1]**	**Application Rate**	**Peak EEC**	**RQ***
		1 app @ 0.25 lb a.i./acre (30 day interval)		
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	2.66	**9.17**
	A	1 app @ 0.5 lb a.i./acre	1.91	**6.59**
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	3.98	**13.72**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	17.43	**60.10**
Non-agricultural Uses				
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.40	**160.00**
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.19	**159.28**
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	18.49	**63.76**
	G	2 apps @ 2 lb a.i./acre (30 day interval)	15.55	**53.62**
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	7.89	**27.21**
CA Residential RLF	G	1 app @ 2 lb a.i./acre	1.04	**3.59**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	1.54	**5.31**
CA Right-of-Way RLF	G	1 app @ 2 lb a.i./acre	2.88	**9.93**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	8.89	**30.66**
CA Turf RLF	G	1 app @ 2 lb a.i./acre	1.54	**5.31**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	3.39	**11.69**
[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified. *LOC exceedances (RQ $\geq$ 1) are bolded. RQ = use-specific peak EEC/ 0.29 µg a.i./L (MRID 452713-02).				

5.1.1.2.2 Aquatic Invertebrates

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on 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 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 5.3.a**. Acute RQ values exceeded the acute LOC in some modeled scenarios for freshwater invertebrate prey items. The uncertainties regarding the potential for enhanced toxic effects under natural lighting, which may further contribute to the risk of toxic effects, are discussed below and in **Section 5.2**.

The RQs in the **Table 5.3.a** are based on acute and life cycle invertebrate studies done under standard laboratory lighting. To better estimate the toxicity of oxyfluorfen under natural sunlight, the “standard lighting: enhanced UV lighting” ratio calculated for the fish early-life study was applied to the toxicity endpoints from the invertebrate studies. The ratio was calculated as 29.2 (ratio of NOAECs from the standard lighting test to the enhanced lighting test for fish early-life, NOAECs = 38 and 1.3 µg/L, respectively). Therefore, the estimated LC_{50} and NOAEC under enhanced UV lighting were calculated as 2.73 µg/L and 0.44 µg/L. Under the enhanced UV lighting setting, the acute RQs ranged from 0.13 to 17.00, resulting in exceedances of the Listed Species LOC for all modeled scenarios. Under the enhanced UV lighting setting, the chronic RQs ranged from 0.33 to 55.45, resulting in exceedances of the chronic LOC for all but five of the modeled scenarios.

RQs were also calculated for sediment-dwelling invertebrates, the LC_{50} was determined to be > 498.5 µg a.i./L-pore water (46% mortality at the highest dose). The highest benthic pore water EEC was calculated at 16.88 µg a.i./L-pore water in the liquid nursery scenario for four applications of 2 lb a.i./acre (**Table 3.4**). The resulting RQ < 0.034 indicated that there were no LOC exceedances for benthic invertebrate prey of CRLFs.

Table 5.3.a Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats)

Scenario	Method[1]	Application Rate	Peak EEC (µg/L)	21-day EEC (µg/L)	Standard lab lighting	
					Indirect Effects Acute RQ	Indirect Effects Chronic RQ
Orchard Uses						
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	5.57	2.14	**0.07***	0.16
CA Olive RLF	G	1 app @ 2 lb a.i./acre	1.67	0.907	0.02	0.07
CA Almond STD	G	1 app @ 2 lb a.i./acre	3.69	1.69	**0.05***	0.13
	A	1 app @ 0.5 lb a.i./acre	1.78	0.761	0.02	0.06
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	1.83	0.983	0.02	0.08
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.08	1.08	0.03	0.08
CA Fruit STD	G	1 app @ 2 lb a.i./acre	1.82	1.02	0.02	0.08
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.34	1.29	0.03	0.10
CA Grapes STD	G	1 app @ 2 lb a.i./acre	1.57	0.814	0.02	0.06
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.27	1.18	0.03	0.09
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	6.81	3.50	**0.09***	0.27
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	3.47	2.36	0.04	0.18
Agricultural – Food Crop Uses						
CA Cole Crop RLF	G	1 app @ 0.5 lb a.i./acre	2.04	1.40	0.03	0.11
	A	1 app @ 0.5 lb a.i./acre	2.53	1.56	0.03	0.12
CA Garlic RLF	G	1 app @ 0.5 lb a.i./acre	1.60	0.759	0.02	0.06
	A	1 app @ 0.5 lb a.i./acre	1.81	0.792	0.02	0.06
CA Lettuce STD	G	1 app @ 0.5 lb a.i./acre	3.53	2.15	0.04	0.17

Table 5.3.a Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats)						
Scenario	Method[1]	Application Rate	Peak EEC (µg/L)	21-day EEC (µg/L)	Standard lab lighting	
					Indirect Effects Acute RQ	Indirect Effects Chronic RQ
	A	1 app @ 0.5 lb a.i./acre	3.60	2.05	**0.05***	0.16
CA Melons RLF	G	1 app @ 0.5 lb a.i./acre	1.27	0.651	0.02	0.05
	A	1 app @ 0.5 lb a.i./acre	1.83	0.908	0.02	0.07
CA Onion STD	G	1 app @ 0.5 lb a.i./acre	0.398	0.220	<0.01	0.02
	A	1 app @ 0.5 lb a.i./acre	1.59	0.611	0.02	0.05
CA Potato RLF	G	1 app @ 0.5 lb a.i./acre	0.347	0.149	<0.01	0.01
	A	1 app @ 0.5 lb a.i./acre	1.55	0.549	0.02	0.04
CA Strawberry RLF	G	1 app @ 0.5 lb a.i./acre	2.02	1.29	0.03	0.10
	A	1 app @ 0.5 lb a.i./acre	2.68	1.51	0.03	0.12
CA Sugarbeet OP	G	1 app @ 0.5 lb a.i./acre	0.532	0.253	0.01	0.02
	A	1 app @ 0.5 lb a.i./acre	1.69	0.652	0.02	0.05
CA Tomato STD	G	1 app @ 0.5 lb a.i./acre	0.820	0.431	0.01	0.03
	A	1 app @ 0.5 lb a.i./acre	1.71	0.718	0.02	0.06
CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	2.36	1.28	0.03	0.10
	A	1 app @ 0.5 lb a.i./acre	2.58	1.44	0.03	0.11
OR Mint	G	1 app @ 2 lb a.i./acre	3.06	2.00	0.04	0.15
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	5.25	2.93	**0.07***	0.23
	A	1 app @ 0.5 lb a.i./acre	1.93	0.923	0.02	0.07
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	1.01	0.587	0.01	0.05
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	2.66	1.27	0.03	0.10
	A	1 app @ 0.5 lb a.i./acre	1.91	1.02	0.02	0.08
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	3.98	2.25	**0.05***	0.17
	G	4 apps @ 2 lb a.i./acre (30 day interval)	17.43	8.69	**0.22***	0.67
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.40	24.40	**0.58***	**1.88***
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.19	23.97	**0.58***	**1.84**[+]
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	18.49	10.50	**0.23***	0.81
	G	2 apps @ 2 lb a.i./acre (30 day interval)	15.55	8.82	**0.19***	0.68
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	7.89	5.31	**0.10***	0.41
CA Residential RLF	G	1 app @ 2 lb a.i./acre	1.04	0.430	0.01	0.03
	G	4 apps @ 2 lb a.i./acre (30 day interval)	1.54	0.891	0.02	0.07

Table 5.3.a Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats)						
Scenario	**Method[1]**	**Application Rate**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Standard lab lighting**	
					Indirect Effects Acute RQ	**Indirect Effects Chronic RQ**
CA Right-of-Way RLF	G	1 app @ 2 lb a.i./acre	2.88	1.63	0.04	0.13
	G	4 apps @ 2 lb a.i./acre (30 day interval)	8.89	6.45	**0.11***	0.50
CA Turf RLF	G	1 app @ 2 lb a.i./acre	1.54	0.74	0.02	0.06
	G	4 apps @ 2 lb a.i./acre (30 day interval)	3.39	2.29	0.04	0.18

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
*,+ = LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0) are bolded. Acute RQ = use-specific peak EEC / 80 µg a.i./L (MRID 452713-01). Chronic RQ = use-specific 21-day EEC / 13 µg a.i./L (MRID 21423-05 and 455502-01).

Table 5.3.b Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats), Individual Effect Probabilities				
Scenario	**Method[1]**	**Application Rate**	**Direct Effects Acute RQ**	**Probability of Individual Effect at RQ[a]**
Orchard Uses				
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	**0.07***	9.88E06 (9.57E01, 7.58E24)
CA Almond STD	G	1 app @ 2 lb a.i./acre	**0.05***	4.18E08 (2.16E02, 1.75E31)
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	**0.09***	7.91E05 (5.48E01, 4.1E20)
Agricultural – Food Crop Uses				
CA Lettuce STD	A	1 app @ 0.5 lb a.i./acre	**0.05***	4.18E08 (2.16E02, 1.75E31)
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	**0.07***	9.88E06 (9.57E01, 7.58E24)
Agricultural – Non-food Crop Uses				
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	**0.05***	4.18E08 (2.16E02, 1.75E31)
	G	4 apps @ 2 lb a.i./acre (30 day interval)	**0.22***	6.48E02 (1.06E01, 6.14E08)
Non-agricultural Uses				
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	**0.58***	6.97E00 (3.14E00, 6.02E01)
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	**0.58***	6.97E00 (3.14E00, 6.02E01)
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	**0.23***	4.91E02 (9.91E00, 2.17E08)
	G	2 apps @ 2 lb a.i./acre	**0.19***	1.71E03

Table 5.3.b Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats), Individual Effect Probabilities				
Scenario	Method[1]	Application Rate	Direct Effects Acute RQ	Probability of Individual Effect at RQ[a]
		(30 day interval)		(1.34E01, 2.35E10)
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	**0.10***	2.94E05 (4.40E01, 8.98E18)
CA Right-of-Way RLF	G	4 apps @ 2 lb a.i./acre (30 day interval)	**0.11***	1.25E05 (3.62E01, 3.19E17)
All other scenarios (If there was no LOC exceedance, the probability of individual effect is evaluated at the Listed Species LOC.)				4.18E08 (2.16E02, 1.75E31)

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[a]A probit slope value and 95% confidence interval for the daphnia acute toxicity test was not available; therefore, the effect probability was calculated based on the default slope of 4.5 with a 95% confidence interval of (2, 9). Probabilities should be read as 1 in 4.31×10^5 for California forestry, ground basal application, for example.
* = LOC exceedances (acute RQ $\geq$ 0.05) are bolded. Acute RQ = use-specific peak EEC / 80 µg a.i./L (MRID 452713-01).

5.1.1.2.3 Fish and Frogs

Fish and frogs also represent potential prey items of adult aquatic-phase CRLFs. RQs associated with acute and chronic direct toxicity to the CRLF (**Table 5.1.a**) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. Acute and chronic RQ values exceed the acute and chronic LOCs in a number of modeled scenarios for fish and frogs. These results are characterized in **Section 5.2** along with the uncertainties regarding the potential for enhanced toxicity under natural lighting conditions.

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

Indirect effects to the CRLF via direct toxicity to aquatic plants are estimated using the most sensitive non-vascular and vascular plant toxicity endpoints. Because there are no obligate relationships between the CRLF and any aquatic plant species, the most sensitive EC_{50} values, rather than NOAEC values, were used to derive RQs (**Tables 5.2** and **5.4**). All RQ values exceeded the LOC (1.0) in all scenarios except ground applications to potatoes for aquatic vascular plants.

Table 5.4 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Vascular Aquatic Plants (habitat of aquatic-phase CRLF)[1]				
Scenario	**Method[2]**	**Application Rate**	**Peak EEC**	**RQ***
Orchard Uses				
CA Avocado RLF	G	1 app @ 2 lb a.i./acre	5.57	**15.91**
CA Olive RLF	G	1 app @ 2 lb a.i./acre	1.67	**4.77**
CA Almond STD	G	1 app @ 2 lb a.i./acre	3.69	**10.54**
	A	1 app @ 0.5 lb a.i./acre	1.78	**5.09**
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	1.83	**5.23**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.08	**5.94**
CA Fruit STD	G	1 app @ 2 lb a.i./acre	1.82	**5.20**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.34	**6.69**
CA Grapes STD	G	1 app @ 2 lb a.i./acre	1.57	**4.49**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	2.27	**6.49**
CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	6.81	**19.46**
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	3.47	**9.91**
Agricultural – Food Crop Uses				
CA Cole Crop RLF	G	1 app @ 0.5 lb a.i./acre	2.04	**5.83**
	A	1 app @ 0.5 lb a.i./acre	2.53	**7.23**
CA Garlic RLF	G	1 app @ 0.5 lb a.i./acre	1.60	**4.57**
	A	1 app @ 0.5 lb a.i./acre	1.81	**5.17**
CA Lettuce STD	G	1 app @ 0.5 lb a.i./acre	3.53	**10.09**
	A	1 app @ 0.5 lb a.i./acre	3.60	**10.29**
CA Melons RLF	G	1 app @ 0.5 lb a.i./acre	1.27	**3.63**
	A	1 app @ 0.5 lb a.i./acre	1.83	**5.23**
CA Onion STD	G	1 app @ 0.5 lb a.i./acre	0.398	**1.14**
	A	1 app @ 0.5 lb a.i./acre	1.59	**4.54**
CA Potato RLF	G	1 app @ 0.5 lb a.i./acre	0.347	0.99
	A	1 app @ 0.5 lb a.i./acre	1.55	**4.43**
CA Strawberry RLF	G	1 app @ 0.5 lb a.i./acre	2.02	**5.77**
	A	1 app @ 0.5 lb a.i./acre	2.68	**7.66**
CA Sugarbeet OP	G	1 app @ 0.5 lb a.i./acre	0.532	**1.52**
	A	1 app @ 0.5 lb a.i./acre	1.69	**4.83**
CA Tomato STD	G	1 app @ 0.5 lb a.i./acre	0.820	**2.34**
	A	1 app @ 0.5 lb a.i./acre	1.71	**4.89**
CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	2.36	**6.74**
	A	1 app @ 0.5 lb a.i./acre	2.58	**7.37**
OR Mint	G	1 app @ 2 lb a.i./acre	3.06	**8.74**
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	5.25	**15.00**
	A	1 app @ 0.5 lb a.i./acre	1.93	**5.51**
Agricultural – Non-food Crop Uses				
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre &	1.01	**2.89**

Table 5.4 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Vascular Aquatic Plants (habitat of aquatic-phase CRLF)[1]				
Scenario	**Method[2]**	**Application Rate**	**Peak EEC**	**RQ***
		1 app @ 0.25 lb a.i./acre (30 day interval)		
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	2.66	**7.60**
	A	1 app @ 0.5 lb a.i./acre	1.91	**5.46**
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	3.98	**11.37**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	17.43	**49.80**
Non-agricultural Uses				
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.40	**132.57**
CA Nursery (granular)	G	4 apps @ 2 lb a.i./acre (90 day interval)	46.19	**131.97**
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	18.49	**52.83**
	G	2 apps @ 2 lb a.i./acre (30 day interval)	15.55	**44.43**
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	7.89	**22.54**
CA Residential RLF	G	1 app @ 2 lb a.i./acre	1.04	**2.97**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	1.54	**4.40**
CA Right-of-Way RLF	G	1 app @ 2 lb a.i./acre	2.88	**8.23**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	8.89	**25.40**
CA Turf RLF	G	1 app @ 2 lb a.i./acre	1.54	**4.40**
	G	4 apps @ 2 lb a.i./acre (30 day interval)	3.39	**9.69**

[1]RQs used to estimate indirect effects to the CRLF via toxicity to non-vascular aquatic plants are summarized in **Table 5.2**.
[2]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
*LOC exceedances (RQ ≥ 1) are bolded. RQ = use-specific peak EEC/ 0.35 µg a.i./L (MRID 458611-03).

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 ground and aerial applications of oxyfluorfen to soil or weed foliage using liquid spray in most cases; one scenario models the direct effects of a granular application. A small bird (20 g), which consumes small insects, is used as a surrogate for the terrestrial-phase CRLF to model exposures to contaminated food.

5.1.2.1.1 Terrestrial-phase CRLF: Liquid Applications

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 3.5**) and acute oral and sub-acute dietary toxicity endpoints for avian species.

Although the LD_{50} for the Northern bobwhite quail was greater than 2150 mg a.i/kg-bw (MRID 921361-02), a single mortality was observed in the highest test group. Because it was uncertain whether or not this mortality was incidental or treatment-related, acute dose-based RQ values were calculated (**Table 5.5**). However, these RQ values, which range from 0.05 to 0.40, are non-definitive and represent an upper bound. Although there are dose-based exceedances of the acute LOC (0.1) at rates above three applications at 0.5 lb a.i./acre, the modeling is highly conservative because the RQ values are based on an LD_{10} rather than an LD_{50}. Along with a lack of two partial mortalities in the treatment groups, this overestimation of risk prevents calculation of an accurate probit slope and, subsequently, chance of individual effect.

The LC_{50} values for both the Northern bobwhite quail and mallard duck were greater than 5000 mg a.i./kg-diet as no mortalities were observed at the highest test concentration (MRID 921361-03, 921361-04). Therefore, definitive acute dietary RQ values could not be derived. Because the predicted dietary-based EEC values are much lower than the LC_{50}, acute dietary-based LOC exceedances are unlikely.

Potential direct chronic effects of oxyfluorfen to the terrestrial-phase CRLF are derived by considering dietary-based exposures modeled in T-REX for a small bird (20 g) consuming small invertebrates. Chronic effects are estimated using the most sensitive toxicity endpoint for birds. EECs are divided by toxicity values to estimate chronic dietary-based RQs. Based on the RQs in **Table 5.5**, oxyfluorfen applications of two or less applications at a minimum of 30 days apart at a rate of 0.5 lb a.i./acre do not exceed the chronic LOC (1.0). However, for all scenarios with rates higher than two applications of 0.5 lb a.i./acre, applications of oxyfluorfen at the highest labeled rates exceed the chronic LOC. Example output from T-REX is located in **Appendix J**.

Table 5.5 Summary of Acute and Chronic RQs Used to Estimate Direct Effects of Liquid Applications of Oxyfluorfen on the Terrestrial-phase CRLF

Scenario	Method[1]	Application Rate	Dose-based EEC[2] (ppm)	Dose-based Acute RQ (LD_{10})[3]	Dietary-based EEC[4] (ppm)	Dietary-based Chronic RQ[5]
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18**[+]
CA Almond STD	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18**[+]
	A	1 app @ 0.5 lb a.i./acre	76.88	0.05	67.50	0.54
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	477.26	**0.31***	419.05	**3.38**[+]
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	142.74	0.09	125.33	**1.01**[+]
CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18**[+]
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	142.74	0.09	125.33	**1.01**[+]
Agricultural – Food Crop Uses						
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	76.88	0.05	67.50	0.54
	A	1 app @ 0.5 lb a.i./acre	76.88	0.05	67.50	0.54
OR Mint	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18**[+]
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18**[+]
	A	1 app @ 0.5 lb a.i./acre	76.88	0.05	67.50	0.54
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	153.75	**0.10***	135.00	**1.09**[+]
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	119.31	0.08	104.76	0.84
	A	1 app @ 0.5 lb a.i./acre	76.88	0.05	67.50	0.54
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18**[+]
	G	4 apps @ 2 lb a.i./acre (30 day interval)	622.70	**0.40***	546.76	**4.41**[+]
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	369.40	**0.24***	324.35	**2.62**[+]
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	428.23	**0.28***	376.00	**3.03**[+]
	G	2 apps @ 2 lb a.i./acre (30 day interval)	477.26	**0.31***	419.05	**3.38**[+]
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	155.68	**0.10***	136.69	**1.10**[+]

Table 5.5 Summary of Acute and Chronic RQs Used to Estimate Direct Effects of Liquid Applications of Oxyfluorfen on the Terrestrial-phase CRLF						
Scenario	**Method[1]**	**Application Rate**	**Dose-based EEC[2] (ppm)**	**Dose-based Acute RQ (LD_{10})[3]**	**Dietary-based EEC[4] (ppm)**	**Dietary-based Chronic RQ[5]**
CA Residential RLF	G	1 app @ 2 lb a.i./acre	307.50	**0.20***	270.00	**2.18[+]**
CA Right-of-Way RLF CA Turf RLF	G	4 apps @ 2 lb a.i./acre (30 day interval)	622.70	**0.40***	546.76	**4.41[+]**

[1]G = ground application. A = aerial application.
[2]EEC based on small (20 g) bird consuming small insects.
[3]Estimation based on Northern bobwhite quail acute oral dose LD_{10} = 2150 mg a.i./kg-bw (MRID 921361-02). An LD_{50} could not be determined because only one death was observed at the highest dose level. It was not possible to rule the death as either incidental or treatment-related; therefore, acute RQs were calculated.
[4]EEC based on consumption of small insects.
[5]Estimation based on Northern bobwhite quail chronic reproduction NOAEC = 124 mg a.i./kg-diet (MRID 460701-02).
*Acute RQ ≥ 0.1 exceeds acute endangered species level of concern (LOC).
[+]Chronic RQ ≥ 1.0 exceeds chronic level of concern (LOC).

5.1.2.1.2 Terrestrial-phase CRLF: Granular Applications

Acute direct effects to the terrestrial-phase CRLF via exposure to oxyfluorfen granules are derived based on LD_{50}/ft^2 values. However, as previously discussed, the lack of a definitive avian LD_{50} enables only a non-definitive upper bound acute RQ to be calculated (based on an LD_{10}) for the one scenario that involves the application of granules. Although this is an overestimation of risk, the predicted RQ value of 0.67 exceeds the acute LOC (0.1).

Table 5.6 Acute RQ Used to Estimate Direct Effects of Granular Applications of Oxyfluorfen on the Terrestrial-phase CRLF			
Scenario	**Application Rate**	**EEC[2] (mg a.i./ft^2)**	**Acute RQ (LD_{10})[3]**
Non-Agricultural Uses			
CA Nursery (granular)[1]	4 apps @ 2 lb a.i./acre (90 day interval)	20.83	**0.67***

[1] Scenario based on ground application of oxyfluorfen.
[2]EEC based on soil concentration.
[3]Estimation based on Northern bobwhite quail acute oral dose LD_{10} = 2150 mg a.i./kg-bw (MRID 921361-02). An LD_{50} could not be determined because only one death was observed at the highest dose level. It was not possible to rule the death as incidental or treatment-related; therefore, acute RQs were calculated.
*Acute RQ ≥ 0.1 exceeds acute endangered species level of concern (LOC).

Chronic direct effects to the terrestrial-phase CRLF via exposure to oxyfluorfen granules were derived according to the methodology presented in **Appendix K**. Exposure estimates and predicted chronic RQ values are based on direct ingestion of soil invertebrates that have bioaccumulated oxyfluorfen residues of granules in soil. Chronic risks to birds associated with ingestion of earthworms that have bioaccumulated oxyfluorfen granules are not expected because the estimated earthworm residue (77.92

mg a.i./kg-earthworm at an application rate of 2 lb a.i./acre) is below the chronic avian endpoint (124 mg a.i./kg-diet), which results in a chronic RQ value of 0.63. It is important to note that the earthworm fugacity model described in **Appendix K** models only one application of oxyfluorfen rather than the four applications that the CA Nursery scenario suggests.

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

5.1.2.2.1 Terrestrial Invertebrates

In order to assess the risks of oxyfluorfen to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the earthworm is used as a surrogate for terrestrial invertebrates because it is the only organism with a definitive LC_{50}, as determined by the seven registrant-submitted studies that evaluate the effects of oxyfluorfen on terrestrial invertebrates. Four of the other six acute contact toxicity studies that were submitted also demonstrate high mortality for the particular test organism, but these risks will be discussed in the risk description portion of this assessment (**Section 5.2**) because definitive toxicity values could not be established.

5.1.2.2.1a Terrestrial Invertebrates: Liquid Applications

T-REX was used to calculate EEC values for earthworms exposed to oxyfluorfen. EECs (**Table 3.6**) for small and large insects were divided by earthworm toxicity value (LC_{50} = 89 mg a.i./kg-dry soil, MRID 459060-07). **Table 5.7** summarizes the acute RQ values for small and large insects, as well as the probability of individual effects occurring. Acute RQ values for small insects ranged from 0.76 to 6.14. For large insects, acute RQ values ranged from 0.08 to 0.68. All acute RQ values for large and small insects exceeded the acute LOC (0.05). The probabilities of individual effects, as calculated by IECv.1.1, show that effects to individuals within the prey population are highly probable. At the lowest application rate of one application at 0.5 lb a.i./acre, there is a 1 in 5 chance that a small insect will be adversely impacted; for large insects, the probability of an individual effect is insignificant at the same application rate. At the acute LOC (0.05), there is a 1 in 2.69E+20 chance that an individual will be adversely affected by the corresponding application rate of oxyfluorfen.

Table 5.7 Summary of Acute RQs Used to Estimate Indirect Effects of Liquid Applications of Oxyfluorfen to the Terrestrial-phase CRLF via Effects to Terrestrial Invertebrate Prey Items						
Scenario	**Method[1]**	**Application Rate**	**Size**	**EEC (ppm)**	**Acute RQ*,[2]**	**Probability of Individual Effect[3] (Confidence Interval)**
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)
CA Almond STD	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)
	A	1 app @ 0.5 lb a.i./acre	Small	67.50	**0.76**	1 in 5.12 (3.64 – 7.56)
			Large	7.50	**0.08**	1 in 7.04E14 (5.81E07 – 2.02E24)
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	Small	419.05	**4.71**	1 in 1 (1 – 1)
			Large	46.56	**0.52**	1 in 48.9 (1.31E01 – 2.55E02)
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Small	125.33	**1.41**	1 in 1.16 (1.29 – 1.09)
			Large	13.93	**0.16**	1 in 2.00E08 (3.20E04 – 2.13E13)
CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Small	125.33	**1.41**	1 in 1.16 (1.29 – 1.09)
			Large	13.93	**0.16**	1 in 2.00E08 (3.20E04 – 2.13E13)
Agricultural – Food Crop Uses						
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	Small	67.50	**0.76**	1 in 5.12 (3.64 – 7.56)
			Large	7.50	**0.08**	1 in 7.04E14 (5.81E07 – 2.02E24)
	A	1 app @ 0.5 lb a.i./acre	Small	67.50	**0.76**	1 in 5.12 (3.64 – 7.56)
			Large	7.50	**0.08**	1 in 7.04E14 (5.81E07 – 2.02E24)
OR Mint	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)

Table 5.7 Summary of Acute RQs Used to Estimate Indirect Effects of Liquid Applications of Oxyfluorfen to the Terrestrial-phase CRLF via Effects to Terrestrial Invertebrate Prey Items						
Scenario	**Method[1]**	**Application Rate**	**Size**	**EEC (ppm)**	**Acute RQ*,[2]**	**Probability of Individual Effect[3] (Confidence Interval)**
	A	1 app @ 0.5 lb a.i./acre	Small	67.50	**0.76**	1 in 5.12 (3.64 – 7.56)
			Large	7.50	**0.08**	1 in 7.04E14 (5.81E07 – 2.02E24)
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	Small	135.00	**1.52**	1 in 1.11 (1.22 – 1.05)
			Large	15.00	**0.17**	1 in 6.64E07 (1.84E04 – 3.40E12)
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	Small	104.76	**1.18**	1 in 1.43 (1.56 – 1.33)
			Large	11.64	**0.13**	1 in 1.13E10 (2.40E05 – 1.82E16)
	A	1 app @ 0.5 lb a.i./acre	Small	67.50	**0.76**	1 in 5.12 (3.64 – 7.56)
			Large	7.50	**0.08**	1 in 7.04E14 (5.81E07 – 2.02E24)
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Small	546.76	**6.14**	1 in 1 (1 – 1)
			Large	60.75	**0.68**	1 in 8.78 (5.01 – 1.71E01)
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	Small	324.35	**3.64**	1 in 1 (1 – 1)
			Large	36.04	**0.40**	1 in 480 (4.41E01 – 1.02E04)
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	Small	376.00	**4.22**	1 in 1 (1 – 1)
			Large	41.78	**0.47**	1 in 110 (2.02E01 – 9.32E02)
	G	2 apps @ 2 lb a.i./acre (30 day interval)	Small	419.05	**4.71**	1 in 1 (1 – 1)
			Large	46.56	**0.52**	1 in 48.9 (1.31E01 – 2.55E02)
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	Small	136.69	**1.54**	1 in 1.1 (1.21 – 1.04)
			Large	15.19	**0.17**	1 in 6.64E07 (1.84E04 – 3.40E12)
CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	1 app @ 2 lb a.i./acre	Small	270.00	**3.03**	1 in 1 (1.01 – 1)
			Large	30.00	**0.34**	1 in 2.69E03 (1.08E02 – 1.73E05)
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Small	546.76	**6.14**	1 in 1 (1 – 1)
			Large	60.75	**0.68**	1 in 8.78

Table 5.7 Summary of Acute RQs Used to Estimate Indirect Effects of Liquid Applications of Oxyfluorfen to the Terrestrial-phase CRLF via Effects to Terrestrial Invertebrate Prey Items						
Scenario	**Method[1]**	**Application Rate**	**Size**	**EEC (ppm)**	**Acute RQ*,[2]**	**Probability of Individual Effect[3] (Confidence Interval)**
						(5.01 – 1.71E01)
All other scenarios (If no LOC exceedance, the probability of individual effect is evaluated at the Listed Species LOC.)						1 in 2.69E20 (3.34E10 – 4.89E33)
[1]G = ground application. A = aerial application. [2]Estimation based on earthworm acute contact LC_{50} = 89 mg a.i./kg-dry soil (MRID 459060-07). [3]The probit slope for the acute contact earthworm toxicity test is 7.20, 95% CI (5.03, 9.36). *Acute RQ ≥ 0.05 exceeds acute level of concern (LOC).						

5.1.2.2.1b Terrestrial Invertebrates: Granular Applications

In order to assess the risks of granular applications of oxyfluorfen to terrestrial invertebrates, the earthworm fugacity model (**Appendix K**) is used to calculate oxyfluorfen concentrations in soil (mg a.i./kg) and earthworms, which are used as a surrogate for terrestrial invertebrates that may be consumed by a terrestrial-phase CRLF. The concentration of oxyfluorfen in soil from granular application rates associated with the CA Nursery scenario (2 lb a.i./acre, only one application modeled) is 77.92 mg a.i./kg (based on a soil depth of 1 cm). The estimated concentration of oxyfluorfen in bulk soil is used to estimate oxyfluorfen concentrations in a terrestrial invertebrate (*i.e.*, earthworm). Oxyfluorfen is assumed to partition between soil organic carbon, the interstitial pore water, and air occupying the residual pore space not occupied by interstitial water. Earthworms dwelling in soil are assumed to be exposed to both soil pore-water and via ingestion of soil (Belfroid *et al.* 1994). The earthworm LC_{50} (89 mg a.i./kg-dry soil) produced an acute RQ value of 0.88, which exceeds the acute LOC of 0.05 (**Table K-4**). The probability of an individual effect, as calculated by IECv1.1, shows that effects to individual earthworms are highly probable. At the acute RQ of 0.88, there is a 1 in 2.9 chance that an individual will be adversely affected at the corresponding oxyfluorfen application rate.

5.1.2.2.2 Mammals

5.1.2.2.2a Mammals: Liquid Applications

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 (15 g) 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.

Definitive acute RQ values for small mammals (15 g) that are potential prey for the terrestrial-phase CRLF could not be derived because the acute mammalian effects data showed no mortality or systemic toxicity at the highest test concentrations; oxyfluorfen was practically non-toxic to rats due to an LD_{50} greater than 5000 mg a.i./kg-bw (MRID 447120-10, 448289-03].

Chronic dose-based RQ values exceed the chronic risk LOC (RQ ≥ 1.0) for small mammals that consume short grass for every modeled scenario of oxyfluorfen application. The RQ values range from 2.60 to 21.08 (**Table 5.8**). It is important to note that since no adverse effects were observed in the dose-based studies, the NOAEL used to determine dose-based RQ values was derived from the NOAEC using the standard FDA lab rat conversion. Chronic dietary-based RQ values exceed the chronic risk LOC for small mammals that consume short grass for scenarios with application rates greater than 1 lb a.i./acre. RQ values for all scenarios range from 0.3 to 2.43 (**Table 5.8**).

Table 5.8 Summary of Chronic RQs Used to Estimate Indirect Effects of Liquid Applications of Oxyfluorfen to the Terrestrial-phase CRLF via Effects to Small Mammals as Dietary Food Items

Scenario	Method[1]	Application Rate	Dose-based EEC[2]	Dose-based Chronic RQ[3]	Dietary-based EEC[4]	Dietary-based Chronic RQ[4]
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
CA Almond STD	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
	A	1 app @ 0.5 lb a.i./acre	114.41	**2.60***	120.00	0.30
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	710.28	**16.16***	744.98	**1.86***
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	212.44	**4.83***	222.82	0.56
CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	212.44	**4.83***	222.82	0.56
Agricultural – Food Crop Uses						
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	1 app @ 0.5 lb a.i./acre	114.41	**2.60***	120.00	0.30
	A	1 app @ 0.5 lb a.i./acre	114.41	**2.60***	120.00	0.30
OR Mint	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
	A	1 app @ 0.5 lb a.i./acre	114.41	**2.60***	120.00	0.30
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	228.82	**5.21***	240	0.60
CA Cotton STD	G	2 apps @ 0.5 lb a.i./acre (30 day interval)	177.57	**4.04***	186.25	0.47

Table 5.8 Summary of Chronic RQs Used to Estimate Indirect Effects of Liquid Applications of Oxyfluorfen to the Terrestrial-phase CRLF via Effects to Small Mammals as Dietary Food Items

Scenario	Method[1]	Application Rate	Dose-based EEC[2]	Dose-based Chronic RQ[3]	Dietary-based EEC[4]	Dietary-based Chronic RQ[4]
	A	1 app @ 0.5 lb a.i./acre	114.41	**2.60***	120.00	0.30
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
	G	4 apps @ 2 lb a.i./acre (30 day interval)	926.74	**21.08***	972.02	**2.43***
Non-agricultural Uses						
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	549.77	**12.51***	576.63	**1.44***
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	637.31	**14.50***	668.45	**1.67***
	G	2 apps @ 2 lb a.i./acre (30 day interval)	710.28	**16.16***	744.98	**1.86***
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	231.69	**5.27***	243.00	0.61
CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	1 app @ 2 lb a.i./acre	457.64	**10.41***	480.00	**1.20***
	G	4 apps @ 2 lb a.i./acre (30 day interval)	926.74	**21.08***	972.02	**2.43***

[1]G = ground application. A = aerial application.
[2]Estimation based on small mammal (15 g), which consumes short grass.
[3]Estimation based on dose-based EEC and oxyfluorfen rat NOAEL = 20 mg a.i./kg-bw (based on standard FDA lab rat conversion of NOAEC from MRID 420149-01).
[4]Estimation based on dietary-based EEC for small mammal (15 g), which consumes short grass, and oxyfluorfen rat NOAEC = 400 mg a.i./kg-diet (MRID 420149-01).
*Chronic RQ ≥ 1.0 exceeds chronic level of concern (LOC).

5.1.2.2.2b Mammals: Granular Applications

Indirect effects to terrestrial-phase CRLFs via ingestion of small mammals that may consume oxyfluorfen granules are based on LD_{50}/ft^2 values. Because of the lack of a definitive LD_{50} for mammals and, subsequently, the lack of acute RQ values, the acute indirect effects of granular applications of oxyfluorfen to the terrestrial-phase CRLF were not modeled.

Although the Agency has no standard methodology for assessing chronic risk to mammals through ingestion of granules, it is possible to estimate chronic granular exposure for mammals via direct ingestion of soil invertebrates that have bioconcentrated pesticide residues of granules in soil. Terrestrial chronic exposure estimates and risks for granular applications of oxyfluorfen were derived according to the methodology presented in **Appendix K**. Based on the dietary method and a granular oxyfluorfen application rate of 2 lb a.i./acre, chronic LOCs are not exceeded for insectivorous mammals because the respective earthworm residue concentration (77.92 mg a.i./kg) is less than the mammalian NOAEC (400 mg a.i./kg-diet); this resulted in a chronic dietary-based RQ value of 0.19. However, chronic doses for insectivorous mammals, based on the adjusted NOAEL for the small class of mammals (15 g) result in an RQ value (1.68) that exceeds the chronic LOC (**Table K-3**). It is important to note that the NOAEL used was derived from the NOAEC based on the standard FDA lab rat conversion because a definitive NOAEL could not be established in the dose-based study.

5.1.2.2.3 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 (20 g) consuming small invertebrates are used for non-granular applications and acute risk of granular applications. For chronic granular applications, methodology described in **Appendix K** was used to estimate risk. See **Section 5.1.2.1** and associated table (**Table 5.5** and **5.6**) for results.

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

Potential indirect effects to the CRLF resulting from direct effects on riparian and upland vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. A supplemental study evaluating the toxicity of oxyfluorfen technical grade active ingredient (71.5%) had been used in the previous RED. Since then, new studies were submitted using the end-use product Goal 2XL (MRID 458611-01, 458611-02), which contained the higher purity active ingredient. Toxicity values from the most sensitive endpoints in the formulation study were used to calculate EECs (**Table 3.10**) and RQs (**Table 5.9** and **5.10**). Dry area RQ values for monocots ranged from 1.61 to 6.45. Semi-aquatic area RQ values ranged from 8.87 to 35.48. Spray drift RQ values for non-granular applications ranged from 0.81 to 4.03. For dicots, dry area RQ values ranged from 1.35 to 5.56. Semi-aquatic area RQ values ranged from 7.64 to 30.56. For non-granular applications, spray drift RQ values ranged from 0.69 to 3.47. Example output from TerrPlant v.1.2.2 is provided in **Appendix J.**

Table 5.9 RQs for Monocots Inhabiting Dry and Semi-aquatic Areas Exposed to Oxyfluorfen via Runoff and Drift

Scenario	Method[1]	Application Rate (lb a.i./acre)	Drift Value (%)	Dry Area RQ[2]	Semi-aquatic Area RQ[2]	Spray Drift RQ[3]
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	2	1	**6.45***	**35.48***	**3.23***
CA Almond STD CA Citrus STD CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	2	1	**6.45***	**35.48***	**3.23***
	A	0.5	5	**4.84***	**12.10***	**4.03***
Agricultural – Food Crop Uses						

Table 5.9 RQs for Monocots Inhabiting Dry and Semi-aquatic Areas Exposed to Oxyfluorfen via Runoff and Drift						
Scenario	**Method[1]**	**Application Rate (lb a.i./acre)**	**Drift Value (%)**	**Dry Area RQ[2]**	**Semi-aquatic Area RQ[2]**	**Spray Drift RQ[3]**
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	0.5	1	**1.61***	**8.87***	0.81
	A	0.5	5	**4.84***	**12.10***	**4.03***
OR Mint	G	2	1	**6.45***	**35.48***	**3.23***
CA Row Crop RLF	G	2	1	**6.45***	**35.48***	**3.23***
	A	0.5	5	**4.84***	**12.10***	**4.03***
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1	1	**3.23***	**17.74***	**1.61***
CA Cotton STD	G	0.5	1	**1.61***	**8.87***	0.81
	A	0.5	5	**4.84***	**12.10***	**4.03***
CA Rangeland Hay RLF	G	2	1	**6.45***	**35.48***	**3.23***
Non-agricultural Uses						
CA Nursery CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	2	1	**6.45***	**35.48***	**3.23***
CA Nursery (granular)	G	2	0	**3.23***	**32.26***	<0.1
CA Forestry RLF	G	1.5	1	**4.84***	**26.61***	**2.42***
	G	2	1	**6.45***	**35.48***	**3.23***
	A	0.5	5	**4.84***	**12.10***	**4.03***

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[2]Based on dry weight of ryegrass (EC_{25} = 0.0063 lb a.i./acre) in seedling emergence study (MRID 458611-01).
[3]Based on shoot dry weight of oat (EC_{25} = 0.27 lb a.i./acre) in vegetative vigor study (MRID 458611-02).
* = Acute LOC exceedances (RQ $\geq$ 1.0) are bolded.

Table 5.10 RQs for Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Oxyfluorfen via Runoff and Drift						
Scenario	**Method[1]**	**Application Rate (lb a.i./acre)**	**Drift Value (%)**	**Dry Area RQ[2]**	**Semi-aquatic Area RQ[2]**	**Spray Drift RQ[3]**
Orchard Uses						
CA Avocado RLF CA Olive RLF	G	2	1	**5.56***	**30.56***	**2.78***
CA Almond STD CA Citrus STD CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	2	1	**5.56***	**30.56***	**2.78***
	A	0.5	5	**4.17***	**10.42***	**3.47***
Agricultural – Food Crop Uses						

Table 5.10 RQs for Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Oxyfluorfen via Runoff and Drift						
Scenario	**Method[1]**	**Application Rate (lb a.i./acre)**	**Drift Value (%)**	**Dry Area RQ[2]**	**Semi-aquatic Area RQ[2]**	**Spray Drift RQ[3]**
CA Cole Crop RLF CA Garlic RLF CA Lettuce STD CA Melons RLF CA Onion STD CA Potato RLF CA Strawberry RLF CA Sugarbeet OP CA Tomato STD CA Wheat RLF	G	0.5	1	**1.39***	**7.64***	0.69
	A	0.5	5	**4.17***	**10.42***	**3.47***
OR Mint	G	2	1	**5.56***	**30.56***	**2.78***
CA Row Crop RLF	G	2	1	**5.56***	**30.56***	**2.78***
	A	0.5	5	**4.17***	**10.42***	**3.47***
Agricultural – Non-food Crop Uses						
CA Alfalfa OP	G	1	1	**2.78***	**15.28***	**1.39***
CA Cotton STD	G	0.5	1	**1.39***	**7.64***	0.69
	A	0.5	5	**4.17***	**10.42***	**3.47***
CA Rangeland Hay RLF	G	2	1	**5.56***	**30.56***	**2.78***
Non-agricultural Uses						
CA Nursery CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	2	1	**5.56***	**30.56***	**2.78***
CA Nursery (granular)	G	2	0	**2.78***	**27.78***	<0.1
CA Forestry RLF	G	1.5	1	**4.17***	**22.92***	**2.08***
	G	2	1	**5.56***	**30.56***	**2.78***
	A	0.5	5	**4.17***	**10.42***	**3.47***

[1]G = ground application. A = aerial application. All applications are liquid unless otherwise specified.
[2]Based on dry weight of lettuce (EC_{25} = 0.0072 lb a.i./acre) in seedling emergence study (MRID 458611-01).
[3]Based on shoot dry weight of lettuce (EC_{25} = 0.0078 lb a.i./acre) in vegetative vigor study (MRID 458611-02).
* = Acute LOC exceedances (RQ $\geq$ 1.0) are bolded.

5.1.3 Primary Constituent Elements of Designated Critical Habitat

5.1.3.1 Aquatic-Phase (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)

Three of the four assessment endpoints for the aquatic-phase primary constituent elements (PCEs) of designated critical habitat for the CRLF are related to potential effects to aquatic and/or terrestrial plants:

- 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.

- 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.
- Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae).

The risk estimation for aquatic-phase PCEs of designated habitat related to potential effects on aquatic and/or terrestrial plants is provided in **Sections 5.1.1.2, 5.1.1.3,** and **5.1.2.3**. These results will inform the effects determination for modification of designated critical habitat for the CRLF.

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." To assess the impact of oxyfluorfen on this PCE, acute and chronic freshwater fish and invertebrate toxicity endpoints, as well endpoints for aquatic non-vascular plants, are used as measures of effects. RQs for these endpoints were calculated in **Sections 5.1.1.1** and **5.1.1.2**., and these results will inform the effects determination for modification of designated critical habitat for the CRLF.

5.1.3.2 Terrestrial-Phase (Upland Habitat and Dispersal Habitat)

Two of the four assessment endpoints for the terrestrial-phase PCEs of designated critical habitat for the CRLF are related to potential effects to terrestrial plants:

- 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
- 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

The risk estimation for terrestrial-phase PCEs of designated habitat related to potential effects on terrestrial plants is provided in **Section 5.1.2.3**. These results will inform the effects determination for modification of designated critical habitat for the CRLF.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of oxyfluorfen on this PCE, acute and chronic toxicity endpoints for birds and mammals and only acute endpoints for terrestrial invertebrates are used as measures of effects. RQs for these endpoints were calculated in **Section 5.1.2.2**.

The fourth terrestrial-phase PCE is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Direct acute and chronic RQs for terrestrial-phase CRLFs are presented in **Section 5.2.1.2**.

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 direct and indirect RQs presented in the Risk Estimation (**Section 5.1**) were to show neither acute nor chronic LOC exceedances nor show modification to PCEs of the CRLF's designated critical habitat, a "no effect" determination would be made, based on oxyfluorfen's use within the action area. However, because direct and indirect effect LOCs are exceeded and 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 oxyfluorfen. A summary of the results of the risk estimation results are provided in **Table 5.11** for direct and indirect effects to the CRLF and in **Table 5.12** for the PCEs of designated critical habitat for the CRLF.

Table 5.11 Risk Estimation Summary for Oxyfluorfen - Direct and Indirect Effects to CRLF		
Assessment Endpoint	**LOC Exceedances (Y/N)**	**Description of Results of Risk Estimation**
Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases.	Yes	*Survival*: Acute LOC exceedances in several scenarios with LC_{50} attained under standard laboratory lighting = 203 µg a.i./L. acute LOC exceedances in all scenarios with LC_{50} estimated under UV lighting from a calculated chronic:acute ratio. *Growth and reproduction:* Chronic LOC exceedances in many of the scenarios with NOAEC attained under UV lighting.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants).	Yes	*Non-vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Freshwater invertebrates, standard laboratory lighting*: Acute LOC was exceeded for several scenarios and chronic LOC exceeded for two scenarios. *Freshwater invertebrates, estimated UV lighting*: Acute LOC exceeded for all scenarios and chronic LOC exceeded for all but five scenarios.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat, cover, and/or primary productivity (*i.e.,* aquatic plant community).	Yes	*Non-vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Vascular aquatic plants*: LOC exceedances in all but one modeled scenario.
Indirect Effects 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.	Yes	*Terrestrial plants*: LOCs are exceeded for both monocots and dicots for all modeled uses of oxyfluorfen (**Tables 5.9** and **5.10**).
Terrestrial Phase (Juveniles and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles.	Yes	*Survival*: Based on the available avian acute toxicity data, which serves as a surrogate for terrestrial-phase amphibians, LOC exceedances were observed for RQ values based on an LD_{10} (**Tables 5.5** and **5.6**) when modeling application rates above 0.5 lb a.i./acre for liquid and 2 lb a.i./acre for granular applications of oxyfluorfen. *Growth and reproduction*: Dietary-based chronic RQ values exceeded the LOC for liquid applications of oxyfluorfen at rates higher than 2 applications of 0.5 lb a.i./acre (**Table 5.5**). Chronic granular exceedances were not observed (**Appendix K**).

Table 5.11 Risk Estimation Summary for Oxyfluorfen - Direct and Indirect Effects to CRLF		
Assessment Endpoint	**LOC Exceedances (Y/N)**	**Description of Results of Risk Estimation**
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial mammals and terrestrial phase amphibians).	Yes	*Terrestrial invertebrates*: For liquid applications affecting small and large insects, the acute LOC was exceeded for all application rates (**Table 5.7**). For granular applications, acute RQ values exceeded the LOC at a rate of 2 lb a.i./acre (**Appendix K**). *Terrestrial-phase amphibians*: For liquid applications, RQ values exceeded the acute LOC for application rates above 0.5 lb a.i./acre. For granular applications at the rate of 2 lb a.i./acre, the acute LOC was exceeded (**Table 5.6**). Dietary-based chronic RQ values exceeded the LOC for liquid applications of oxyfluorfen at rates higher than 2 applications of 0.5 lb a.i./acre (**Table 5.5**). Chronic granular exceedances were not observed (**Appendix K**). *Small terrestrial mammals*: Acute RQs were not calculated due to the lack of mortality and systemic toxicity. For liquid applications of oxyfluorfen, chronic dose-based LOCs were exceeded for all application rates (**Table 5.8**). Chronic dietary-based LOCs were exceeded for application rates greater than 1 lb a.i./acre. For granular applications at the rate of 2 lb a.i./acre, the chronic dose-based RQ exceeded the LOC for small mammals (**Appendix K**).
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat (*i.e.*, riparian vegetation).	Yes	*Terrestrial plants:* LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen (**Tables 5.9** and **5.10**).

Table 5.12 Risk Estimation Summary for Oxyfluorfen – PCEs of Designated Critical Habitat for the CRLF		
Assessment Endpoint	**LOC Exceedances (Y/N)**	**Description of Results of Risk Estimation**
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.	Yes	*Terrestrial plants*: LOCs are exceeded for both monocots and dicots for all modeled uses of oxyfluorfen (**Tables 5.9** and **5.10)**
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.	Yes	*Terrestrial plants*: LOCs are exceeded for both monocots and dicots for all modeled uses of oxyfluorfen (**Tables 5.9** and **5.10)**
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Yes	*Freshwater fish*: Acute LOC exceedances in several scenarios with LC_{50} attained under standard laboratory lighting = 203 µg a.i./L. Acute LOC exceedances in all scenarios with LC_{50} estimated under UV lighting from a calculated chronic:acute ratio. Chronic LOC exceedances in many of the scenarios with NOAEC attained under UV lighting. *Non-vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Freshwater invertebrates, standard laboratory lighting*: Acute LOC was exceeded for several scenarios and chronic LOC exceeded for two scenarios. *Freshwater invertebrates, estimated UV lighting*: Acute LOC exceeded for all scenarios and chronic LOC exceeded for all but five scenarios.
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae).	Yes	*Non-vascular aquatic plants*: Acute LOCs are exceeded for all uses.
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
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.	Yes	*Terrestrial plants*: LOCs are exceeded for both monocots and dicots for all modeled uses of oxyfluorfen (**Tables 5.9** and **5.10**).

Table 5.12 Risk Estimation Summary for Oxyfluorfen – PCEs of Designated Critical Habitat for the CRLF		
Assessment Endpoint	**LOC Exceedances (Y/N)**	**Description of Results of Risk Estimation**
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	Yes	*Terrestrial plants*: LOCs are exceeded for both monocots and dicots for all modeled uses of oxyfluorfen (**Tables 5.9** and **5.10**).
Reduction and/or modification of food sources for terrestrial phase juveniles and adults.	Yes	*Terrestrial food sources*: Based on likely effects to small mammals, amphibians, and terrestrial invertebrates, reduction in food sources is expected (**Tables 5.5**, **5.6**, **5.7**, **5.8** and **Appendix K**).
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Yes	*Terrestrial food sources*: Chronic RQs for mammals and CRLFs exceeded the LOCs for all modeled non-granular and granular uses (except granular RQ for CRLFs) of oxyfluorfen (**Tables 5.5**, **5.8**, and **Appendix K**). Therefore, chronic effects are possible for small insectivorous mammals and amphibians that are food items of the CRLF. Acute RQs for small terrestrial invertebrates exceed the LOC for all modeled uses of oxyfluorfen (**Table 5.7** and **Appendix K**).

Following this "may affect" determination, additional information will be 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:

- Significance of Effect: 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 additional characterization 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**.

As previously discussed, the results of this analysis lead to a preliminary "may effect" determination for the CRLF based on labeled oxyfluorfen usage in California due to the large number of LOC exceedances across multiple taxonomic groups. Further, this "may effect" determination is refined to a "likely to adversely effect" determination based on the characterization of potential effects and likelihood of exposure discussed below.

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 oxyfluorfen.

Based on the multiple lines of evidence presented below, there is a potential for direct impact to the aquatic-phase of the CRLF.

LOC exceedances:
Of the 28 scenarios modeled (some with multiple application rates and either ground or aerial methods), listed species LOCs were exceeded in forestry, right-of-ways (non-crop), rangeland/hay, and nursery uses (exceeding RQs ranged from 0.05 to 0.23). Chronic LOCs were exceeded in those scenarios as well as in avocado, cole crops, right-of-ways (non-agricultural), row crop, turf, wine grape, and lettuce (exceeding RQs ranged from 1.01 to 16.18). The acute RQs may not reflect actual risk as the toxicity study was not conducted using lighting similar to natural sunlight. The action of oxyfluorfen is enhanced in the presence of natural sunlight, as evidenced in the fish early life stage study (MRID 465851-04). It is unknown what increased effect, if any, sunlight would have on the acute toxicity of oxyfluorfen to fish. If it was assumed that the ratio of standard lighting to UV enhanced lighting was the same for acute toxicity as it was for chronic toxicity (ratio = 29.2), acute Listed Species LOCs would be exceeded for all modeled scenarios. No studies have been submitted to the Agency that evaluate the effects of enhanced UV lighting on acute toxicity of oxyfluorfen or any other LDPH chemical.

Light-enhanced phototoxicity:
Based on the effects noted in the UV-enhanced early-life fish study (decreased hatching time and reduced larval survival) and the mode of action of LDPHs, it is a likely explanation that oxyfluorfen may have affected the viability of the egg cell membrane surrounding the larva. This caused premature hatching (2-3 days in fish eggs exposed to oxyfluorfen and UV light vs. 4-5 days in fish eggs exposed to UV light only). CRLF 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). Given that CRLF eggs are at or near the water surface and UV rays do penetrate the surface layers of water bodies (Barron *et al*. 2000, Diamond *et al*. 2005), photoenhanced toxicity to the CRLF eggs and larvae is a possibility.

Species sensitivity analysis:
A formal species sensitivity analysis was not conducted, since data from only three species of fish were available. For the bluegill sunfish, rainbow trout, and channel catfish, the LD_{50}'s ranged from 203 to 402 µg/L. Given that the studies were conducted in different laboratories over a 20 year period using different methods (measured vs. nominal concentrations, static vs. flow-through, etc.) and different batches of technical, the observed variability between species is minimal.

Comparison of modeled to observed water concentrations:
Oxyfluorfen measured in water from the NAWQA program indicated concentrations were much less than those modeled. Of the 192 samples collected in California, only 18.2% had positive detections. Of the positive samples, the average concentration was 0.0208 µg/L, and the maximum reported concentration was 0.0875 µg/L. These measured concentrations are considerably lower than peak concentrations resulting from PRZM/EXAMS modeling which ranged from 0.347 to 46.40 µg/L. There are several potential explanations for these differences:

- Monitoring sites were not necessarily targeted to areas of high oxyfluorfen usage
- Sampling times were not designed to capture the high peak values and were not frequent enough to assure the peak values were captured
- Water samples were filtered prior to analysis, removing oxyfluorfen that had sorbed to suspended particles in the water.
- Average application rates of oxyfluorfen based on the California PUR data tend to be less than the maximum label rates modeled in this assessment.

Similarly, dissolved water concentrations from the San Joaquin River (range 0.12 to 0.82 µg/L) were also much lower than modeled concentrations.

Monitoring data from Keese *et al*. (1994), suggest that the PRZM/EXAMS modeling estimates may be lower than observed in targeted sampling. Runoff to a pond was evaluated after application of 2.0 lb a.i./acre (Rout granular end-use product) to a nursery plot. Measured concentrations averaged 147 µg/L one day after application, averaged approximately 40 µg/L three days after application, and were still detectable fourteen days after application. Measurement of oxyfluorfen at concentrations higher than solubility (116 µg/L) may be due to colloidal material (to which oxyfluorfen may have sorbed) passing through the laboratory filter. These measured concentrations could be compared with the PRZM/EXAMS estimates from a single granular application of 2 lb a.i./acre to an ornamental nursery where the resulting peak concentration was 5.20 µg/L and the 21-day concentration was 5.18 µg/L. Unlike the pond in PRZM/EXAMS, the nursery pond had a water runoff point; sampled concentrations may have been even higher than observed if no runoff had occurred in the nursery pond. Unfortunately, pond measurements (*e.g*., depth, suspended sediments, organic carbon) were not provided in the paper to facilitate a stronger comparative analysis between the sampled pond and the 'standard pond' in PRZM/EXAMS.

Spray drift buffers:
The buffer distance needed to get below the acute aquatic fish Listed Species LOC was estimated using AgDRIFT. This distance identifies those locations where water bodies can be impacted by spray drift deposition alone (no runoff considered) resulting in concentrations above the LOC. The most sensitive freshwater fish was the bluegill with an LC_{50} value of 203 µg/L. Several labels were used to represent the range of application methods (ground and aerial), application rates (0.5 to 2.0 lb a.i./acre), and drop size distribution specifications. Required buffer distance under all evaluated labels was 0 feet (**Table 5.13**). This required buffer of 0 feet only considers the exposure due to spray drift; based on EFED's modeling, spray drift exposure alone does not cause the LOC to be exceeded. Runoff (an important exposure component for oxyfluorfen) is not assessed in this spray drift analysis conducted with AgDRIFT. This analysis indicates that the primary exposure to oxyfluorfen would be through runoff, based on the AgDRIFT modeling. This spray drift analysis also does not include reproductive or growth effects or cumulative exposure due to multiple applications.

Table 5.13. Estimation of Buffer Distance Required to Eliminate LOC Exceedances (only spray drift exposure considered) for Freshwater Fish Based on AgDRIFT

Pesticide Label	Application Rate (lb/acre)	Method (Boom Height for Ground)	Tier	Parameters	Required Buffer Distance (ft)
Rawhide (62719-448)	0.5	Ground (high)	I	DSD = ASAE fine to medium/coarse	0
Rawhide (62719-448)	2.0	Ground (high)	I	DSD = ASAE fine to medium/coarse	0
Goal 2XL (62719-424)	0.5	Aerial	I	DSD = ASAE medium to coarse	0
EndZone (34707-877)[a]	0.5	Ground (high)	I	DSD = ASAE very fine to fine	0
EndZone (34707-877)[a]	2.0	Ground (high)	I	DSD = ASAE very fine to fine	0
EndZone (34707-877)[b]	0.5	Aerial	II	DSD = ASAE Very fine to fine (average size = 137 microns) Nonvol rate = 2.25 lb/ac Active rate = 0.5 lb/ac Spray vol rate = 5 gal/ac All else = defaults	0

Table 5.13. Estimation of Buffer Distance Required to Eliminate LOC Exceedances (only spray drift exposure considered) for Freshwater Fish Based on AgDRIFT
[a]Label did not specify droplet sizes for ground application; the most conservative size available in Tier I was chosen: ASAE very fine to fine. [b]Label specifies droplet size to be greater than 100 microns for aerial spray. The available droplet size distribution that most closely matches this is ASAE Very fine to fine.

5.2.1.2 Terrestrial-Phase CRLF

Although acute avian RQ values exceeded LOCs for the terrestrial-phase CRLF via exposure to spray and granular applications of oxyfluorfen, adverse effects are unlikely because the EECs were compared to an LD_{10} since an LD_{50} was not established from the submitted avian toxicity data. Probabilities of individual effects were not calculated because the effects to a single individual cannot be meaningfully measured, detected, or evaluated without a definitive LD_{50}. However, a refinement of the risks posed to the terrestrial-phase CRLF from ingestion of residues on prey items (based on liquid applications of oxyfluorfen) was performed using the T-HERPS v. 1.0 model. This model considers the lower amount of food intake by amphibians as compared to the higher avian food intake (due to higher metabolic rate) in the T-REX model.

Using T-HERPS to refine the risk estimation, there were only four dose-based acute LOC exceedances for liquid applications (example output located in **Tables J-10** through **J-12**). The exceedances applied to medium CRLFs that consumed small herbivore mammals for scenarios with rates of three applications of 1.5 lb a.i./acre and applications of 2 lb a.i./acre and greater and ranged from 0.14 to 0.28. Again, these RQ values provide a highly conservative estimate of risk as they are based on an LD_{10} rather than an LD_{50}. Dose-based acute RQ values that exceed the LOC (0.1) for acute endangered species are located in **Table 5.14**. A complete table with all of the RQ values is located in **Table J-13**. T-HERPS does not allow for a refinement of granular applications, but the acute RQ for granular applications would expectedly decrease, and as previously discussed, likelihood of the effect occurring is very small because of the LD_{10} basis for risk estimation.

Table 5.14 Summary of T-HERPS Terrestrial-Phase Amphibian Dose-based RQ Exceedances for Direct Effects to the CRLF from Ingestion of Residues on or in Prey Items (Based on Liquid Applications of Oxyfluorfen)					
Scenario	**Method**[1]	**Application Rate**	**Food Item**	**Medium (37 g)**	
				Dose-based EEC (ppm)	**Dose-based Acute RQ**
Orchard Uses					
CA Avocado RLF CA Olive RLF CA Almond STD CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	Small herbivore mammals	299.20	**0.14***
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	Small herbivore mammals	464.37	**0.22***
Agricultural – Food Crop Uses					
OR Mint CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	Small herbivore mammals	299.20	**0.14***
Agricultural – Non-food Crop Uses					
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	Small herbivore mammals	299.20	**0.14***
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Small herbivore mammals	605.88	**0.28***
Non-agricultural Uses					
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	Small herbivore mammals	359.42	**0.17***
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	Small herbivore mammals	416.66	**0.19***
	G	2 apps @ 2 lb a.i./acre (30 day interval)	Small herbivore mammals	464.37	**0.22***
CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	1 app @ 2 lb a.i./acre	Small herbivore mammals	299.20	**0.14***
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Small herbivore mammals	605.88	**0.28***
[1]G = ground application. A = aerial application. *Exceeds acute LOC (RQ ≥ 0.1).					

T-HERPS was used to refine chronic risks to the terrestrial-phase CRLF via consumption of large insects, small herbivorous mammals, small insectivorous mammals, and small terrestrial-phase amphibians exposed to liquid applications already identified by T-REX. Chronic LOC exceedances were seen at rates greater than two applications of oxyfluorfen at 0.5 lb a.i./acre for CRLFs that consumed small insects and small herbivorous mammals. At the rate of three applications of 0.5 lb a.i./acre, chronic RQ values would drop below the chronic LOC if a longer interval were practiced. Dietary-based chronic RQ values that exceed the LOC are located in **Table 5.15**. A complete list of RQ values can be found in **Table J-14**.

Table 5.15 T-HERPS Terrestrial-Phase Amphibian Dietary-based RQ Values for Direct Effects to the CRLF from Ingestion of Residues on or in Prey Items (Based on Liquid Applications of Oxyfluorfen)

Scenario	Method[1]	Application Rate	Food Item	Dietary-based EEC (ppm)	Dietary-based Chronic RQ
Orchard Uses					
CA Avocado RLF CA Olive RLF	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
CA Almond STD	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
CA Citrus STD	G	2 apps @ 2 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	419.05 490.90	**3.38**[+] **3.96**[+]
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	125.33 146.82	**1.01**[+] **1.18**[+]
CA Fruit STD CA Grapes STD CA Wine Grapes RLF	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
	A	3 apps @ 0.5 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	125.33 146.82	**1.01**[+] **1.18**[+]
Agricultural – Food Crop Uses					
OR Mint	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
CA Row Crop RLF	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
Agricultural – Non-food Crop Uses					
CA Alfalfa OP	G	1 app @ 1 lb a.i./acre & 1 app @ 0.25 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	135.00 158.15	**1.09**[+] **1.28**[+]
CA Rangeland Hay RLF	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	546.76 640.50	**4.41**[+] **5.17**[+]
Non-agricultural Uses					
CA Nursery	G	4 apps @ 2 lb a.i./acre (90 day interval)	Broadleaf plants/sm insects Small herbivore mammals	324.35 379.96	**2.62**[+] **3.06**[+]
CA Forestry RLF	G	3 apps @ 1.5 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	376.00 440.47	**3.03**[+] **3.55**[+]
	G	2 apps @ 2 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	419.05 490.90	**3.38**[+] **3.96**[+]
	A	4 apps @ 0.5 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	136.69 160.13	**1.10**[+] **1.29**[+]
CA Residential RLF CA Right-of-Way RLF CA Turf RLF	G	1 app @ 2 lb a.i./acre	Broadleaf plants/sm insects Small herbivore mammals	270.00 316.29	**2.18**[+] **2.55**[+]
	G	4 apps @ 2 lb a.i./acre (30 day interval)	Broadleaf plants/sm insects Small herbivore mammals	546.76 640.50	**4.41**[+] **5.17**[+]

[1]G = ground application. A = aerial application.
[+]Exceeds chronic LOC (RQ ≥ 1.0).

T-REX is not a bioaccumulation model. Because CRLFs ingest small mammals, another refinement included in the T-HERPS model was a conservative bioaccumulation model for residues in small herbivorous and insectivorous mammals. The bioaccumulation model assumes that the animal ingests 100% of its daily intake instantaneously and that there is no metabolism or elimination of the pesticide residues before being consumed. Additionally, the diet of the herbivorous small mammal is modeled as short grass, which has the highest chemical residues after a pesticide exposure of any of the plant residues modeled. This scenario is highly improbable and also not relevant for oxyfluorfen because of its low bioaccumulation potential. Therefore, oxyfluorfen is not likely to be bioavailable for a secondary poisoning type exposure once consumed by a small mammal; this bioaccumulation refinement was not conducted for oxyfluorfen**.**

No ecological incidents involving birds or amphibians were reported for oxyfluorfen.

Although acute LOC exceedances still exist following the T-HERPS refinement at rates of 1.5 lb a.i./acre and greater, they are extremely unlikely to occur because the estimations are based on a non-definitive LD_{10} rather than a definitive LD_{50}. However, chronic LOC exceedances provide a more credible risk estimation of the direct effects to the terrestrial-phase CRLF. Chronic direct effects, which are neither insignificant nor discountable, to the terrestrial-phase CRLF via exposure of oxyfluorfen would be expected at the rate of three applications of 0.5 lb a.i./acre each and all scenarios with applications greater than 1 lb a.i./acre.

5.2.2 Indirect Effects (via Reductions in Prey Base)

5.2.2.1 Algae (non-vascular 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.

Based on the multiple lines of evidence presented below, there is a potential for indirect impact to the aquatic-phase of the CRLF through reductions in the prey base (specifically non-vascular plants).

LOC exceedances:
Of the 28 scenarios modeled (some with multiple application rates and either ground or aerial methods), acute risk LOCs were exceeded in all scenarios (RQs ranged from 1.37 to 160.00).

Comparison of modeled to observed water concentrations:
As the EECs estimated for aquatic plants are the same as for freshwater fish, the discussion presented in **Section 5.2.1.1** is also applicable here. In summary, PRZM/EXAMS estimates were higher than the concentrations measured in non-targeted sampling, and were similar to or less than concentrations measured in one targeted sampling study in an ornamental nursery pond.

Spray drift buffers:
The buffer distance needed to get below the non-vascular aquatic plant LOC was determined. This distance identifies those locations where water bodies can be impacted by spray drift deposition alone (no runoff considered) resulting in concentrations above the LOC. The most sensitive aquatic non-vascular plant was *Selenastrum capricornutum* with an EC_{50} value of 0.29 µg/L. Several labels were used to represent the range of application methods (ground and aerial), application rates (0.5 to 2.0 lb a.i./acre), and drop size distribution specifications. Required buffer distances ranged from 6.6 to 2,739 feet (**Table 5.16**).

Table 5.16. Estimation of Buffer Distance Required to Eliminate LOC Exceedances (only spray drift exposure considered) for Aquatic Non-vascular Plants Based on AgDRIFT

Pesticide Label	Application Rate (lb/acre)	Method (Boom Height for Ground)	Tier	Parameters	Required Buffer Distance (ft)
Rawhide (62719-448)	0.5	Ground (high)	I	DSD = ASAE fine to medium/coarse	6.6
Rawhide (62719-448)	2.0	Ground (high)	I	DSD = ASAE fine to medium/coarse	230
Goal 2XL (62719-424)	0.5	Aerial	I	DSD = ASAE medium to coarse	331
EndZone (34707-877)[a]	0.5	Ground (high)	I	DSD = ASAE very fine to fine	141
EndZone (34707-877)[a]	2.0	Ground (high)	I	DSD = ASAE very fine to fine	574
EndZone (34707-877)[b]	0.5	Aerial	II	DSD = ASAE Very fine to fine (average size = 137 microns) Nonvol rate = 2.25 lb/ac Active rate = 0.5 lb/ac Spray vol rate = 5 gal/ac All else = defaults	> 900 out of range
EndZone (34707-877)[b]	0.5	Aerial	III	DSD = ASAE Very fine to fine (average size = 137 microns) Nonvol rate = 2.25 lb/ac Active rate = 0.5 lb/ac Spray vol rate = 5 gal/ac Specific gravity(nonvol) = 1.08 Max downwind dist = 3000 ft All else = defaults	2739

[a]Label did not specify droplet sizes for ground application; the most conservative size available in Tier I was chosen: ASAE very fine to fine.
[b]Label specifies droplet size to be greater than 100 microns for aerial spray. The available droplet size distribution that most closely matches this is ASAE Very fine to fine.

5.2.2.2 Aquatic Invertebrates

The potential for oxyfluorfen 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 the multiple lines of evidence presented below, there is potential for indirect impact to the aquatic-phase of the CRLF through reductions in the prey base (specifically aquatic invertebrates).

LOC exceedances:
Of the 28 scenarios modeled (some with multiple application rates and either ground or aerial methods), Listed Species LOCs were exceeded in multiple scenarios (exceeding RQs ranged from 0.05 to 0.58). Those scenarios were: avocado, forestry, rangeland/hay, right-of-ways (non-agricultural), row crops, wine grapes, almonds, lettuce, and nursery. The chronic LOC was only exceeded at the highest rate (four applications of 2 lb a.i./acre) for liquid nusery applications (RQ = 1.88) and granular nursery applications (RQ = 1.84).

To better estimate the toxicity of oxyfluorfen under natural sunlight, the "standard lighting: enhanced UV lighting" ratio calculated for the fish early-life study was applied to the toxicity endpoints from the invertebrate studies. The ratio was calculated as 29.2 (ratio of NOAECs from the standard lighting test to the enhanced lighting test for fish early-life, NOAECs = 38 and 1.3 µg/L, respectively). Therefore, the estimated LC_{50} and NOAEC under enhanced UV lighting were calculated as 2.73 µg/L and 0.44 µg/L. Under the enhanced UV lighting setting, the acute RQs ranged from 0.13 to 17.00, resulting in exceedances of the Listed Species LOC for all modeled scenarios. Under the enhanced UV lighting setting, the chronic RQs ranged from 0.33 to 55.45 resulting in exceedances of the chronic LOC for all but five of the modeled scenarios. Because toxicity of the LDPHs is affected by the presence of ultraviolet (UV) radiation, toxicity tests conducted under standard laboratory lighting conditions, which generally only include visible light, may underestimate the toxicity of oxyfluorfen to some taxa. Given that many zooplankters have translucent bodies and are present in the surface layers of water bodies where UV rays might penetrate (Barron *et al.* 2000, Diamond *et al*. 2005), photoenhanced toxicity to these taxa is a possibility. No tests conducted under UV light conditions were available for aquatic invertebrates for any LDPHs, thus the type or magnitude of phototoxic effects on these types of organisms is unknown.

Comparison of modeled to observed water concentrations:
As the EECs estimated for aquatic invertebrates are the same as for freshwater fish, the same discussion presented in **Section 5.2.1.1** is also applicable here. In summary, PRZM/EXAMS estimates were higher than the concentrations measured in non-targeted sampling, and were similar to or less than concentrations measured in one targeted sampling study in an ornamental nursery pond.

Spray drift buffers:
The buffer distance needed to get below the aquatic invertebrate LOC was determined. This distance identifies those locations where water bodies can be impacted by spray drift

deposition alone (no runoff considered) resulting in concentrations above the LOC. The most sensitive aquatic invertebrate was the daphnid with an LC_{50} value of 80 µg/L obtained under standard laboratory lighting conditions. Several labels were used to represent the range of application methods (ground and aerial), application rates (0.5 to 2.0 lb a.i./acre), and drop size distribution specifications. Required buffer distance under all evaluated labels was 0 feet (**Table 5.17**). This required buffer of 0 feet only considers the exposure due to spray drift; based on EFED's modeling, spray drift exposure alone does not cause the LOC to be exceeded. Runoff (an important exposure component for oxyfluorfen) is not assessed in this spray drift analysis conducted with AgDRIFT. This analysis indicates that the primary exposure to oxyfluorfen would be through runoff, based on the AgDRIFT modeling. This spray drift analysis also does not include reproductive or growth effects or cumulative exposure due to multiple applications.

Table 5.17. Estimation of Buffer Distance Required to Eliminate LOC Exceedances (only spray drift exposure considered) for Aquatic Invertebrates Based on AgDRIFT

Pesticide Label	Application Rate (lb a.i./acre)	Method (Boom Height for Ground)	Tier	Parameters	Required Buffer Distance (ft)
Rawhide (62719-448)	0.5	Ground (high)	I	DSD = ASAE fine to medium/coarse	0
Rawhide (62719-448)	2.0	Ground (high)	I	DSD = ASAE fine to medium/coarse	0
Goal 2XL (62719-424)	0.5	Aerial	I	DSD = ASAE medium to coarse	0
EndZone (34707-877)[a]	0.5	Ground (high)	I	DSD = ASAE very fine to fine	0
EndZone (34707-877)[a]	2.0	Ground (high)	I	DSD = ASAE very fine to fine	0
EndZone (34707-877)[b]	0.5	Aerial	II	DSD = ASAE Very fine to fine (average size = 137 microns) Nonvol rate = 2.25 lb/ac Active rate = 0.5 lb/ac Spray vol rate = 5 gal/ac All else = defaults	0

[a]Label did not specify droplet sizes for ground application; the most conservative size available in Tier I was chosen: ASAE very fine to fine.
[b]Label specifies droplet size to be greater than 100 microns for aerial spray. The available droplet size distribution that most closely matches this is ASAE Very fine to fine.

5.2.2.3.1 Fish and Aquatic-phase Frogs

Indirect effects to fish and frogs as food items are based on the direct effects analysis for aquatic-phase CRLFs (**Section 5.2.1.1**). Based on the multiple lines of evidence presented in **Section 5.2.1.1**, there is a potential for indirect impact to the aquatic-phase of the CRLF due to reduction of fish and aquatic-phase frogs as a prey base.

5.2.2.3.2 Terrestrial Invertebrates

When the terrestrial-phase CRLF reaches juvenile and adult stages, its diet is mainly composed of terrestrial invertebrates. As previously discussed in **Section 5.1.2.1**, indirect effects to the terrestrial-phase CRLF via reduction in terrestrial invertebrate prey items that are exposed to liquid and granular applications of oxyfluorfen are expected. RQ values representing acute (LOC = 0.05) exposures to terrestrial invertebrates (**Table 5.7**) indicate that all liquid and granular applications of oxyfluorfen may potentially result in adverse effects to small and large invertebrates.

Predicted chance of individual effect (**Table 5.7**) using probit dose-response curve slope from the earthworm study (slope = 7.20) and median lethal estimate (LC_{50} = 89 ppm) for a small terrestrial invertebrate is 100% at the rate of three applications of 1.5 lb a.i./acre and one application at 2 lb a.i./acre and greater (RQ range: 3.03 to 6.14). At the lowest application rate (one application at 0.5 lb a.i./acre), a 1 in 5.12 chance of individual effect occurs at an RQ value of 0.76 for small terrestrial invertebrates. For large terrestrial invertebrates, the predicted chance of individual effect is 1 in 8.78 at the highest RQ value of 0.68 (corresponds to the rate of four applications at 2 lb a.i./acre). At the lowest RQ value of 0.08, the corresponding estimated chance of an individual acute mortality to a large terrestrial invertebrate is 1 in 7.04E14 (corresponds to the rate of one application at 0.5 lb a.i./acre) .

Although quantitative risk estimations are based on Goal 2XL formulation earthworm acute contact toxicity, several other studies were submitted that demonstrated the effects of oxyfluorfen to various types of insects through different routes of exposure. The earthworm toxicity data was chosen for risk estimation because it was the only submitted study in which definitive toxicity values could be established.

Only two of the other six submitted studies showed that oxyfluorfen was practically non-toxic to the tested organism. For honeybees (MRID 423681-01), the LD_{50} was >100 µg a.i./bee using the old technical grade active ingredient (71.4% purity). This was the only study that used a technical material, as suggested by EFED, rather than a formulation. For ground beetles (MRID 459060-04), application of oxyfluorfen (Goal 2XL formulation) at a rate of 1.29 lb a.i./acre, which is lower than the maximum labeled rate, resulted in no significant reduction of survival or feeding rates. However, it is possible that the hard carapace of the beetle protected it from exposure to the chemical, which prevented toxic effects.

Four submitted studies demonstrated complete mortality shortly after oxyfluorfen exposure at rates lower than the maximum labeled rates. Two predatory mite studies were submitted that resulted in 98-100% mortality within seven days of exposure. In the first study (MRID 452713-03), application of oxyfluorfen (Goal 4F formulation) at a rate of 1.28 lb a.i./acre resulted in 98% mortality within seven days of exposure. In the second study (MRID 459060-06), application of oxyfluorfen (Goal 2XL formulation) at a rate of 1.29 lb a.i./acre resulted in 100% mortality within seven days of exposure. A study of parasitic wasps (MRID 459060-03) involved application of oxyfluorfen (Goal 2XL formulation) at a rate of 1.29 lb a.i./acre, which resulted in 100% mortality within 24 hours of exposure. Finally, 100% mortality was seen with the application of oxyfluorfen (Goal 2XL formulation) to spiders at a rate of 1.08 lb a.i./acre within 24 hours of exposure (MRID 459060-05). Because all of these studies tested organisms at only one dose level, definitive LD_{50}'s could not be calculated. However, significant adverse effects would be expected as a result of application of oxyfluorfen at the currently labeled rates.

5.2.2.3.3 Mammals

Life history data for terrestrial-phase CRLFs indicate that large adult frogs consume terrestrial vertebrates, including mice. As previously discussed, definitive acute RQ values could not be derived for liquid and granular applications of oxyfluorfen because the mammalian LD_{50} value was >5000 mg a.i./kg-bw, and no systemic toxicity was observed in the submitted studies.

Chronic RQ values representing oxyfluorfen exposures to small mammals indicate risks resulting from some application scenarios. Although a NOAEL was not established and was derived from the NOAEC using the standard FDA lab rat conversion, chronic dose-based RQ values exceeded LOCs for all liquid application scenarios. The more credible NOAEC yielded dietary-based LOC exceedances for liquid applications of three applications of 1.5 lb a.i./acre and greater. For granular applications, chronic dietary RQ values did not exceed the chronic LOC, but the derived chronic dose-based RQ value did exceed the chronic LOC. The dose-based chronic risk estimations are unlikely to result in significant adverse indirect effects to the terrestrial-phase CRLF. The dose-based study resulted in no observable mortalities or systemic toxicity. However, the dietary-based chronic exceedances are neither insignificant nor discountable.

5.2.2.3.4 Frogs

Terrestrial-phase adult CRLFs also consume small frogs. RQ values, estimated using T-REX, representing direct exposures of oxyfluorfen to terrestrial-phase CRLFs are used to represent exposures of oxyfluorfen to small frogs in terrestrial habitats. The indirect effects to frogs as food items are based on the direct effects analysis for the terrestrial-phase CRLF (**Section 5.2.1.2**).

After using T-HERPS to refine the risk estimate for small frogs (**Table J-13**), there were no acute exceedances for liquid applications of oxyfluorfen. It was not possible to refine the risk using T-HERPS for granular applications. However, the toxicity value is based on an LD_{10} rather than an LD_{50}. Therefore, the risk of indirect effects to the terrestrial-phase CRLF via acute reduction of terrestrial-phase amphibian prey items at the granular rate of four applications of 2 lb a.i./acre each is not likely to be significant.

Indirect chronic dietary-based risks to the terrestrial-phase CRLF are modeled in the same way as direct chronic risks. Chronic RQ exceedances provide a more credible risk estimation of the indirect effects to the terrestrial-phase CRLF than acute RQ exceedances (because acute RQ values are based on an LD_{10} rather than an LD_{50}). T-

HERPS was used to refine indirect chronic risks to the terrestrial-phase CRLF via consumption of small terrestrial-phase amphibians exposed to liquid applications. Results are described in **Section 5.2.1.2.** These indirect effects to the terrestrial-phase CRLF via reduction in terrestrial-phase amphibians are neither insignificant nor discountable.

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 as attachment sites and refugia for many aquatic invertebrates, fish, and juvenile organisms, such as fish and frogs. In addition, vascular plants also provide primary productivity and oxygen to the aquatic ecosystem. Rooted plants help reduce sediment loading and provide stability to nearshore 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 were assessed using RQs from freshwater aquatic vascular and non-vascular plant data. Based on the multiple lines of evidence presented in **Section 5.2.2.1**, there is a potential for indirect impact to the aquatic-phase of the CRLF due to reduction effects on its habitats through impact on vascular and non-vascular aquatic plants.

5.2.3.2.1 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. Terrestrial plants also provide energy to the terrestrial ecosystem through primary production. 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.

Loss, destruction, and alteration of habitat were identified as threats to the CRLF in the USFWS Recovery Plan (USFWS 2002). Herbicides can adversely impact habitat in a number of ways. In the most extreme case, herbicides in spray drift and runoff from the site of application have the potential to kill (or reduce growth and/or biomass) all or a substantial amount of the vegetation, thus removing or impacting structures that define the habitat, and reducing the functions (*e.g.*, cover, food supply for prey base) provided by the vegetation.

Oxyfluorfen is a contact herbicide that is applied to foliar surfaces or soil and does not translocate within the plant. Signs of toxicity to post-emergent broadleaf weeds include localized chlorosis and necrosis. When applied to soil as a pre-emergent treatment, oxyfluorfen forms a chemical barrier and affects plants at emergence. Based on the available toxicity data for terrestrial plants (using Goal 2XL formulation, MRID 458611-01, 458611-02), it appears that seedling monocots in the seedling emergence study are typically more sensitive to oxyfluorfen via soil or root uptake than emerged monocots in the vegetative vigor study via foliar exposure. The opposite effect was observed in dicots: foliar exposure of oxyfluorfen to emerged dicots caused adverse effects at lower rates than dicots that were exposed to the chemical through soil or root uptake.

Riparian vegetation typically consists of three tiers of vegetation, which includes a groundcover of grasses and forbs, an understory of shrubs and young trees, and an overstory of mature trees. Frogs spend a considerable amount of time resting and feeding in riparian vegetation; the moisture and cover of the riparian plant community provides good foraging habitat and may facilitate dispersal in addition to providing pools and backwater aquatic areas for breeding (USFWS 2002). According to Hayes and Jennings (1988), the CRLF tends to occupy water bodies with dense riparian vegetation including willows (*Salix* sp.). Upland habitat includes grassland and woodlands, as well as scrub/shrub habitat. No guideline data are available regarding the toxicity of oxyfluorfen to woody plants, but one non-guideline submitted study showed toxic effects to newly seeded deciduous trees (E073249). Because oxyfluorfen is labeled for use near and on (basal spray rather than foliar spray) several woody species, toxicity to the woody part of the plant, excluding green bark, is not expected.

As shown in **Tables 5.9** and **5.10**, RQ values greatly exceed LOCs for monocots and dicots inhabiting dry and semi-aquatic areas exposed to liquid formulations of oxyfluorfen via runoff and drift. Spray drift RQ values did not exceed LOCs for granular formulations or liquid ground applications at a single application rate of 0.5 lb a.i./acre.

Based on exceedances of the terrestrial plant LOCs for all oxyfluorfen use patterns following runoff and spray drift to dry and semi-aquatic areas, the following general conclusions can be made with respect to potential harm to riparian habitat:

- Oxyfluorfen may enter riparian areas via runoff and/or spray drift where it may contact foliar surfaces of emerged seedlings or form a chemical barrier on soil, which would affect pre-emergent plants.

- Based on oxyfluorfen's mode of action and a comparison of seedling emergence and vegetative vigor EC_{25} values to EECs estimated using TerrPlant, emerging or developing seedlings may be affected in areas receiving both runoff and drift and in areas receiving drift alone at applications rates greater than a single application of 0.5 lb a.i./acre. Furthermore, based on the residual nature of oxyfluorfen, it is possible that impacts to germinating seedlings and emerging plants would occur for several months after application. If inhibition of new growth occurs, it could result in degradation of high quality riparian habitat over time because as older growth dies from natural or anthropogenic causes, plant biomass may be prevented from being replenished in the riparian area.

- Because all ten of the species tested in the seedling emergence studies and nine out of ten species tested in the vegetative vigor studies were affected, it is likely that many species of herbaceous plants may be potentially affected by exposure to oxyfluorfen via runoff and spray drift.

A review of oxyfluorfen incidents for terrestrial plants that were reported in the EIIS database indicated that there were fifteen incidents involving terrestrial plants. However, none of these incidents reported effects to wild plants. Most incidents involved spray drift or improper use of the chemical on agricultural crops. The absence of reports of adverse effects on wild terrestrial plants does not provide evidence of an absence of incidents and, consequently, risk.

In summary, terrestrial plant RQs exceed LOCs, which indicates risk to upland and riparian vegetation. However, while it is not expected that woody plants with mature bark are sensitive to environmentally relevant oxyfluorfen concentrations, the lack of a guideline study on established woody plants precludes estimation of effects. Because upland and riparian areas are comprised of a mixture of both woody plants and herbaceous vegetation, terrestrial-phase CRLFs may be indirectly affected by adverse effects solely to herbaceous vegetation, which provides habitat and cover for the CRLF and its prey. Therefore, the indirect effect to the terrestrial-phase CRLF via reduction in terrestrial plants is neither insignificant nor discountable.

In order to estimate buffer distances that are protective of plant species that the terrestrial-phase CRLF or its prey may depend on for food and cover, AgDRIFT was used to model the dissipation distance to the EC_{25} levels for terrestrial plants. Input parameters for AgDRIFT are described in **Table 5.18**.

Because oxyfluorfen is used as a pre-emergent and post-emergent herbicide, buffer distances were calculated for the most sensitive endpoints for both monocots and dicots in the seedling emergence and vegetative vigor studies (**Table 5.18**). For established monocots, dissipation distances ranged from 0 to 19.68 feet. For established dicots and seedling monocots and dicots, dissipation distances ranged from 13.12 to 593.82 feet for Tier I ground and aerial applications. For Tier II aerial applications, AgDRIFT was not able to calculate buffer distances as estimations are limited to 1,000 feet and below. If input of the fraction applied (EC_{25} divided by application rate) resulted in an out of range estimation for the Tier II aerial application, the Tier III AgDRIFT model was used.

Table 5.18 Estimation of Buffer Distance Required to Eliminate LOC Exceedances (only spray drift exposure considered) for Terrestrial Plants Based on AgDRIFT								
Pesticide Label	**App. Rate (lb/acre)**	**Method (Boom Height for Ground)**	**Tier**	**Parameters**	**Required Buffer Distance (ft)**			
					Seedling Emergence		**Vegetative Vigor**	
					Monocot	**Dicot**	**Monocot**	**Dicot**
Rawhide (62719-448)	0.5	Ground (high)	I	DSD = ASAE fine to medium/coarse	49.21	39.37	3.28	39.37
Rawhide (62719-448)	2	Ground (high)	I	DSD = ASAE fine to medium/coarse	269.03	226.38	3.28	13.12
Goal 2XL (62719-424)	0.5	Aerial	I	DSD = ASAE medium to coarse	357.61	311.68	0.00	295.27
EndZone (34707-877)	0.5	Ground (high)	I	DSD = ASAE very fine to fine	196.85	170.60	6.56	160.76
EndZone (34707-877)	2	Ground (high)	I	DSD = ASAE very fine to fine	593.82	531.49	19.68	511.80
EndZone (34707-877)	0.5	Aerial	II	DSD = ASAE very fine to fine (average size = 137 microns) Nonvol rate = 2.25 lb/acre Active rate = 0.5 lb/acre Spray vol rate = 5 gal/acre All else = defaults	out of range	out of range	16.40	out of range
EndZone (34707-877)	0.5	Aerial	III	DSD = ASAE very fine to fine (average size = 137 microns) Nonvol rate = 2.25 lb/acre Active rate = 0.5 lb/acre Spray vol rate = 5 gal/acre Specific gravity(nonvol) = 1.08 Max downwind dist = 3000 ft All else = defaults	2621.36	2450.76	NC	2375.3
NC – Not calculated. Estimation obtained from Tier II model.								

5.2.4 Modification to Designated Critical Habitat

5.2.4.1 Aquatic-Phase PCEs

Three of the four assessment endpoints for the aquatic-phase primary constituent elements (PCEs) of designated critical habitat for the CRLF are related to potential effects to aquatic and/or terrestrial plants:

- 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.
- 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.

- Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae).

Conclusions for potential indirect effects to the CRLF via direct effects to aquatic and terrestrial plants are used to determine whether modification to critical habitat may occur. There is a potential for habitat modification via impacts to aquatic plants (**Sections 5.2.2.1** and **5.2.3.1**) and terrestrial plants (**Section 5.2.3.2**)

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." Other than impacts to algae as food items for tadpoles (discussed above), this PCE is assessed by considering direct and indirect effects to the aquatic-phase CRLF via acute and chronic freshwater fish and invertebrate toxicity endpoints as measures of effects. There is a potential for habitat modification via impacts to aquatic-phase CRLFs (**Section 5.2.1.1**) and effects to freshwater invertebrates and fish as food items (**Sections 5.2.2.2** and **5.2.2.3**).

5.2.4.2 Terrestrial-Phase PCEs

Two of the four assessment endpoints for the terrestrial-phase PCEs of designated critical habitat for the CRLF are related to potential effects to terrestrial plants:

- 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 drip line surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provide the CRLF shelter, forage, and predator avoidance.

- 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.

As discussed above, there is potential for habitat modification of the terrestrial-phase CRLF via impacts to terrestrial plants as indicated by potential impacts to herbaceous vegetation, which provides habitat, cover, and a means of dispersal for the terrestrial-phase CRLF and its prey. This habitat modification could be caused by all modeled uses of oxyfluorfen at the maximum labeled rate.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of oxyfluorfen on this PCE, acute toxicity endpoints for terrestrial invertebrates and acute and chronic toxicity endpoints for mammals and terrestrial-phase frogs are used as measures of effects. Based on the characterization of indirect effects to the terrestrial-phase CRLF via reduction in prey base (**Section 5.2.2.4** for terrestrial invertebrates, **Section 5.2.2.5** for mammals, and **Section 5.2.2.6** for frogs), there is potential for critical habitat modification via a reduction of terrestrial invertebrates, small mammals, and frogs as food items.

The fourth terrestrial-phase PCE is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. As discussed in **Section 5.2.1.2**, direct acute effects to the terrestrial-phase CRLF are unlikely. However, direct chronic effects to the terrestrial-phase CRLF are likely for liquid applications of oxyfluorfen at rates of three applications of 0.5 lb a.i./acre and greater. Indirect effects to the terrestrial-phase CRLF via reduction in prey base are likely. Therefore, there is potential for habitat modification via direct and indirect effects to the terrestrial-phase CRLF.

6. Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario and Label Uncertainties

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 dependent on pest resistance, timing of applications, cultural practices, and market forces.

In many instances, the mitigation recommendations resulting from the 2002 RED (see **Section 2.4.4**) have not yet been implemented on oxyfluorfen product labels. It is anticipated that implementation of these mitigations would reduce environmental exposure to oxyfluorfen. The focus of this assessment is to evaluate exposure based on current, stamped labels; therefore, EFED is not evaluating the effects of the mitigations at this time. Relative reductions can be determined for some of these mitigations (*e.g.,* rate reductions, increase in droplet sizes). However, relative reductions cannot be determined for other mitigations (*e.g*., impact on runoff due to a 25 ft buffer) as EFED does not have models to evaluate buffer effects on runoff.

Most oxyfluorfen product labels specify application rates on a per crop cycle basis (not on a per year basis). Information from BEAD indicates that many crops can be grown more than one time/year in California (USEPA 2007). Since standard PRZM scenarios only consist of one crop per year, applications to only one crop per year were modeled. The crops that may be grown multiple times in a calendar year that can be treated by oxyfluorfen include beets, broccoli, cabbage, cauliflower, celery, collards, leafy green vegetables, lettuce, onions, radish, and spinach. The cropping seasons range between two and four cycles per year. If oxyfluorfen is applied for multiple cropping cycles within a year, EECs presented in this assessment may underpredict underpredict exposures. For all other labeled uses, it was assumed that a maximum seasonal application specified on the label was equivalent to a maximum annual application.

The product label for Zoomer (EPA Reg. No. 66222-157, dated 12/7/2007) was not included in the LUIS report. It provides a single application rate of 0.4 lb a.i./acre and allows for two applications per year (total of 0.8 lb a.i./acre/year), with no restrictions on the re-application interval. Crops listed on the Zoomer label include many crops listed under 'Orchard' and 'Agricultural – Food Crop Uses'. For some of these crops, the modeled rate was 0.5 lb a.i./acre with only one application per season (**Table 2.3**). It is anticipated that the rates on the Zoomer label would result in higher EECs than those modeled. Since there were already LOC exceedances for at least one taxonomic group for all modeled crops at the rates, these additional rates were not modeled in this assessment.

In some instances, BEAD could not convert a label application rate (*e.g.*, ready-to-use homeowner product) to lb a.i./acre. These products were included in the LUIS report, but no application rate in lb a.i./acre was given; therefore, those particular uses were excluded from this effects determination. It was presumed that products without an application rate specified in lb a.i./acre or easily convertible to lb a.i./acre were more likely to be used as spot treatments rather than over a large unit area, and, thus, the environmental exposure would be minimal.

When multiple applications were permissible according to the label but no interval was specified, the interval was assumed to be 30 days based on EFED's knowledge of herbicide cultural practices. Oxyfluorfen labels did not provide any re-application interval specifications with the exception of some nursery uses that recommended re-application at 90 days. Some labels for lactofen and sodium acifluorfen (other chemicals in the same class) have re-application interval minimums specified as 14 or 15 days, other labels had no re-application restrictions. Another chemical in this class, fomesafen, has a minimum re-application interval of one year, and for some crops, an alternate year application interval is required. Based on this information and oxyfluorfen's persistence in soil, a minimum re-application interval of 30 days was chosen for all uses for which the re-application interval was not specified. If, in practice, the re-application interval was longer, then the EECs used in this risk assessment would tend to overestimate exposure.

In case of right-of-ways and residential uses, the general label language describing the extent of the application area led EFED to use conservative assumptions regarding the post-processing techniques to obtain EECs. In this modeling approach, it is assumed that right-of-ways and residential application sites are composed of equal parts pervious and impervious surfaces (*i.e.*, the EECs of both surfaces are multiplied by 50%). However, in reality, it is likely that right-of-ways and residential uses contain different ratios of the two surfaces. In general, incorporation of impervious surfaces into the exposure assessment results in increasing runoff volume in the watershed, which tends to reduce overall pesticide exposure assuming 1% overspray to the impervious surface. 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 (USEPA 2006).

6.1.2 Aquatic Exposure Modeling of Oxyfluorfen

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 habitats 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. Additionally, model inputs from the environmental fate degradation studies are chosen to 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. 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 PRZM-EXAMS modeling results in oxyfluorfen accumulation from year to year. This observation is not unexpected due to the persistence of oxyfluorfen in aquatic and soil environments as well as the static nature of the PRZM/EXAMS ‘standard pond’ scenario. The 1-in-10 year concentrations, as routinely reported for Tier II aquatic exposure modeling, may or may not be conservative for actual aquatic environments depending on how water bodies depart from assumptions in PRZM/EXAMS. For example, if flow conditions that result in the removal of pesticide mass are present in the actual water body, then the modeled concentrations may be higher than any measured concentrations. In addition, the probabilistic interpretation of the 1-in-10 year concentrations as a return frequency may not be defensible because of temporal auto-correlation in the modeled concentrations.

In order to account for uncertainties associated with modeling, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for oxyfluorfen concentrations measured in surface waters receiving runoff from agricultural areas, mixed, and urban areas (no detects). The specific use patterns (*e.g.*, application rates and timing, crops) associated with the agricultural and urban areas are unknown; however, they are assumed to be representative of potential oxyfluorfen use areas.

Oxyfluorfen measured in water from the NAWQA program indicated concentrations were much less than those modeled by PRZM/EXAMS. Of the 192 samples collected in California, only 18.2% had positive detections. Of the positive samples, the average concentration was 0.0208 µg/L, and the maximum reported concentration was 0.0875 µg/L. These measured concentrations are considerably lower than peak concentrations resulting from PRZM/EXAMS modeling which ranged from 0.347 to 46.40 µg/L. There are several potential explanations for these differences:

- Monitoring sites were not necessarily targeted to areas of high oxyfluorfen usage
- The PRZM/EXAMS EECs are based on an assumption of 100% of the watershed area being treated as compared to the actual usage pattern would likely result in

less of the watershed being treated, with the exception of residential and right-of-ways being 50% treated.

- Sampling times were not designed to capture the high peak values and were not frequent enough to assure the peak values were captured. The probability that the actual highest peak concentrations were captured by infrequent grab samples at only six sites spread across a large portion of California is extremely low.
- Water samples were filtered prior to analysis, removing oxyfluorfen that had sorbed to suspended particles in the water.
- Average application rates of oxyfluorfen based on the California PUR data tend to be less than the maximum label rates modeled in this assessment.

Similarly, dissolved water concentrations from the San Joaquin River (range 0.12 to 0.82 µg/L) were also much lower than modeled concentrations.

Monitoring data from Keese *et al*. (1994), suggest that the PRZM/EXAMS modeling estimates may be lower than observed in targeted sampling. Runoff to a pond was evaluated after application of 2.0 lb a.i./acre (Rout granular end-use product) to a nursery plot. Measured concentrations averaged 147 µg/L one day after application, averaged approximately 40 µg/L three days after application, and were still detectable 14 days after application. Measurement of oxyfluorfen at concentrations higher than solubility (116 µg/L) may be due to colloidal material (to which oxyfluorfen may have sorbed) passing through the laboratory filter. These measured concentrations could be compared with the PRZM/EXAMS estimates from a single granular application of 2 lb a.i./acre to an ornamental nursery where the resulting peak concentration was 5.20 µg/L and the 21-day concentration was 5.18 µg/L. Unlike the pond in PRZM/EXAMS, the nursery pond had a water runoff point; sampled concentrations may have been even higher than observed if no runoff had occurred in the nursery pond. Unfortunately, pond measurements (e.g., depth, suspended sediments, organic carbon) were not provided in the paper to facilitate a stronger comparative analysis between the sampled pond and the 'standard pond' in PRZM/EXAMS.

In contrast to spray drift modeling, 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 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 Usage Uncertainties

County-level usage data for eight years (1999-2006) were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. 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 cancelled. The CPDR PUR data does not include homeowner-applied pesticide usage; 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.

6.1.4 Terrestrial Exposure Modeling of Oxyfluorfen

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% (USEPA 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.

Additional information on uncertainties in the terrestrial exposure models are described in the EPA OPP Overview Document and in guidance specific to each exposure model.

6.1.5 Spray Drift Modeling

Although there may be multiple oxyfluorfen applications at a single site, 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 oxyfluorfen from multiple applications, each application of oxyfluorfen would have to occur under identical atmospheric conditions (*e.g.*, same wind speed and – for plants – same wind direction) and (if it is an animal) the animal being exposed would have to be present directly downwind at the same distance after each application. Although there may be sites where the dominant wind direction is fairly consistent (at least during the relatively quiescent conditions that are most favorable for aerial spray applications), it is nevertheless highly unlikely that plants in any specific area would receive the maximum amount of spray drift repeatedly. It appears that in most areas (based upon available meteorological data) wind direction is temporally very changeable, even within the same day. Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT/AGDISP 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/AGDISP may overestimate exposure even from single applications, 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 often 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 (*e*.g., aerial), release heights and wind speeds. Alterations in any of these inputs would change the area of potential effect. Current oxyfluorfen labels have varying directions regarding factors affecting droplet size distributions. The impact of some of these differences buffer distances required to eliminate LOC exceedances are characterized in **Section 5.2**.In addition, when mitigation measures from the 2002 RED are implemented, the use of an ASAE coarse, very coarse, or extremely coarse spray with a volume median diameter (VMD) of 385 microns or larger would likely minimize spray drift potential.

6.2 Effects Assessment Uncertainties

6.2.1 Specific Toxicological Concerns Associated with Oxyfluorfen

Oxyfluorfen is a diphenyl-ether, one of a class of herbicides sometimes referred to as light-dependent peroxidizing herbicides (LDPHs), which have enhanced toxicity in the presence of solar ultraviolet radiation. Because toxicity of the LDPHs is affected by the presence of ultraviolet (UV) radiation, most toxicity tests used in this assessment, which were conducted under standard laboratory lighting conditions, may underestimate the toxicity of oxyfluorfen to some taxa under natural sunlight conditions. The Agency and the LDPH Task Force are currently in the process of developing a protocol for aquatic studies that evaluate the effect of UV light on the toxicity of these herbicides, but at the time of this assessment, it had not been finalized (EFED 2007). Preliminary studies have been submitted for some chemicals, including oxyfluorfen. Fish early life-cycle studies on oxyfluorfen conducted under UV light indicate larval fish LD_{50}s are approximately an order of magnitude lower than LD_{50}'s based on standard lighting conditions (MRID 465851-04). In this study, the larval fish appeared to hatch prematurely compared to the controls and then die. Based on the mode of action, it is possible that disruption of the egg cell membrane caused the premature hatch.

Based on the effects noted in the UV-enhanced early-life fish study (decreased hatching time and reduced larval survival) and the mode of action of LDPHs, it is a likely explanation is that oxyfluorfen may have affected the viability of the egg cell membrane surrounding the larva. This caused premature hatching (2-3 days in fish eggs exposed to oxyfluorfen and UV light vs. 4-5 days in fish eggs exposed to UV light only). CRLF 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). Given that CRLF eggs are at or near the water surface and UV rays do penetrate the surface layers of water bodies (Barron *et al.* 2000, Diamond *et al*. 2005), photoenhanced toxicity to the CRLF eggs and larvae is a possibility.

The extent to which UV light enhances the toxicity of oxyfluorfen to other taxa or other life stages is unknown; existing studies conducted under standard laboratory lighting may underestimate the toxicity. At the current time, the Agency has no data to support an extrapolation of phototoxic effects to terrestrial animals but does not discount the potential for such enhancement to occur. As discussed previously, the potential for phototoxic effects is a serious concern for this chemical. Anemia and other hematologic consequences were observed in the developmental studies in mammals. In wild mammal populations, hematologic effects have the potential to magnify since the lack of natural sunlight in the laboratory reduces the likelihood of activating the phototoxic effects of oxyfluorfen.

6.2.2 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, and 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.

6.2.3 Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on oxyfluorfen are not available for frogs or any other aquatic-phase amphibian; therefore, freshwater fish are used as surrogate species for aquatic-phase amphibians. Similarly, avian toxicity data is used as a surrogate for terrestrial-phase amphibians due to the lack of guideline toxicity tests and open literature data evaluating the effects of oxyfluorfen exposure. Therefore, endpoints based on freshwater fish and bird ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase and terrestrial–phase amphibians including the CRLF. 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 at a low level, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

6.2.4 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 effects determination 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. However, the full suite of sublethal effects from valid open literature studies is considered for the purposes of defining the action area.

Sublethal effects (increases in liver proteins, changes in levels of several enzymes that are indicators of stress levels) in tilapia fish were identified at oxyfluorfen concentrations of 300 and 600 µg a.i./L. Both of these test concentrations were higher than the most sensitive LD_{50} identified in bluegill (LD_{50} = 203 µg a.i./L) which potentially indicates a wide variation in species sensitivities to oxyfluorfen. Krijt *et al.* conducted a series of experiments evaluating effects of oxyfluorfen on mice and rat liver and kidney components. The most sensitive sublethal effect was noted at 200 mg a.i./kg-diet and included increases in liver and kidney porphyria and changes in enzyme activity. These effects were observed at less than the most sensitive mammalian chronic NOAEC (2-generation rat NOAEC = 400 mg a.i./kg-diet). Therefore, it is possible that effects to mammalian prey population of the CRLF may be seen at concentrations less than those used for RQ calculation. To the extent to which sublethal effects are not considered in this assessment, the potential direct and indirect effects of oxyfluorfen on CRLF may be underestimated.

6.2.5 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 areas adjacent to a treated 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. 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 oxyfluorfen to the CRLF and its designated critical habitat.

Based on the best available information, the Agency makes a May Effect/Likely to Adversely Affect determination for the CRLF from the use of oxyfluorfen. Additionally, the Agency has determined that there is the potential for modification of CRLF designated critical habitat from the use of the chemical. Based on potential for effects to aquatic and terrestrial plants, all currently registered uses of oxyfluorfen in California have the potential to cause indirect effects to the CRLF and to modify its habitat. Given the LAA determination for the CRLF and potential modification of designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment 2**.

The LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the CRLF or its designated critical habitat. To determine this area, the footprint of oxyfluorfen's use pattern is identified, using land cover data that correspond to oxyfluorfen's use pattern. The spatial extent of the LAA effects determination also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift. The identified direct and indirect effects and/or modification to critical habitat are anticipated to occur only for those currently occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that overlap with the initial area of concern plus up to approximately 2,600 feet (based on spray drift analysis for terrestrial plants) from its boundary. It is assumed that non-flowing water bodies (or potential CRLF habitat) are included within this area. Further discussion of spray drift buffers for terrestrial plants is found in **Section 5.2.3.2**.

In addition to the spray drift buffer, the results of the downstream dilution extent analysis show that all California stream reaches may be impacted from the initial footprint. If any of these streams reaches flow into CRLF habitat, there is potential to affect either the CRLF or modify its habitat. These lotic habitats within the CRLF core areas and critical habitats potentially contain concentrations of oxyfluorfen sufficient to result in LAA determination or modification of critical habitat.

Appendix D provides maps of the initial area of concern, along with CRLF habitat areas, including currently occupied core areas, CNDDB occurrence sections, and designated critical habitat. It is expected that any additional areas of CRLF habitat that are located 2,600 ft (to account for offsite migration via spray drift) outside the initial area of concern may also be impacted and are part of the full spatial extent of the LAA/modification of critical habitat effects determination.

A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat, given the uncertainties discussed in **Section 6**, is presented in **Tables 7.1** and **7.2**.

Table 7.1 Effects Determination Summary for Oxyfluorfen Use and the CRLF Impact Analysis

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Survival, growth, and/or reproduction of CRLF individuals	LAA[1]	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults): Freshwater fish data used as surrogate for CRLF *Adult survival*: Acute LOC exceedances in several scenarios with LC_{50} attained under standard laboratory lighting = 203 µg a.i./L. Acute LOC exceedances in all scenarios with LC_{50} estimated under UV lighting from a calculated chronic:acute ratio. *Growth and reproduction:* Chronic LOC exceedances in many of the scenarios with NOAEC attained under UV lighting.
		Terrestrial-phase (Juveniles and Adults): Avian data used as surrogate for CRLF *Survival:* No significant concerns based on acute studies. *Growth and reproduction*: Dietary-based chronic RQ values exceeded the LOC for liquid applications of oxyfluorfen at rates higher than 2 applications of 0.5 lb a.i./acre. Chronic granular exceedances were not observed.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity *Non vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Vascular aquatic plants*: LOC exceedances in all but one modeled scenario. *Freshwater invertebrates, standard laboratory lighting*: Acute LOC was exceeded for several scenarios and chronic LOC exceeded for two scenarios. *Freshwater invertebrates, estimated UV lighting*: Acute LOC exceeded for all scenarios and chronic LOC exceeded for all but five scenarios.
		Terrestrial prey items, riparian habitat *Terrestrial invertebrates*: For liquid applications affecting small and large insects, the acute LOC was exceeded for all application rates. For granular applications, the acute RQ exceeded the LOC at a rate of 2 lb a.i./acre. *Terrestrial-phase amphibians, acute toxicity*: No significant concerns based on acute studies.

Table 7.1 Effects Determination Summary for Oxyfluorfen Use and the CRLF Impact Analysis		
Assessment Endpoint	**Effects Determination [1]**	**Basis for Determination**
		Terrestrial-phase amphibians, growth and reproduction: Dietary-based chronic RQ values exceeded the LOC for liquid applications of oxyfluorfen at rates higher than 2 applications of 0.5 lb a.i./acre. Chronic granular exceedances were not observed. *Small terrestrial mammals, acute toxicity:* No concerns based on acute studies. *Small terrestrial mammals, growth and reproduction:* For liquid applications of oxyfluorfen, chronic dose-based LOCs were exceeded for all application rates. Chronic dietary-based LOCs were exceeded for application rates greater than 1 lb a.i./acre. For granular applications at the rate of 2 lb a.i./acre, the chronic dose-based RQ exceeded the LOC for small mammals. *Terrestrial plants*: LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen.
[1]No effect (NE); May affect, but not likely to adversely affect (NLAA); May affect, likely to adversely affect (LAA)		

Table 7.2 Effects Determination Summary for Oxyfluorfen Use and CRLF Critical Habitat Impact Analysis		
Assessment Endpoint	**Effects Determination [1]**	**Basis for Determination**
Modification of aquatic-phase PCE	HM[1]	*Terrestrial plants*: LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen. *Non-vascular aquatic plants*: LOC exceedances in all modeled scenarios. *Vascular aquatic plants*: LOC exceedances in all but one modeled scenario.
Modification of terrestrial-phase PCE		*Terrestrial plants*: LOCs were exceeded for both monocots and dicots for all modeled uses of oxyfluorfen.
[1]Habitat modification (HM) or No effect (NE)		

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 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.

8. References

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.

Barron, MG, Little EE, Calfee R, and S. Diamond. 2000. Quantifying solar spectral irradiance in aquatic habitats for the assessment of photoenhanced toxicity. Environmental Toxicology and Chemistry 19:920-925.

Belfroid, A., M. Sikkenk, W. Seinen, K.V. Gestel, J. Hermens. 1994. The toxicokinetic behavior of chlorobenzenes in earthworm (*Eisenia andrei*) experiments in soil. Environ. Toxicol. Chem. 13:93-99.

Bergamaschi, B.A., K.L Crepeau, and K.M. Kuivila. 1997. US Geological Survey Open-File Report 97-24. Available at: http://water.wr.usgs.gov/ofr97-24/spatial.html

CalEPA. 2006. Environmental Justice Pilot Project: Pesticide Air Monitoring in Parlier, Second Progress Report. *By* Department of Pesticide Regulation. December 2006. 18pp. http://www.cdpr.ca.gov/docs/envjust/pilot_proj/interim/narrative.pdf. All reports are: http://www.cdpr.ca.gov/docs/envjust/pilot_proj/

Carter, J. and M. Kaul. 2007. County-Level Usage for glyphosate and associated isomers, permethn, phorate, rotenone and associated isomers, tribufos, oxyfluorfen and ziram in California in Support of a Red Leggql Frog Endangered Species Assessment. Memo from BEAD to EFED (Holly Galovatti). 4 June 2007.

Diamond, SA, Trenham, PC, Adams MJ, Hossack, BR, Knapp, RA, Stark, SL, Bradford, D, Corn PS, Czarnowski, K, Brooks, PD Fagre, D, Breen , B, Detenbeck NE, and K Tonessen. 2005. Estimated Ultraviolte radiation doeses in wetlands in six national parks. *Ecosystems*. 8:462-477.

Environmental Fate and Effects Division (EFED). 2007. Memo on: Environmental Fate and Effects Division recommendation regarding the light dependent peroxidizing herbicides (LDPHs), DP Barcode D333803, dated 4/16/2007.

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. xxi+1094 pp. (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. xxi+227.

Fletcher, J.S., J.E. Nellessen, and T.G. Pfleeger. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, and instrument for estimating pesticide residues on plants. Environmental Toxicology and Chemistry 13 (9):1383-1391.

Food and Agriculture Organization of the United Nations. 2000. FAO PESTICIDE DISPOSAL SERIES 8. Assessing Soil Contamination: A Reference Manual. Appendix 2. Parameters of pesticides that influence processes in the soil. Editorial Group, FAO Information Division: Rome, 2000. http://www.fao.org/DOCREP/003/X2570E/X2570E00.htm

Frank, R. B. S. Clegg, G. Ritcey. 1991. Disappearance of oxyfluorfen (Goal) from onions and organic soils. *Bull. Environ. Contam. Toxicol*. 46:485-491.

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. Pp. 144-158. In Proceedings of the symposium on the management of amphibians, reptiles, and small mammals in North America. R. Sarzo, K.E. Severson, and D.R. Patton (technical coordinators). USDA 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 Publ, Stuttgart, West Germany, pp. 9-28.

Hoffman, D. J., Spann, J. W., LeCaptain, L. J., Bunck, C. M., and Rattner, B. A. (1991). Developmental Toxicity of Diphenyl Ether Herbicides in Nestling American Kestrels. *J.Toxicol.Environ.Health* 34: 323-336. (EcoReference No.: 97949)

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.

Keese, R. J., N. D. Camper, T. Whitwell, M. B. Riley, and P. C. Wilson. 1994. Herbicide runoff from ornamental container nurseries. J. Environ. Qual. 23:320-324.

Krijt, J, Stranska, P, Maruna, P, Vokurka, M, and Sanitrak, J. (1997) Herbicide-induced experimental variegate porphyria in mice: tissue porphyrinogen accumulation and response to porphyrogenic drugs. Canadian Journal of Physiology and Pharmacology 75:1181-1187.

Krijt, J., Stranska, P., Sanitrak, J., Chlumska, A., and Fakan, F. 1999. Liver preneoplastic changes in mice treated with the herbicide fomesafen. Hum. Exp. Toxicol. 18: 338-344. (EcoReference No.: 95400)

Krijt, J, van Hosteijn, I, Vokurka, M, and Blaauboer, B. (1993) Effect of diphnyl ether herbicides and oxadiazon on porphyrin biosynthesis in mouse liver, rat primary hepatocyte culture and HepG2 cells. Archives of Toxicology 67:255-261. (Eco Ref No: 95026)

Krijt, J, Vokurka, M, Sanitrák, J, and Janousek, V. (1994) Effect of Protophyrinogen Oxidase Inhibitors on Mammalian Porphyrin Metabolism. American Chemical Society Symposium Series 559:247-254. (Eco Ref No: 95589)

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.

Peixoto, F., Alves-Fernandes, D., Santos, D., and Fontainhas-Fernandes, A. (2006). Toxicological Effects of Oxyfluorfen on Oxidative Stress Enzymes in Tilapia *Oreochromis niloticus. Pestic.Biochem.Physiol.* 85: 91-96. (EcoReference No.: 95831)

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

Reis, D.K. 1999. 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.

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.

U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. Volume I of II. EPA/600/R-93/187a. Office of Research and Development, Washington, D. C. 20460. EPA/600/R-93/187a.

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

USEPA. 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.

USEPA. 2007. Maximum Number of Crop Cycles Per Year in California for Methomyl Use Sites. Memo from Monisha Kaul (BEAD) to Melissa Panger (EFED). Dated 27 February 2007.

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. 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.

Warren, S. L. and Skroch, W. A. (1991). Evaluation of Six Herbicides for Potential Use in Tree Seed Beds. *J.Environ.Hortic.* 9: 160-163. (EcoReference No.: 73249)

Willis, G.H. and L.L. McDowell. 1987. Pesticide Persistence on Foilage in Reviews of Environmental Contamination and Toxicology. 100:23-73.

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

Yen, J.-H., W.-S. Sheu, and Y.-S. Wang. 2003. Dissipation of the herbicide oxyfluorfen in subtropical soils and its potential to contaminate groundwater. *Ecotox. and Environ. Safety* 54:151–156.

Ying, G.G. and B. Williams. 2000. Dissipation of herbicides in soil and grapes in a South Australian vineyard. *Agric. Ecosyst. Environ.* 78:283-289.