Risks of Permethrin Use to the Federally Threatened California Red-legged Frog (*Rana aurora draytonii*) and Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), and the Federally Endangered California Clapper Rail (*Rallus longirostris obsoletus*), Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*), and San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)

Pesticide Effects Determinations

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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), California clapper rail (*Rallus longirostris obsoletus*) (CCR), Salt marsh harvest mouse (*Reithrodontomys raviventris*) (SMHM), San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) (SFGS), and Bay checkerspot butterfly (*Euphydryas editha bayensis*) (BCB) arising from FIFRA regulatory actions regarding use of permethrin on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitat for the CRLF and BCB. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

The listing date and a general description of the range of each assessed species is as follows.

- 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.
- The CCR was listed as an endangered species by the USFWS in 1970. Currently, known CCR breeding populations are found only in tidal marshes in the San Francisco estuary. The CCR only occurs in coastal wetlands in Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties, all of which form the San Francisco-Suisun Bay complex.
- The SFGS was listed as an endangered species by the USFWS in 1967 and was grandfathered under the Endangered Species Act (ESA) when it was signed into law in 1973. The SFGS is endemic to the San Francisco Peninsula and San Mateo County and historically inhabited densely vegetated ponds or shallow marshlands near open hillsides found from San Francisco to Santa Cruz, including the San Francisco Peninsula. The current distribution of the SFGS is unknown because most of their historic range is now privately owned; however, it appears that the SFGS can still be found in much of its historic range.
- The SMHM was listed as an endangered species by the USFWS in 1970. The SMHM is currently found in tidal and non-tidal salt marshes in San Francisco, San Pablo, and Suisun bays.
- The BCB was listed as a threatened species in 1987 by the USFWS. The species primarily inhabits native grasslands on serpentine outcrops around the San Francisco Bay Area in California. The distribution of known BCB populations is currently limited to Santa Clara and San Mateo Counties.

Permethrin, a racemic mixture of the cis and trans isomers (currently registered technical active product has a content of cis isomer ranging from 35%-55%), is a Type I synthetic pyrethroid currently registered for numerous diverse uses in California that span a large variety of use sites and geographical regions throughout the entire state. It is a broad spectrum insecticide that targets adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying invertebrates. Permethrin is a neural toxic insecticide with contact and stomach action, having a slight repellent effect. The primary biological effects of permethrin and other pyrethroids on insects and vertebrates reflect an inhibition of the correct firing of neurotransmitter deliver signals from one cell to another via nerve membrane inhibition of the voltage gated Ca^{2+} channels coupled with a stimulatory effect on the voltage gated Na^{+} channels (sodium ion channels); effects are observed on both the peripheral and central nervous system.

Permethrin can be formulated in a diverse array of end-use products including wettable powders, dispersible granules, emulsifiable concentrates, liquids, ready to use products, granulars, seed treatments, and dust formulations. Application methods include, but may not be limited to: aerial spray, ground spray, hand spray, airblast, mist/fogging, soil band spray, surface spray, soil incorporation, granular (aerial or ground), and chemigation. In addition, spray methods may use ultra-low volume (ULV) nozzles which suspend the product in the air for a longer duration, in order to intercept flying insects. Permethrin can be essentially in any form anywhere, at any time of the year. Potential permethrin uses include agricultural (in/on food/feed crops); nursery uses; home garden uses; ornamental uses; forestry uses; turf uses; indoor/outdoor industrial, commercial, and residential uses; fire ant control; control of ectoparasites on domestic animals; and public health uses (*i.e.* for mosquito abatement) in urban and rural settings. Non-agricultural use exceeds that of use on agricultural crops. In California, the greatest average annual usage from 1999-2006 was the use in structural pest control and landscape maintenance. Agricultural uses include a number of agronomic crops, but crops with the greatest average annual usage of permethrin include nuts, leafy vegetables, residential gardens, corn, alfalfa and fruits. Thus, there are no areas within the state of California where permethrin may not be used, so potential exposure to insects and other invertebrates, fish, and other wildlife exists statewide. Both agricultural and non-agricultural uses of permethrin in California are considered as part of the federal action evaluated in this assessment.

Permethrin is a relatively persistent pyrethroid in the environment and is slow to biodegrade and hydrolyze. Permethrin is more stable to sunlight than other synthetic pyrethroids, such as allethrin and resmethrin, because it has the isobutenyl group attached to the cyclopropane moiety. Permethrin has a low solubility in water (5.5 ppb, Laskowski, 2002) and has a hydrophobic nature ($K_{OW} = 1.26x10^6$, Laskowski, 2002), which indicates that the chemical strongly adsorb to soils and partitions with sediments in aquatic systems. This is confirmed by the high $K_{FOC} \geq 28,200$ (MRID 41868001). Octanol/ water partition coefficient suggests that permethrin may bioconcentrate in aquatic organisms. The major routes of dissipation of permethrin appear to be aerobic soil and aquatic metabolism (37 and 38-43 days, respectively) and soil binding

(K_{FOC}≥28,000). Permethrin is persistent to hydrolysis, aqueous and soil photolysis (80 days and 106 days, respectively). Permethrin is also relatively persistent in anaerobic environments (anaerobic soil and anaerobic aquatic metabolism half-lives of 204 and 113-175 days, respectively). With limited monitoring data in California, *cis*-permethrin 1.1-1.5% of the samples) and sediment samples (*cis*- and *trans*-permethrin, 2.1-3.8% of the samples). But no detections were reported in ground waters (only *cis*-permethrin was monitored). Major mechanisms of pesticide transport for permethrin include spray drift and movement with surface water runoff dissolved in water or associated with the eroded soil particles.

The effects determinations for each listed species assessed is based on a weight-of-evidence method that relies heavily on an evaluation of risks to each taxon relevant to assess both direct and indirect effects to the listed species and the potential for modification of their designated critical habitat (*i.e*., a taxon-level approach). Since some of the assessed species exist within aquatic and terrestrial habitats, exposure of the listed species, their prey and their habitats to permethrin are assessed separately for the two habitats (if applicable). Tier-II aquatic exposure models are used to estimate high-end exposures of permethrin in aquatic habitats resulting from runoff and spray drift from different uses. Peak model-estimated environmental concentrations resulting from different permethrin uses range from 0.162 µg/L to 5.50 µg/L (5.50 µg/L is the solubility limit for permethrin). These estimates are supplemented with analysis of available California 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 permethrin reported by NAWQA for California surface waters with agricultural watersheds is 0.146 µg/L. This value is approximately 38 times lower than the maximum model-estimated environmental concentration. The maximum concentration of permethrin reported by the California Department of Pesticide Regulation surface water database (0.195 µg/L) is roughly 28 times lower than the highest peak model-estimated environmental concentration. Existing monitoring data in California from the USGS NAWQA database show highest sediment sample concentration of 16 ug/kg. Limited atmospheric monitoring data in California show detections in air samples.

To estimate permethrin exposures to terrestrial species resulting from use of permethrin applications, the T-REX model is used for foliar, granular, and seed treatment uses. In addition, an earthworm fugacity model is used to predict concentrations of permethrin in soil (as a result of granular use) as well as concentrations in terrestrial invertebrates as food items for terrestrial species. In addition, exposure of terrestrial animals that may consume aquatic organisms that have bioconcentrated permethrin in aquatic habitats is evaluated by multiplying a laboratory derived bioconcentration factor (BCF) in fish by estimated water concentrations from PRZM/EXAMS to estimate tissue concentrations in aquatic organisms. Although the TerrPlant model is typically used to estimate exposures to terrestrial habitat, including plants inhabiting semi-aquatic and dry areas, no toxicity data were available for terrestrial plants so the model is not employed in this assessment. The T-HERPS model is used to allow for further characterization of dietary exposures of terrestrial-phase amphibians and reptiles relative to birds.

The effects determination assessment endpoints for the listed species include direct toxic effects on the survival, reproduction, and growth of the listed species itself, as well as indirect effects, such as reduction of the prey base or modification of its habitat. If appropriate data are not available, toxicity data for birds are generally used as a surrogate for reptiles and terrestrial-phase amphibians and toxicity data from fish are used as a surrogate for aquatic-phase amphibians.

Although trans-DCVA, 3-PBalcohol and 3-PBA are major degradation products of permethrin that occur as a result of the ester bond breakage, data on the toxicity of these degradates were not available for this review. However, evaluation of the chemical moiety of the degradates suggest little or no similarity to the active parent compound, and the cleavage of the ester linkages during degradation of the parent structure is expected to result in a significantly decreased toxicity of those degradates relative to the parent. These conclusions are in agreement with EPA's Health Effects Division's (HED) approach of considering only the parent as the residue of concern for purposes of tolerance expression and risk assessment (HED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin; Dated April 4th 2006; DP Barcode D324993). Therefore, this assessment is based on the parent, *cis*- and *trans*-permethrin only.

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 permethrin use within the action area has the potential to adversely affect the assessed species and designated critical habitat (if applicable) via direct toxicity or indirectly based on direct effects to its food supply or habitat. When RQs for each particular type of effect are below LOCs, the pesticide is determined to have "no effect" on the listed species being assessed. Where RQs exceed LOCs, a potential to cause adverse effects is identified, leading to a conclusion of "may affect." If a determination is made that use of permethrin use "may affect" the listed species being assessed and/or its designated critical habitat (if applicable) additional information is considered to refine the potential for exposure and effects. 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) for each listed species assessed. For designated critical habitat, distinctions are made for actions that are expected to have 'no effect' on a designated critical habitat from those actions that have a potential to result in 'habitat modification'.

Based on the best available information, the Agency makes a May Affect and Likely to Adversely Affect (LAA) determination for the CRLF, CCR, SFGS, SMHM, and BCB from the use of permethrin. Additionally, the Agency has determined that there is the potential for modification of CRLF designated critical habitat from the use of the chemical. This is based on the potential for direct effects (to both aquatic and terrestrial-phase CRLF), indirect effects due to potential decreases in aquatic and terrestrial prey items, and the potential for modification of designated critical habitat due to the potential loss of aquatic and terrestrial prey items.

However, the Agency has determined that there is not the potential for modification of BCB designated critical habitat from the use of the chemical. Although there were no data to reliably quantitatively evaluate the effects and the potential risks of permethrin to terrestrial plants, aquatic non-vascular plants are not particularly sensitive to permethrin, permethrin has a neural toxic mode of action, and no studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. In addition, since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants, and none have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants.

A summary of the risk conclusions and effects determinations for each listed species assessed here and their designated critical habitat (if applicable) is presented in **Tables 1.1** and **1.2**. 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, CCR, SFGS, SMHM, and BCB and potential modification of designated critical habitat for the CRLF, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment 2**, and the baseline status and cumulative effects for the CCR, SFGS, SMHM, and BCB is provided in **Attachment 4**.

Table 1.1. Effects determination summary for effects of permethrin on the CRLF, CCR, SFGS, SMHM, and BCB.

Species	Effects Determination [1]	Basis for Determination
California red-legged frog (*Rana aurora draytonii*) (CRLF)	LAA[1]	**Potential for Direct Effects** ***Aquatic-phase (Eggs, Larvae, and Adults)***: -Acute RQs for freshwater fish (used as a surrogate for aquatic-phase CRLFs) exceed the listed species acute risk LOC for all 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater fish (surrogate for aquatic-phase CRLFs) is as high as ~1 in 1. - Chronic RQs for freshwater fish (used as a surrogate for aquatic-phase CRLFs) exceed the chronic risk LOC for 40 of the 48 modeled scenarios. -24 of 26 aquatic ecological incidents reported to the Agency involve fish; the link to permethrin for 7 of these incidents is highly probable; 11 resulted from registered uses. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with each of the critical life-stages of the aquatic-phase CRLF. ***Terrestrial-phase (Juveniles and Adults)***: -Based on refined model estimates, chronic RQs for birds (used as a surrogate for terrestrial-phase CRLFs) exceed the chronic risk LOC for up to 13 of the 34 modeled spray application scenarios. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with each of the critical life-stages of the terrestrial-phase CRLF. **Potential for Indirect Effects**

Table 1.1. Effects determination summary for effects of permethrin on the CRLF, CCR, SFGS, SMHM, and BCB.		
Species	**Effects Determination [1]**	**Basis for Determination**
		Aquatic prey items, aquatic habitat, cover and/or primary productivity *Freshwater invertebrates*: -Acute and chronic RQs for freshwater invertebrates exceed the non-listed species acute and chronic risk LOCs for all 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater invertebrates is as high as ~1 in 1. -Two of three incidents reported to the Agency involving aquatic invertebrates were a result of registered uses that were linked to the observed effects as highly probable. *Freshwater fish and aquatic-phase amphibians*: -Acute RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the non-listed species acute risk LOC for 39 of the 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for fish and aquatic-phase amphibians is as high as ~1 in 1. - Chronic RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the chronic risk LOC for 40 of the 48 modeled scenarios.
		Terrestrial prey items, riparian habitat *Terrestrial-phase amphibians*: -Based on refined model estimates, chronic RQs for birds (used as surrogate for terrestrial-phase amphibians) exceed the chronic risk LOC for 13 of the 34 modeled spray application scenarios. *Terrestrial invertebrates*: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects. -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. *Small mammals*: -Acute RQs for small mammal prey items exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e.*, mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammal prey items exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses.
California clapper rail (*Rallus longirostris obsoletus*) (CCR)	LAA[1]	**Potential for Direct Effects**
		- Risk of direct acute lethality to the CCR under the Residential Turf and Ornamentals exposure scenario cannot be precluded given the potential for very high exposure levels and non-definitive toxicity estimates. -Chronic RQs for birds exceed the chronic risk LOC for up to 24 of the 34 modeled spray application scenarios, as well as for all seed treatment uses. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with the CCR breeding season. -Two peaks in nesting activity in late April to early May and late June to early July coincide temporally with peak usage of permethrin (May through September).
		Potential for Indirect Effects

Table 1.1. Effects determination summary for effects of permethrin on the CRLF, CCR, SFGS, SMHM, and BCB.		
Species	**Effects Determination [1]**	**Basis for Determination**
		Prey items, habitat, cover and/or primary productivity *Freshwater invertebrates*: -Acute and chronic RQs for freshwater invertebrates exceed the non-listed species acute and chronic risk LOCs for all 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater invertebrates is as high as ~1 in 1. -Two of three incidents reported to the Agency involving aquatic invertebrates were a result of registered uses that were linked to the observed effects as highly probable. *Freshwater Fish*: -Acute RQs for freshwater fish exceed the non-listed species acute risk LOC for 39 of the 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater fish is as high as ~1 in 1. - Chronic RQs for freshwater fish exceed the chronic risk LOC for 40 of the 48 modeled scenarios. *Estuarine/marine invertebrates*: -Acute and chronic RQs for estuarine/marine invertebrates exceed the non-listed species acute and chronic risk LOCs for all 45 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for estuarine/marine invertebrates is as high as ~1 in 1. *Estuarine/marine Fish*: -Acute RQs for estuarine/marine fish exceed the non-listed species acute risk LOC for 10 of the 45 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for estuarine/marine fish is as high as ~1 in 1.04. - Chronic RQs for estuarine/marine fish exceed the chronic risk LOC for 18 of the 45 modeled scenarios. *Terrestrial invertebrates*: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects. -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. *Small mammals*: -Acute RQs for small mammal prey items exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e.*, mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammal prey items exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses. *Birds*: -Chronic RQs for birds exceed the chronic risk LOC for up to 24 of the 34 modeled spray application scenarios, as well as for all seed treatment uses.
San Francisco garter snake *Thamnophis sirtalis*	LAA[1]	**Potential for Direct Effects** -Based on refined model estimates, chronic RQs for birds (used as a surrogate for reptiles) exceed the chronic risk LOC for up to 13 of the 34 modeled spray application scenarios.

Table 1.1. Effects determination summary for effects of permethrin on the CRLF, CCR, SFGS, SMHM, and BCB.		
Species	**Effects Determination [1]**	**Basis for Determination**
tetrataenia) (SFGS)		- Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with the SFGS breeding season in the spring and fall.
		Potential for Indirect Effects
		Prey items, habitat, cover and/or primary productivity <u>Freshwater invertebrates</u>: -Acute and chronic RQs for freshwater invertebrates exceed the non-listed species acute and chronic risk LOCs for all 48 modeled scenarios. -The chance of individual effects (*i.e*., mortality) for freshwater invertebrates is as high as ~1 in 1. -Two of three incidents reported to the Agency involving aquatic invertebrates were a result of registered uses that were linked to the observed effects as highly probable. <u>Freshwater fish and aquatic-phase amphibians</u>: -Acute RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the non-listed species acute risk LOC for 39 of the 48 modeled scenarios. -The chance of individual effects (*i.e*., mortality) for fish and aquatic-phase amphibians is as high as ~1 in 1. - Chronic RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the chronic risk LOC for 40 of the 48 modeled scenarios. <u>Terrestrial invertebrates</u>: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects. -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e*., mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. <u>Terrestrial-phase amphibians and reptiles</u>: -Based on refined model estimates, chronic RQs for birds (used as surrogate for terrestrial-phase amphibians) exceed the chronic risk LOC for 13 of the 34 modeled spray application scenarios. <u>Small mammals</u>: -Acute RQs for small mammal prey items exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e*., mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammal prey items exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses.
Salt marsh harvest mouse (*Reithrodontomys raviventris*) (SMHM)	LAA[1]	**Potential for Direct Effects**
		-Acute RQs for small mammals exceed the listed species acute risk LOC for up to 31 of the 34 modeled spray application scenarios, as well as for all granular and seed treatment uses. -The chance of individual effects (*i.e*., mortality) for mammals is as high as ~1 in 1. -Chronic RQs for mammals exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses. - Given the number and diversity of registered uses (agricultural, industrial,

Table 1.1. Effects determination summary for effects of permethrin on the CRLF, CCR, SFGS, SMHM, and BCB.		
Species	**Effects Determination [1]**	**Basis for Determination**
		commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with the SMHM breeding season. - In addition, there is strong potential for periods of breeding activity to overlap temporally with peak usage of permethrin (May through September).
		Potential for Indirect Effects
		Prey items, habitat, cover and/or primary productivity <u>*Terrestrial invertebrates*</u>: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects. -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. <u>*Small mammals*</u>: -Acute RQs for small mammals that may help provide suitable habitat exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e.*, mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammals that may help provide suitable habitat exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses. <u>*Birds (nests)*</u>: -Chronic RQs for birds exceed the chronic risk LOC for up to 24 of the 34 modeled spray application scenarios, as well as for all seed treatment uses.
Bay checkerspot butterfly (*Euphydryas editha bayensis*) (BCB)	LAA[1]	**Potential for Direct Effects**
		- Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects. -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects on hundreds to thousands of butterflies as highly probable. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with all of the critical life-stages of the BCB, and disrupt its life-cycle at various points. -In addition, there may be a short overlap of peak usage with the occurrence of pre-diapause larvae in May, prior to larvae going into dormancy during the rest of months of peak usage of permethrin (May through September). -In order for there to be no exceedances of the Agency's LOCs for insects for any use, all uses would have to be limited to a single application at a rate of 0.000069 lb a.i./A or lower.

[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 the critical habitat impact analysis.		
Designated Critical Habitat for:	**Effects Determination [1]**	**Basis for Determination**
CRLF	HM[1]	-There is a potential for direct effects to the aquatic-phase CRLF and indirect effects via reduction of aquatic-phase prey items (aquatic invertebrates, fish, and aquatic-phase amphibians) as described in **Table 1.1** above. - There is a potential for direct effects to the terrestrial-phase CRLF and indirect effects via reduction of terrestrial-phase prey items (mammals, amphibians, and terrestrial invertebrates) as described in **Table 1.1** above.
BCB	NE[1]	-Although effects to terrestrial plants cannot be quantified due to the lack of data, aquatic non-vascular plants are not particularly sensitive to permethrin. -Permethrin has a neural toxic mode of action. -No studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. -Since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants, and none have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants.
[1] Habitat Modification 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 for the CRLF, CCR, SFGS, SMHM, and BCB, 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. However, given the broad scope of labeled uses, and since there are no areas within the state of California where permethrin use is restricted, and it is not unlikely that multiple uses for (and applications of) permethrin will occur simultaneously within the same areas, there are no areas where potential effects from permethrin use can be categorically discounted. Therefore, potentially mitigating effects such as 'downstream dilution' or 'drift attenuation' (to areas where permethrin is not used) were not considered in this assessment, as no region lies outside the bounds of potential permethrin use.

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, CCR, SFGS, SMHM, and BCB life stages within the action area and/or applicable designated critical habitat. 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 assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, 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 species 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 U.S. EPA's *Guidance for Ecological Risk Assessment* (U.S. EPA 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS 1998) and is consistent with procedures and methodology outlined in the Overview Document (U.S. EPA 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS 2004).

2.1 Purpose

The purpose of this listed species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog *(Rana aurora draytonii*) (CRLF), California clapper rail (*Rallus longirostris obsoletus*) (CCR), Salt marsh harvest mouse (*Reithrodontomys raviventris*) (SMHM), San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) (SFGS), and Bay checkerspot butterfly (*Euphydryas editha bayensis*) (BCB) arising from FIFRA regulatory actions regarding use of permethrin on a variety of crops such as alfalfa, nut trees, cole crops, corn, leafy vegetables, cucurbit vegetables and fruit trees, as well as uses on forestry and nurseries, and non-crop uses such as turf, residential and mosquito control. In addition, this assessment evaluates whether use on these use sites is expected to result in modification of designated critical habitat for the CRLF and the BCB. This ecological risk assessment has been prepared consistent with the settlement agreement in *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. This assessment also addresses four species for which permethrin was alleged to be of concern in a separate suit (*Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS)).

In this assessment, direct and indirect effects to the CRLF, CCR, SMHM, SFGS, and BCB and potential modification to designated critical habitat for the CRLF and BCB are evaluated in accordance with the methods described in the Agency's Overview Document (U.S. EPA 2004). The effects determinations for each listed species assessed is based on a weight-of-evidence method that relies heavily on an evaluation of risks to each taxon relevant to assess both direct and indirect effects to the listed species and the potential for modification of their designated critical habitat (*i.e.*, a taxon-level approach). Screening level methods include use of acute-to-chronic ratios to estimate toxicity when appropriate data are unavailable, and the use of standard models such as PRZM-EXAMS, T-REX, AgDRIFT, and AGDISP, all of which are described at length in the Overview Document. Additional refinements include an analysis of the usage data, use of the T-HERPS and E-FAST models, use of an earthworm fugacity model to predict concentrations of permethrin in terrestrial invertebrates as food items for the terrestrial-phase CRLF, CCR, SFGS, SMHM, and other birds and mammals, and use of a laboratory derived bioconcentration factor (BCF) in fish along with estimated water concentrations from PRZM/EXAMS to estimate exposure of terrestrial animals that may consume aquatic organisms that have bioconcentrated permethrin in aquatic habitats. Use of such information is consistent with the methodology described in the Overview Document (U.S. EPA 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 U.S. EPA 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 permethrin 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 permethrin 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, CCR, SFGS, SMHM and BCB and their designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached separately for each of the assessed species in the lawsuits regarding the potential use of permethrin in accordance with current labels:

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

The CRLF and BCB have designated critical habitats associated with them. 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 the CRLF are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat. The PCEs for the BCB are the presence of annual or perennial grasslands with little to no overstory and N-S or E-W slopes with a tilt of >7 degrees, areas of serpentinite ultramafic rock or similar soils that support the primary larval host plant (*i.e.*, dwarf plantain) and at least one of the species' secondary host plants, the presence of adult nectar sources, aquatic features that provide moisture during the spring drought, and the presence stable holes and cracks in the soil, and surface rock outcrops that provide shelter during the summer diapause.

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

If a determination is made that use of permethrin "may affect" a listed species or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to each species and other taxonomic groups upon which these species depend (*e.g.*, prey items). Additional information, including spatial analysis (to determine the geographical proximity of the assessed species' habitat and permethrin use sites) and further evaluation of the potential impact of permethrin on the PCEs is also used to determine whether modification of designated critical habitat may occur. Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the assessed listed species and/or result in "no effect" or potential modification to the PCEs of its designated critical habitat. This information is presented in the "Risk Description" section (**Section 5.2**) 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 permethrin is expected to directly impact living organisms within the action area (defined in **Section 2.7**), critical habitat analysis for permethrin 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 permethrin that may alter the PCEs of the assessed species' critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the assessed species' designated critical habitat have been identified by the Services and are discussed further in **Section 2.6**.

2.2 Scope

Permethrin, a racemic mixture of the cis and trans isomers (currently registered technical active product has a content of cis isomer ranging from 35%-55%), is a synthetic pyrethroid currently registered for numerous diverse uses in California that span a large variety of use sites and geographical regions. Potential uses include agricultural (in/on food/feed crops); nursery uses; forestry uses; turf uses; indoor/outdoor industrial, commercial, and residential uses; fire ant control; control of ectoparasites on domestic animals; and adulticide uses (*i.e.* for mosquito abatement). It is a broad spectrum insecticide that targets adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects that include but are not limited to mites, ants, mosquitoes, caterpillars, loopers, weevils, moths, ticks, beetles, cockroaches, grubs, aphids, leafhoppers, scabs, armyworms, borers, lady beetles, garden beetles, lace bugs, leaf rollers, girdlers, whiteflies, bagworms, hornets, boring insects, bat bugs, bed bugs, leafminers, bees, billbugs, lice, biting flies, midges, carpenter ants, blackflies, spiders, blow flies, bollworms, booklouse, bot flies, boxelder bugs, budworms, cabbageworms, cadelle, cankerworms, centipedes, chewing insects, chiggers, chinch bugs, cicadas, thrips, cutworms, cloverworms, clover mites, cluster flies, collembola, coneworms, corn cockles, earworms, rootworms, fleahoppers, leafworms, crickets, termites, deer flies, wasps, fleas, drain flies, dung beetles, earwigs, ectoparasites, chafers, crane flies, gnats, face flies, webworms, skippers, fireworms, fleeceworms, fruit flies, grasshoppers, heel flies, meal worms, millipedes, mirids, daubers, nematodes, no-see-ums, blight, phyllophaga, pickelworms, pillbugs, engravers, scales, tuberworms, punkies, rindworms, slugs, scorpions, screwworms, seed bugs, silverfish, skipper flies, stink bugs, sow bugs, thistle butterflies, fruitworms, hornworms, pinworms, wasps, maggots, woollybears, yellow jackets, etc.

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 permethrin in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment. Currently, numerous permethrin products are registered by the EPA (2,700 products covered by over 900 labels).

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

Although trans-DCVA, 3-PBalcohol and 3-PBA are major degradation products of permethrin that occur as a result of the ester bond breakage, data on the toxicity of these degradates were not available for this review. However, evaluation of the chemical moiety of the degradates suggest little or no similarity to the active parent compound, and the cleavage of the ester linkages during degradation of the parent structure is expected to result in a significantly decreased toxicity of those degradates relative to the parent. These conclusions are in agreement with HED's approach of considering only the parent as the residue of concern for purposes of tolerance expression and risk assessment (HED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin; Dated April 4th 2006; DP Barcode D324993). Therefore, this assessment is based on the parent, *cis*- and *trans*-permethrin 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 (U.S., EPA 2004; USFWS/NMFS 2004).

No product data have been submitted to the Environmental Fate and Effects Division to evaluate the potential for differences in toxicity between technical grade permethrin and permethrin formulated with multiple active ingredients. In addition, due to the numerous products containing multiple active ingredients, the extensive body of open literature on these products, and the limited amount of time for review, multiple active ingredient product mixture data from the ECOTOX open literature database were not extracted and reviewed in time for this assessment. Instead, the Agency is relying on the available mammalian toxicity data for mixtures of permethrin submitted to the Agency and reviewed by the Health Effects Division (HED) to inform this assessment. The HED analysis of the acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in **APPENDIX A**. For additional information on the data available in the open literature for multiple active ingredient products containing permethrin and the potential for enhanced/altered toxicity, please refer to **APPENDIX B.**

It is recognized that other pesticides may combine with permethrin to produce synergistic (*e.g.*, piperonyl butoxide), additive, and/or antagonistic toxic effects. If chemicals that show synergistic effects with permethrin are present in the environment in combination with permethrin, the toxicity of permethrin may be increased, offset by other environmental factors, or even reduced by the presence of antagonistic contaminants if they are also present in the mixture. The actual observed toxic effect of permethrin in combination with other pesticides used in the environment, can be a function of many factors including but not necessarily limited to: (1) the exposed species, (2) the co-contaminants in the mixture, (3) the ratio of permethrin and co-contaminant concentrations, (4) differences in the pattern and duration of exposure among contaminants, and (5) the differential effects of other physical/chemical characteristics of the receiving waters (*e.g.* organic matter present in sediment and suspended water). Therefore, quantitatively predicting the combined effects of all these variables on mixture toxicity to any given taxa with confidence is beyond the capabilities of the available data.

To the extent to which synergistic toxic effects resulting from mixtures of active ingredients are not considered in this assessment, the potential direct and indirect effects of permethrin on listed species may be underestimated. However, it is generally understood that permethrin is most often formulated with multiple active ingredients and synergists (*e.g.*, piperonyl butoxide) in order to enhance the insecticidal activity and efficacy of permethrin, not decrease it, and this enhanced toxicity may have carry over effects to non-target organisms. Therefore, given the outcome of previous risk assessments based on the technical grade active ingredient permethrin (discussed in the following section) and the already very highly toxic nature of permethrin alone to non-target aquatic organisms and terrestrial invertebrates, it is expected that further review of the available data is not likely to result in radical alterations of this risk assessment's conclusions.

2.3 Previous Assessments

A number of ecological risk assessments have been written for permethrin since it was first registered in the United States in 1979, with the most comprehensive review coming in the form of the Reregistration Eligibility Decision Document (RED) for permethrin (EPA 738-R-06-017; Dated April 2006; available via the internet at http://www.epa.gov/oppsrrd1/REDs/permethrin_red.pdf). The national-level scope of the EFED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin (Dated April 5th 2006; DP Barcode D326784) and the subsequent Addendum to the Revised EFED RED Chapter for Permethrin (Dated April 5th 2006; DP Barcode D328142) found that permethrin exposure in aquatic media (water column and sediment/ pore water), can potentially occur at levels that exceed the Agency's levels of concern (LOCs). Risks were identified for aquatic organisms (fish and water-column and sediment-dwelling invertebrates) and were significant with LOCs exceeded for acute risk, restricted use, listed species, and chronic risk. For terrestrial organisms, the potential for chronic risk to mammalian species was also identified, with dose-based chronic RQs exceeding the LOC for all but one of the scenarios tested. Although risk was not quantified for terrestrial invertebrates, risk could not be precluded and it was noted that a number of studies demonstrated that applications of formulations of permethrin are likely to reduce the numbers and possibly eliminate populations of beneficial insects. Acute risk to mammalian species and acute and chronic risk to avian species appeared to be low, and no exceedances of the Agency's LOCs were identified. Finally, it was also concluded that although toxicity data are not available for terrestrial plants and the potential for risk remains an uncertainty, risk to plants is likely low due to permethrin's neural toxic mode of action.

In addition to the assessment associating risks with mosquito abatement uses and agricultural uses, the document also raised the concern that the greatest volume of permethrin is used on non-agricultural sites. There was concern with the potential for permethrin runoff from residential areas and the applications such as perimeter treatments in and around buildings and lawn care use that could potentially result in residues being transported to adjacent aquatic areas (possibly because of irrigation). It was indicated that residues of permethrin and other synthetic pyrethroids toxic to aquatic organisms have been found in aquatic areas that receive runoff from suburban developments (*e.g.* California).

It should also be noted that some toxicity endpoints in this document are lower than those used in the permethrin RED. Although the RED was published in 2006, little open literature toxicity data (ECOTOX) were incorporated into the risk assessment. Review of the open literature data has resulted in a number of lower endpoints for mammals and freshwater aquatic invertebrates. In addition, a re-evaluation of the registrant-submitted avian toxicity data has revealed a more sensitive chronic endpoint than was employed in the RED. Lastly, some of the acute and chronic aquatic endpoints previously relied upon had a significant degree of uncertainty associated with them (*e.g.*, chronic NOAECs were less sensitive than acute endpoints). Therefore, in some instances, new toxicity values were estimated in this assessment using acute-to-chronic ratio methods. A detailed discussion of available toxicity endpoints and discussion regarding the calculation and selection of toxicity endpoints for quantitative use can be found in the "Effects Assessment" section of this document (**Section 4**).

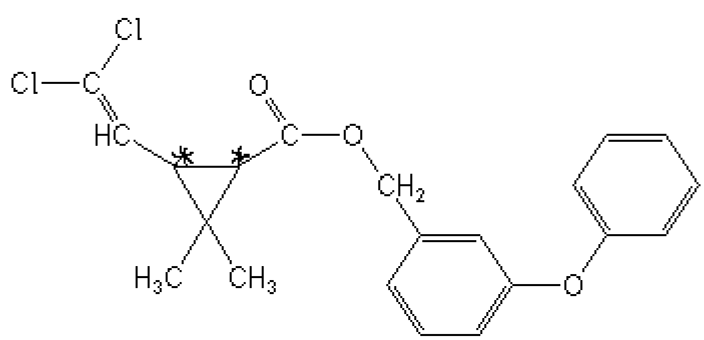
Regardless of the differences in employed toxicity endpoints, risk conclusions in the RED are generally similar to those of this assessment in that listed species LOCs are exceeded; however, the risk quotients (RQs) presented in this document may be higher (*e.g.,* due to more sensitive endpoint selection) or lower than corresponding RQs in the RED (*e.g.,* due to the incorporation of mitigation measures; discussed further in **Section 2.4.4**).

2.4 Stressor Source and Distribution

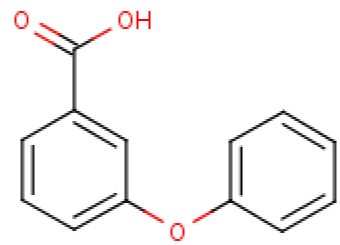
This assessment considered parent permethrin as the stressor. Permethrin is a type I synthetic pyrethroid. It is an ester of the dichloro analogue of chrysanthemic acid, and 3-phenoxybenzyl alcohol. Permethrin has four stereoisomers with the configurations [1R, *trans*], [1R, *cis*], [1S, *trans*] and [1S, *cis*], arising from the two stereocenters in the cyclopropane ring. The [1R, *cis*] isomer is the most insecticidally active, followed by the [1R, *trans*] isomer. The optical ratio of 1R:1S is usually 1:1 (racemic). According to the agricultural label, the maximum amount of cis isomers is 55% in the product (based upon the sample label of Pounce WSB Insecticide, EPA Reg. No. 279-3083). **Figure 2.1** provides the structures of permethrin related compounds (stereoisomers) and major transformation products.

Figure 2.1. Chemical structures of permethrin and related compounds.

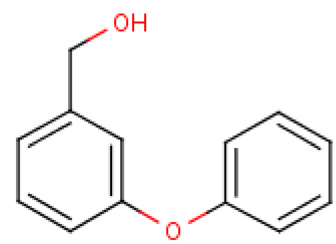
<u>**Permethrin**</u> – CAS # 52645-53-1 – Parent chemical (unspecified stereochemistry, quiral centers marked)



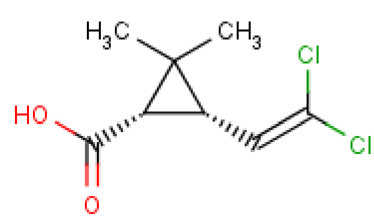
<u>***m*-PBA (*m*-Phenoxybenzoic acid)**</u> – CAS # 3739-38-6 (Breakdown product)



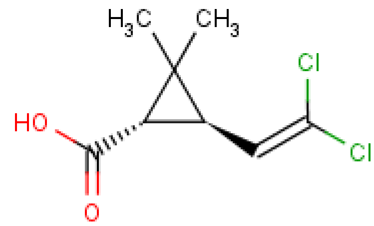
***m*-PB-alc (*m*-Phenoxybenzyl alcohol)** – CAS # 13826-35-2 (Breakdown product)



***cis*-Permethric acid** (*cis*-DCVA)– CAS # 59042-49-8 (Breakdown product)



***trans*-Permethric acid** (*trans*-DCVA)– CAS # 59042-50-1 (Breakdown product)



2.4.1 Environmental Fate Properties

Permethrin is a relatively persistent synthetic pyrethroid in the environment as it is slow to hydrolyze and biodegrade. Pyrethroids such as permethrin, that have the isobutenyl group attached to the cyclopropane moiety, are more stable to sunlight than the early pyrethroids like allethrin or resmethrin. Permethrin has relatively low water solubility (0.0055 mg/L, Laskowski, 2002), and its hydrophobic nature leads to strong soil adsorption and a tendency to partition to sediment in aquatic systems ($K_{FOC} \geq 28{,}200$, MRID 41868001). The reported value of Octanol/ water partition coefficient of 6.1 suggests that permethrin may bio-concentrate in aquatic organisms. **Table 2.1** lists various important physiochemical characteristics of the chemical.

Table 2.1. Summary of physiochemical properties of permethrin.

Property	***Value*** [1]	***Reference***
Empirical Formula	$C_{21}H_{20}Cl_2O_3$	Permethrin data sheet [2]
Molecular Formula	391.30 g/mol	Extoxnet data base [3]
CAS Name (mixed isomers)	(3-phenoxyphenyl) methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclo propanecarboxylate	
IUPAC Name	3-phenoxybenzyl (1*RS*,3*RS*;1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclo propanecarboxylate **Or** 3-phenoxybenzyl (1*RS*)-*cis-trans*-3-(2,2-dichlorovinyl)-2,2- dimethylcyclo propanecarboxylate	
CAS Number	52645-53-1	Permethrin data sheet [4]
Vapor Pressure (mmHg at 20°C)	**1.48x10^{-8}** (Average of two values)	MRID No. 421098-01
	2.18x10^{-8}	USDA, Agric. Res. Service [5]
	1.9x10^{-8} (*cis*), and 1.1x10^{-8} (*trans*)	Wells *et al*., 1986
Henry's Law Constant (atm m^3 mol^{-1})	**1.4x10^{-6}** (Calculated using solubility of 0.0055 mg/L and VP of 1.5x10^{-8} mmHg	Calculated
	1.6x10^{-7} (Calculated using solubility of 0.0055 mg/L and VP of2.15x10^{-8} mmHg	Calculated
Water Solubility (mg/L)	0.175 (Average of 0.22, and 0.13)	MRID No. 421098-01

Table 2.1. Summary of physiochemical properties of permethrin.		
Property	***Value*** [1]	***Reference***
	0.0055	Wollerton, 1987 [6]
Solubility in Organic Solvents	Soluble in most organic solvents except ethylene glycol	Farm Chemicals Handbook, 2000 [2] Screened
log K_{ow}	6.1	Wollerton, 1987 [6]

[1] If more than one value is given, the best value is **bolded**.
[2] http://www.alanwood.net/ pesticides/permethrin.html (Accessed 05/01/08)
[3] http://extoxnet.orst.edu/pips/permethr.html (Accessed 05/01/08)
[4] http://www.alanwood.net/ pesticides/permethrin.html (Accessed 05/01/08)
[5] Information taken from the Hazardous Substances Data Bank (HSDB).
[6] As cited in Laskowski, 2002.

Table 2.2 provides a summary of the environmental fate properties of permethrin, and its major degradation products,

Table 2.2. Summary of environmental fate properties available for permethrin.			
Study	***Value***	***Degradation Products***	***Reference*** [1]
Persistence			
Hydrolysis (25°C)	**Stable** @ pH 3 & 6 **125-350 days** @ pH 9	**Major:** *m*-PB-alc (15.5%), **Minor**: *cis-/trans*-DCVA (6.5%)	102043
Photolysis Half-Life ($t_{½}$) in Water	**80 days**	**Major:** None	40242801
Photo degradation Half-Life ($t_{½}$) on Soil	**106 days** in a Loam soil (estimated by extrapolation)	**Major:** None, **Minor**: *m*-PBA, and *m*-PBA	40190101
Aerobic Soil Metabolism Half-Life ($t_{½}$)	**37** days in a sandy loam soil	**Major:** CO_2 (34-40% after 6 months), *trans*-DCVA (10% at 14 DAT), and *m*-PB-alc (12-15% at 30 DAT)	42410002
Anaerobic Soil Metabolism Half-Life ($t_{½}$)	**204 days** in a sandy loam soil	**Major:** *trans*-DCVA (13%) and *m*-PBA (12%); maxima observed at 60 days	41970601
Aerobic Aquatic Metabolism Half-Life ($t_{½}$)	**38 days** (Acid label) **43 days** (Alcohol label)	**Major:** *trans*-DCVA (20% at 21 DAT) **Minor**: *cis*-DCVA and *m*-PBA (≤5.7%)	43938201
Anaerobic Aquatic Metabolism Half-Life ($t_{½}$)	**175 days** (Acid label) **113 days** (Alcohol label)	**Major:** *cis-* and *trans*-DCVA, *m*-PBA, CO_2 (33.8-43.6% by 367 DAT)	43982001
Mobility			
Adsorption/Desorption Coefficients (K_F and K_{FOC}; L/Kg)	**K_F** (parent): **446, 355, 344, 378 and 401** and **K_{FOC}**: **194,000, 34,100, 28,200, 31,500, and 96,000** In Sand, Sandy Loam, Silty Loam, and Clay Soils, and Sandy Loam sediment, respectively.		41868001
	K_F (*m*-PBA degradate): **0.98 to 3.11** and **K_{FOC}**: **118 to 215** **K_F** (*trans*-DCVA degradate): **0.16 to 0.54** and **K_{FOC}**: **18 to 48** In Sand, Silt clay, Clay, Sandy loam, and another Sandy loam soils		43424901
Terrestrial Field Dissipation			
Terrestrial Field Dissipation ($t_{½}$)	**17 days**, NC soil, and **43 days** IL soil	**Observed:** *trans*-DCVA and *m*-PBA at both NC and IL sites	42359109
Aquatic Field Dissipation			
Aquatic Field Dissipation: CA site (*cis-/trans*-permethrin dissipation $t_{½}$)	**<2 days** from the pond water), and **18-118 days** from the sediment top 2”	**Observed:** *cis-/ trans*-DCVA and *m*-PBA dissipated from the water with $t_{½}$ of 28, 22 and 7.5 days, respectively.	44030501

Table 2.2. Summary of environmental fate properties available for permethrin.			
Study	***Value***	***Degradation Products***	***Reference*** [1]
Aquatic Field Dissipation: NC site (*cis*-/*trans*-permethrin dissipation $t_{½}$)	**<4 days** from the pond water), and **62-256 days** from the sediment top 2"	*cis*-/ *trans*-DCVA and *m*-PBA dissipated from the water with half-lives of 33, 23 and 14 days, respectively	44157101
Bioconcentration			
Accumulation in Fish (BCF)	**180-230X** (edible); **510-610X** (whole fish); and **950-1,100X** (non-edible) **Depuration**: **4.7 days** for **50%** depuration	Only *trans*-DCVA was identified, at 4-10% of the total radioactivity	41300401, 41300402, 41300403
1. Referenced by MRID Number			

As shown in **Table 2.2**, permethrin is stable to hydrolysis at pH's 3.0-7.6 but it degrades at relatively slow rate (t½= 125-350 days) in alkaline solutions (pH 9) at 25°C in the dark. The hydrolysis products were *m*-PB-alcohol and *cis-/trans*-DCVA. In contrast, permethrin did not appear to degrade substantially for a period of 30 days (extrapolated half-life 106 days) on a loam soil following irradiation with a xenon arc lamp at 25°C. The reported half-life of ^{14}C-permethrin in soil under aerobic soil conditions was 37 days, with $^{14}CO_2$, *trans*-DCVA and *m*-PBA being the major degradation products. It was noted that the *trans*-isomer of permethrin degraded at a faster rate when compared to the *cis*-isomer. It was also noted that the degradation of permethrin was slightly biphasic, with faster degradation from 0-90 days. A supplemental biodegradation study showed that microbial activity appeared to be inhibited (possibly by toxicity) when permethrin was applied to aerobic soil at fortification level similar to the maximum application rate for terrestrial non-food uses. In an aerobic aquatic metabolism study, the reported half-life ranged from 38 to 43 days (the study lasted only 30 days). In this study, the trans-permethrin yielded shorter half-lives than the cis-permethrin, but the data were normalized. The half-life in the anaerobic soil metabolism study was 204 days (in a study that lasted 90 days, 30 aerobic and 60 anaerobic) and major degradates were *trans*-DCVA and *m*-PBA. The half-lives reported for permethrin in an anaerobic aquatic study ranged from 113 days to 175 days, which indicates that the degradation in soil and water/sediment systems is slower as the oxygen levels are reduced. Inspection of the available metabolism studies shows that high levels of non-extracted residues were observed in some studies (*e.g.* non-extracted residues reached ~15-35% in the aerobic soil metabolism study at or after 30 days posttreatment, however, adequate attempts were made to extract the residues in such instance).

Permethrin was hardly mobile to immobile (according to the FAO mobility classification) in several soils tested, both sterile and viable (K_{FOC}>10,000). K_{FOC} values in the range of 28,000 to 194,000 were measured in four soils and one sediment sample. In contrast, the main degradates of permethrin, *m*-PBA and *trans*-DCVA were shown to have a much higher potential for mobility in the soils tested (K_{FOC}'s for *m*-PBA=118 to 215 (moderately mobile) and for *trans*-DCVA= 18 to 48 (mobile). As indicated earlier, based upon its low Henry's Law constant and vapor pressure, permethrin is expected to have a relatively low potential for volatilization from soil and water surfaces.

Acceptable terrestrial field dissipation studies showed that permethrin degraded in the field with half-lives ranging from 17 days in a North Carolina field to 43 days for a field located in Illinois. These studies were conducted at the terrestrial food use rate of 0.4 lb a.i./A. Neither parent nor its two principal soil degradates (*trans*-DCVA and *m*-PBA) were detected (detection limits 2.5 µg/kg below a depth of 6-inches at either site, suggesting that leaching was minimal). More rapid dissipation rates of permethrin were reported in a study measuring permethrin concentrations in environmental components of a boreal plantation forest in Ontario, Canada treated with an aerial spray of permethrin. Permethrin concentrations in soil and forest floor litter ranged from 25 to 7 µg/kg and 33 to 18 µg/kg, respectively, during the 4 days after application (Sundaram, *et al.*, 1992). These concentrations represent measurements taken 1 hour to 4 days after the application of 0.06 lb of permethrin per acre (detection limits 2 µg/kg) Permethrin appeared to persist in forest litter longer than in soil. Ten days after application, permethrin was not detected in soil while 8 µg/kg of permethrin were detected in forest litter.

An acceptable aquatic field dissipation study employing a site in North Carolina, and a second site in California showed that permethrin dissipated (moved) rapidly from the water column by binding to suspended solids and sediment. At both sites *cis*-/*trans*-permethrin appeared to be immobile and remained in the upper portions (0-2-inch fraction) of the sediment. There were no detects of metabolites in sediment. In North Carolina, *cis*- and *trans*-permethrin were removed from the water surface with half-lives of 3.1 and 1.9 days, respectively. In sediment the reported degradation half-lives for *cis*- and *trans*-permethrin were 256 and 62 days, respectively. In California, *cis*- and *trans*-permethrin were removed from the water surface with half-lives of 1.8 and 1.4 days, respectively. In sediment the reported degradation half-lives for *cis*- and *trans*-permethrin were 118 and 18 days, respectively.

The Agency has a study available that shows that there is some potential for bioconcentration in fish should exposure occur for extended periods. Acceptable fish bioconcentration studies showed that permethrin bioconcentrated 950 – 1100X in viscera, 570 – 610X in the whole fish, and 180 – 230X in the fillet. The study was conducted with two radiolabels. With the acid label, the maximum BCF was 610X for whole fish. For the alcohol label, the maximum BCF for whole fish was 570X. After 14 days of depuration, 79% and 73% of the day 28 value had depurated, respectively. In both instances, the residues were mostly parent. For the acid label, 4-10% was detected and identified to be DCVA, while for the alcohol label <1% was 3-PBA. In both instances, an unidentified fraction was speculated to be phospholipid conjugates. The time for 50% depuration was estimated to be 4.6-4.7 days. Depuration was moderate with 73-83% depuration occurring after 14 days, and the time to reach 90% of steady state was estimated at 15-16 days. The parent molecule appears to be resistant to biodegradation since most of the residues in fish were permethrin.

2.4.2 Environmental Transport Mechanisms

A number of studies have documented atmospheric transport and re-deposition of pesticides from the Central Valley to the Sierra Nevada Mountains (Fellers et al., 2004, Sparling *et al*., 2001, LeNoir *et al*., 1999, and McConnell *et al*., 1998). Prevailing winds blow across the Central Valley eastward to the Sierra Nevada Mountains, transporting airborne industrial and agricultural pollutants into the Sierra Nevada ecosystems (Fellers *et al.,* 2004, LeNoir *et al.*, 1999, and McConnell *et al.*, 1998). Several sections of the range and critical habitat for the CLRF are located east of the Central Valley. None of the other species considered in this assessment are found or have critical habitat each of the Central Valley. The magnitude of transport via secondary drift depends on the permethrin's ability to be mobilized into air and its eventual removal through wet and dry deposition of gases/particles and photochemical reactions in the atmosphere. Therefore, physicochemical properties of permethrin that describe its potential to enter the air from water or soil (*e.g.,* Henry's Law constant and vapor pressure), pesticide use data, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevadas are considered in evaluating the potential for atmospheric transport of permethrin to locations where it could impact the CRLF.

Potential transport mechanisms for permethrin include spray drift and movement with surface water runoff dissolved in water or associated with the eroded soil particles. Furthermore, soil bound permethrin may undergo secondary drift with dust storms, that may cause its deposit on nearby or distant ecosystems. Surface waters runoff, runoff events accompanied with erosion and spray drift are expected to be the major routes of exposure for permethrin. Because of its high tendency to sorb to soil (as evidenced by its high K_d/K_{OC} values), permethrin is expected to reach water bodies primarily sorbed to sediment. With its relative persistence, permethrin may accumulate in sediment, where it may be a reservoir for exposure for benthic organisms. Permethrin has a low vapor pressure (1.48×10^{-8} mmHg, MRID 42109801) and Henry's Law constant (1.4×10^{-6} atm-m^3/mol); thus, volatilization from water and soil surfaces is expected to be very low. Permethrin's potential for volatilization is also reduced significantly because it adsorbs strongly to soils and suspended solids or sediment in the water column.

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

2.4.3 Mechanism of Action

Permethrin is a neural toxic insecticide with contact and stomach action, having a slight repellent effect. The primary biological effects of permethrin and other pyrethroids on insects and vertebrates reflect an inhibition of the correct firing of neurotransmitter deliver signals from one cell to another via nerve membrane inhibition of the voltage gated Ca^{2+} channels coupled with a stimulatory effect on the voltage gated Na^+ channels (sodium ion channels).

The pyrethroids (including permethrin) share similar modes of action and are considered axonic poisons that affect both the peripheral and central nervous system. It is now well established that severe neurological symptoms of poisoning with pyrethroids in mammals and insects are the result of modification of Na^+ channel activity (cellular pores through which sodium ions are permitted to enter the axon to cause excitation) (Matsamura, 1985). Advanced electrophysiological experiments using voltage clamp and patch clamp, together with ligand binding and ionic flux experiments, have unveiled unique actions of pyrethroids of keeping the Na^+ channel in the open state for an extremely long period, sometimes as long as several seconds. This modification of Na^+ channel properties leads to hyperactivity of the nervous system. Pyrethroids have also been shown to suppress GABA and glutamate receptor-channel complexes and voltage-activated Ca^{2+} channels, but the toxicological significance of these actions is uncertain.

Relative to physiological responses, researchers have designated two types of pyrethroids, Type I (*e.g.* pyrethrins, S-bioallethrin, resmethrin and permethrin) and Type II (*e.g.* cypermethrin, deltamethrin, fenvalerate). Type I pyrethroids action is mainly associated with compounds that cause nerve excitation symptoms typified by the appearance of repetitive firing of axons in the peripheral nervous system and a negatively correlated temperature reversible knockdown property (Clark and Matsamura, 1987). The toxicity of permethrin is dependent on the ratio of the isomers present; the cis-isomer being more toxic.

2.4.4 Use Characterization

2.4.4.1 Permethrin Labeled Use Patterns

Analysis of labeled use information for permethrin is the critical first step in evaluating the federal action. The current label for permethrin represents the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs.

Permethrin is labeled for use in numerous agricultural and non-agricultural sites. Currently, there are 2,700 products covered by over 900 labels. Therefore, the Agency's Biological and Economic Analysis Division (BEAD) relied on the process of reviewing only "data doer" labels to collect label use data. This method relies on extracting data from the technical registrants and major end use producers of permethrin to get representative label data from a subset (about 100 labels) of all possible labels; use data is not based on an exhaustive review of the entire population of labels.

Furthermore, this assessment considered all of the mitigation measures included in the recently issued labels. It is noted that these mitigation measures are described in detail in the permethrin RED (USEPA, 2006c & d). In summary, the mitigation measures included substantial reduction in application rates and number of applications for almost all major uses in addition to label language on buffers and spray drift requirements. A summary of important mitigation measures that affect exposure are included in **APPENDIX C**.

Table 2.3 presents agricultural crop uses and corresponding application rates and methods of label application considered in this assessment.

Table 2.3. Labeled permethrin crop use patterns (liquid sprays after applying the RED mitigation). ♠

Crop	*Crop*	*Labeled Application Parameter (rates in lb a.i./A)*

		Method [1& 2] and Timing	Single	Number	Total [3]	Minimum Intervals (Day)
			Rate (Maximum/Season)			
Alfalfa	Hay crop	1-5 Foliar	**0.20**	**5**	**1.00**	**30**
	Seed crop					
Nuts	Almond	1-6 Dormant, Foliar and Hull split	**0.25**	**3**	**0.75**	**10**
	Filbert (Hazelnut)	1-5 Foliar	**0.25**	**3**	**0.75**	**10**
	Pistachio		**0.30**	**3**	**0.90**	**10**
	Walnut		**0.25**	**3**	**0.75**	**10**
Avocado	Avocado	1-5 Foliar	**0.20**	**4**	**0.80**	**7**
Major Cole Crops [3]	Broccoli	1-5 Foliar	**0.20**	**4**	**0.80**	**5**
	Cabbage	1-5 Foliar	**0.20**	**2**	**0.40**	**5**
	Cauliflower	1-5 Foliar	**0.10**	**4**	**0.40**	**5**
Minor Cole Crops	Collards	1 and 3-5 Foliar	**0.15**	**3**	**0.45**	**3**
	Horseradish		**0.15**	**3**	**0.45**	**10**
	Kohlrabi	1-5 Foliar	**0.10**	**8**	**0.80**	**5**
	Turnip (Greens)	1 and 3-5 Foliar	**0.15**	**3**	**0.45**	**3**
Corn	Field	1-5 and 7 Pre-plant, At planting, Pre-emergence and Foliar	**0.15**	**3**	**0,45**	**7**
	Pop		**0.20**	**6**	**0.6**	**5**
	Sweet		**0.2**	**4**	**0.80**	**3**
Forestry	Cottonwood Hybrid (Poplar)	2 Foliar	**0.20**	**N/S**	**N/S**	**N/S**
	Softwood (Conifer)	1-5 Foliar	**0.20**	**N/S**	**N/S**	**5**
Fruits	Apple	1-6 Foliar	**0.25**	**2**	**0.50**	**10**
	Cherry	Petal fall, and Foliar 1-6	**0.20**	**3**	**0.60**	**10**
	Papaya	1-6 Foliar	**0.15**	**5**	**0.75**	**10**
	Peach	1-6 Dormant, and Foliar	**0.25**	**3**	**0.75**	**10**
	Pear	1-6 Dormant, Delay dormant, Pre-bloom, Foliar, and Post harvest	**0.40**	**1st Spray**	**0.65**	**10**
			0.25	**2nd Spray**		
Garlic	Garlic	1-5 Foliar	**0.20**	**4**	**0.80**	**10**
Major Leafy Vegetables	Brussels Sprouts	1-5 Foliar	**0.10**	**4**	**0.40**	**5**
	Lettuce (Head/Leafy)		**0.20**	**4**	**0.80**	**7**

Table 2.3. Labeled permethrin crop use patterns (liquid sprays after applying the RED mitigation). ♠

Crop Category	*Crop Pattern*	*Labeled Application Parameter (rates in lb a.i./A)*				
		Method [1& 2] and Timing	*Single*	*Number*	*Total [3]*	*Minimum Intervals (Day)*
			Rate (Maximum/Season)			
	Spinach, Orach (Mountain Spinach), and New Zealand		**0.20**	**3**	**0.60**	**3**
Minor Leafy Vegetables	Amaranth (Chinese), Celetuce, Chard (Swiss), Chervil, Chicory, Chrysanthemum (Leafy), Corn Salad, Cress (Garden & Upland), Dandelion, Dock (Sorrel), Cardoon, Parsley, . Purslane (Garden/Winter, Roquette (Arrugula)	1-5 or not specified Foliar	**0.20**	**10**	**2**	**3**
Major Cucurbits [4]	Cantaloupe	1-5 Foliar	**0.20**	**4**	**0.80**	**7**
	Cucumber, Pumpkin, Squash 1, and Watermelon		**0.20**	**6**	**1,2**	**7**
Minor Cucurbits [5]	C. Mixta/C.Pepo and Cucuzzi (Squash), Gherkin, Gourd, Luffa, Melons, Momordica, and Squash 2	1-5 or not specified Foliar	**0.24**	**8**	**N/S**	**N/S**
Eggplant	Eggplant	1-5 Foliar	**0.15**	**4**	**0.60**	**7**
Nursery	Christmas trees	1 and 3-5 Foliar	**0.20**	**N/S**	**N/S**	**N/S**
	Pine (Seed orchard)	Ground Foliar	**1.60**	**6**	**N/S**	**28**
		Aerial Foliar	**0.75**	**6**	**N/S**	**28**
	Nursery Stock	Ground Foliar	**0.20**	**N/S**	**N/S**	**N/S**
Onion	Fennel	1-5 or not specified Foliar	**0.20**	**10**	**2**	**3**
	Onion	1 and 3-5 Foliar	**0.10**	**1st Spray**	**1.00**	**7**
			0.30	**2nd, 3rd & 4th**		
Others	Ant Mound Treatment in Agricultural areas	Mound Spray	**0.84**	**4**		**7**
Potato	Potatoes	1-5 Foliar	**0.20**	**4**	**0.80**	**10**
	Turnip (Root)		**0.10**	**8**	**0.8**	**N/S**
Row Crops	Artichoke	1-5 Foliar	**0.30**	**3**	**0.90**	**10**

Table 2.3. Labeled permethrin crop use patterns (liquid sprays after applying the RED mitigation). ♠						
Crop Category	*Crop Pattern*	*Labeled Application Parameter (rates in lb a.i./A)*				
		Method 1& 2 and Timing	*Single*	*Number*	*Total 3*	*Minimum Intervals (Day)*
			Rate (Maximum/Season)			
	Asparagus		**0.10**	**4**	**0.40**	**7**
	Celery		**0.20**	**5**	**1.00**	**7**
	Pepper		**0.20**	**4**	**0.80**	**5**
	Rhubarb	1-5 or not specified Foliar	**0.20**	**10**	**2**	**5**
	Roses (Field grown)	Ground/Aerial Foliar	**0.20**	**N/S**	**N/S**	**N/S**
Tomatoes	Tomatillo	1-5 Foliar	**0.20**	**6**	**1.2**	**N/S**
	Tomato		**0.20**	**3**	**0.60**	**7**
Turf	Golf Course	Mist/Ground Foliar	**0.82**	**N/S**	**N/S**	**N/S**
	Recreational/Industrial Areas	ULV/Ground Foliar	**0.87**	**N/S**	**N/S**	**N/S**

♠ Rates in red color are the new mitigated rates while those in black are not mitigated as yet.
[1] **Methods of Application:** **(1)** Spray/Ground (Low & High Volume Spray); **(2)** Spray/Aerial; **(3)** Chemigation/Sprinkler**;** **(4)** Soil Incorporation; **(5)** Soil Surface Spray**;** **(6)** Air-blast; and **(7)** Band Spray (Note: rates in lbs/A with no further description).
[2] **N/S=** Not Specified.
[3] **Cole Crops Notes:** Broccoli, including Chinese Broccoli; and Cabbage, including Chinese cabbage.
[4] **Cucurbits Notes:** Squash 1= (winter "Hubbard",
[5] **Cucurbits Notes:** Cucuzzi (Spaghetti squash); Gourd including Wax & Chinese; Melons: Bitter, Citron & Balsam pear, Honeydew, Mango, Musk, and winter "Casaba/Crenshaw/Honeydew/Persian, and summer); and Squash 2= (Butternut, Zucchini)

Home and garden labeled use are included in **Table 2.4**. These are not currently mitigated uses. The labels cover use on home nut trees, corn, turf, and ornamentals in addition to outdoor residential perimeter, barrier, and termite treatments.

Table 2.4. Labeled permethrin use pattern (liquid formulations for home and garden use). ♠						
Crop Category	*Crop Pattern*	*Labeled Application Parameter (rates in lb a.i./A)*				
		Method of Application	*Single*	*Number*	*Total 3*	*Minimum Intervals (Day)*
			Rate (Maximum/Season)			
Nuts	Almond	Ground/ Air blast	**0.40**	**5**	**2.0**	**N/S**
	Hazelnut, Pistachio, and Walnut		**0.40**	**4**	**1.6**	**N/S**
Corn	Sweet corn	Ground	**0.25**	**6**	**N/S**	**3**
Residential	Perimeter treatment [1]	Ground Spray	**1.43**	**N/S**	**N/S**	**N/S**
	Barrier treatment [2]		**1st = 0.08 2nd = 0.10**	**2**	**0.18**	**N/S**
	Residential Turf		**4.18**	**N/S**	**N/S**	**N/S**
	Ornamentals [3]		**4.23**	**N/S**	**N/S**	**N/S**
	Termite Treatment [4]	Injection and Ground Spray	**0.77**	**N/S**	**N/S**	**N/S**

Table 2.4. Labeled permethrin use pattern (liquid formulations for home and garden use). ♠

Crop Category	Crop Pattern	Labeled Application Parameter (rates in lb a.i./A)				
		Method of Application	Single	Number	Total [3]	Minimum Intervals (Day)
			Rate (Maximum/Season)			

♠ New mitigation rates were not applied to home and garden products.

[1] Includes Patios; Commercial, Institutional, Industrial Premises and outdoor Equipment; Household and Domestic Dwellings; Food Processing Plants (nonfood contact & nonfood handling areas); Food Stores, Markets, Supermarkets Premises; Farm Premises; Eating Establishments (nonfood contact) Calculated from label information: 0.8 lb a.i/1,000 sq. ft of premises X 43,560/1,000= 34.84 lb a.i./Acre of home perimeter. As per label area treated 5-10 ft (assume 10 ft) X average home perimeter (Assume 180 ft) = 1,800 sq. ft treated= 4.1% of an acre, therefore rate= 34.84 lb a.i X 4.1%= 1.429

[2] Includes Household and Domestic Dwellings (Outdoors); Urban Areas; Non-agriculture Areas; Commercial, Institutional, Industrial Premises and Equipment; Industrial Areas; Fencerows and Hedgerows; Cattle Feedlots; Commercial Storage and Warehouses; Eating Establishments (nonfood contact); Refuse Waste Sites

[3] Include: Shade trees, herbaceous plants, Non-flowering plants, Non-edible/non-bearing fruits, and woody shrubs and vines.

[4] Calculated from label information: 4.25 lb a.i/1,000 sq. ft of treated area X 43,560/1,000= 185 lb a.i./Acre if the whole acre is treated. As per label area treated 1 ft X average home perimeter (Assume 180 ft) = 180 sq. ft treated= 0.41% of an acre, therefore rate=180 lb a.i X 0.41%= 0.7645

Labeled use patterns in **Tables 2.3** and **2.4** cover treatments in which liquid sprays are used. Liquid sprays for these uses are prepared from formulations that include wettable powders (WP), dispersible granules (DG), emulsifiable concentrates (EC), liquids (L), and ready to use products (RTU). Additionally, permethrin formulations include granules and dust. Label information on the granular formulation use in agricultural crops are summarized in **Table 2.5** while those related to dust use in home and garden vegetables are included in **Table 2.6**.

Table 2.5. Labeled permethrin use pattern (granular formulations). ♠

Crop Category	*Crop Pattern*	*Labeled Application Parameter (rates in lb a.i./A)*				
		Method of Application	*Single*	*Number*	*Total* [3]	*Minimum Intervals (Day)*
			Rate (Maximum/Season)			
Nuts	Almond	Ground/Aerial	**0.25**	**3**	**0.75**	**10**
	Pistachio		**0.30**	**3**	**0.90**	**10**
Corn	All types [1]	Ground	**0.2**	**4**	**0.8**	**3**
Turf	Sod & Golf turf	Ground	**0.2**	**4**	**0.8**	**3**
Residential	Corn (band treatment) [2]	Ground	0.27	**6**	**N/S**	**5**
	Residential Turf		0.33 [3]	**N/S**	**N/S**	**N/S**
	Fire Ant mounds		1.00	**N/S**	**N/S**	**N/S**
	Perimeter treatment		0.01 [4]	**N/S**	**N/S**	**N/S**

♠ New mitigation rates were applied only on agricultural crops (nuts and corn in red); however, new rates were not applied for home and garden products (all items under residential in black).

[1] All types: Field, pop, and sweet.

[2] Corn (band treatment): Based on row width of 2.5 ft, 80 rows of 218 ft long in one acre (30,000 plants /Acre): http://msucares.com/pubs/infosheets/is1548.htm

[3] Calculated from label information 15 lb product (0.25% a.i) treats 5,000 ft square; this gives= 0.0375 lb a.i. X 43,560/5,000= 0.3267 lb a.i./A.

[4] Calculated from label information: 2 lb product (0.25% a.i) treats 1,000 ft square of home perimeter; this gives= 0.005 lb a.i/1,000 sq. ft X 43,560/1,000= 0.2178/Acre of home perimeter. As per label area treated 5-10 ft (assume 10 ft) X average home perimeter (Assume 180 ft) = 1,800 sq. ft treated= 4.1% of an acre, therefore rate= 0.2178 lb a.i X 4.1%= 0.0089.

Table 2.6. Labeled permethrin crop use patterns (dust formulations for home and garden use). ♠

Crop Category	*Crop Pattern*	*Labeled Application Parameter* [1 & 2]	
		Number	*Minimum Intervals (Day)*
Nuts	Walnut	**8**	**N/S** [3]
Cole Crops	Broccoli & Cauliflower	**8**	**5**
	Cabbage	**10**	**5**
	Horseradish	**7**	**N/S**
Corn	Field, Pop & Sweet	**6**	**5**
Fruits	Apple	**N/S**	**N/S**
	Peach	**5**	**N/S**
Garlic	Garlic	**6**	**N/S**

Table 2.6. Labeled permethrin crop use patterns (dust formulations for home and garden use). ♠			
		Labeled Application Parameter [1 & 2]	
Crop Category	*Crop Pattern*	*Number*	*Minimum Intervals (Day)*
Leafy Vegetables	Brussels Sprouts	**8**	**5**
	Lettuce (Head/Leafy),	**7**	**N/S**
	Spinach, and Spinach (New Zealand)	**7**	**N/S**
	Others: Amaranth (Chinese), Celetuce, Chervil, Chrysanthemum (Leafy), Corn Salad, Dandelion, Dock (Sorrel), Parsley, Purslane, (Garden/Winter), and Roquette (Arrugula),	**7**[4]	**N/S**
Cucurbits	Cucumber, Most melons, Gherkin, Pumpkin, Squash (All), and Watermelon	**8**	**N/S**
Onion	Fennel	**7**[4]	**N/S**
	Onion	**6**	**N/S**
Potato	Potatoes	**12**	**N/S**
Row Crops	Asparagus	**7**	**N/S**
	Celery	**7**	**N/S**
	Pepper	**8**	**N/S**
	Rhubarb	**7**[4]	**N/S**
Tomatoes	Tomato	**6**	**N/S**

♠ The new rates were not applied for home and garden products (all items in this table).
[1] **Methods of Application:** Dusting equipment to arrive at a complete coverage of foliage
[2] **Application rates** were not specified. With the exception of only 3 crops (denoted by [4], more applications are stated in the home and garden dust formulation label than those for the liquid formulations used in agricultural crops. (**Table 2.3**).
[3] **N/S=** Not Specified.
[4] **Note:** The numbers of applications for these uses are 7 and are less than that specified for the liquid sprays in **Table 2.3.**

Furthermore, permethrin is used for dip and seed treatments, labeled uses which are summarized in **Table 2.7**.

Table 2.7. Additional permethrin use patterns: dip and seed treatments.			
	Seeding and Chemical Application Rates		
Use Pattern	*Cwt (lb a.i./100 lbs Seed)*	*lbs Seeds/Acre* [1]	*lb a.i./Acre*
I. Dip Treatments			
Horseradish	Pre-plant dip inn a tank containing 0.84 lb a.i/100 gal		
II. Seed Treatments (using slurry or mist seed treatment equipment)			
(1) Cole Crops			
Broccoli and Chinese Broccoli	**0.0313**	**6.8**	**0.00213**
Cabbage & Chinese Cabbage	**0.0313**	**6.8**	**0.00213**
Cauliflower	**0.0313**	**6.8**	**0.00213**
(2) Corn			
Field, Pop & Sweet	**0.0313**	**18**	**0.00563**
(3) Melons			
C. Mixta (Squash) , and Squash	**0.0313**	**2**	**0.00063**

Table 2.7. Additional permethrin use patterns: dip and seed treatments.			
	Seeding and Chemical Application Rates		
Use Pattern	*Cwt (lb a.i./100 lbs Seed)*	*lbs Seeds/Acre [1]*	*lb a.i./Acre*
Cucumber	**0.0313**	**2**	**0.00063**
Gherkin, Gourd (Wax, Chinese), Gourds	**0.0313**	**2**	**0.00063**
Melons (Bitter, Balsam pear)	**0.0313**	**2**	**0.00063**
Melons (Citron)	**0.0313**	**2**	**0.00063**
(4) Pepper & Tomatoes	**0.0313**	**0.3**	**0.00009**

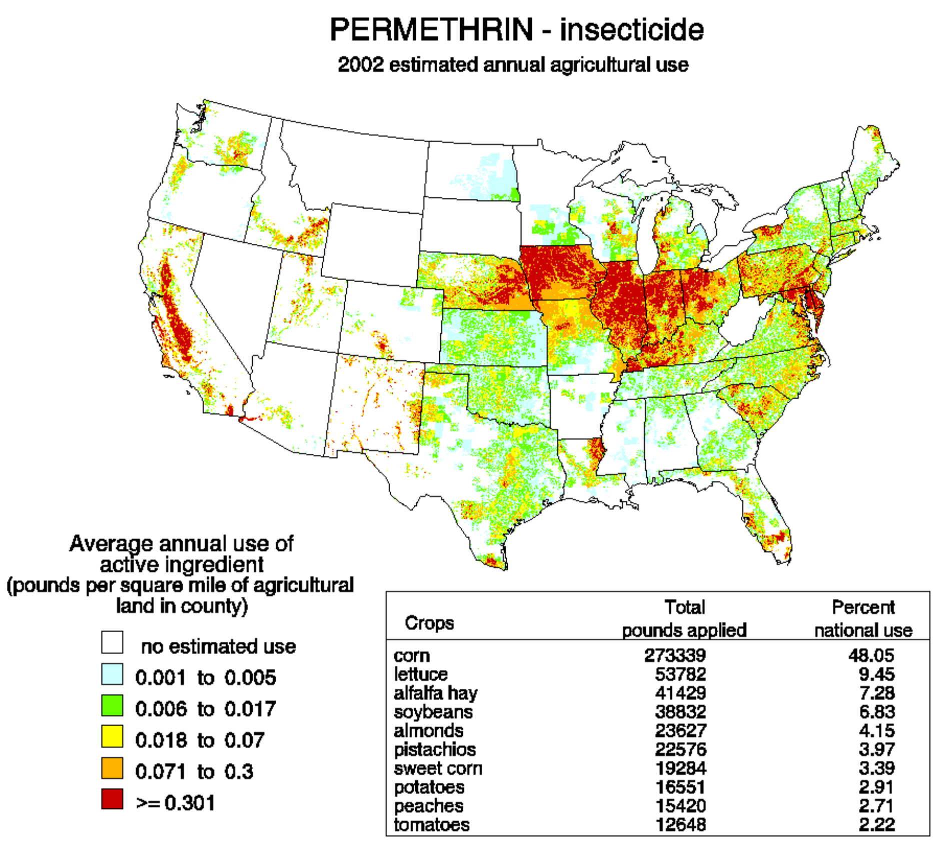
[1] References used for obtaining seeding rate, when available, or data to calculate the rate:
Corn: http://agric.ucdavis.edu/crops.htm and http://www.ag.ndsu.edu/procrop/sds/susrvc04.htm
Broccoli, cabbage, and Cauliflower: http://www.hort.purdue.edu/fruitveg/veg/broccoli.shtml
Cucurbits: http://anrcatalog.ucdavis.edu/pdf/7209.pdf
Peppers: http://www.hort.purdue.edu/fruitveg/veg/pepper.shtml

Finally, non-agricultural use patterns for permethrin include a vast number of uses; information on important uses are included in **Table 2.8** which is summarized from much larger non-agricultural use tables included in **APPENDIX C**. **Table 2.8** includes only the non-agricultural uses that are likely to result in significant exposure of non-target terrestrial and aquatic wildlife to permethrin.

Table 2.8. Labeled permethrin use patterns assessed for California (other than crop uses).				
Treatment Type	*Spray Type*	*Application Method*	*Use Pattern*	*Application Rate (lb a.i./A And Other Parameters*
Soil Barrier Treatment	Liquid, Mist and ULV sprays	Ground	Fencerows and Hedgerows	0.01 lb a.i/A with no other information
			Range Land	0.1 lb a.i/A with no other information
Urban & Rural Structures Barrier Treatment	Liquid Sprays		Outdoors of varied urban and rural structures	Two applications: 1st @ 0.08 lb a.i/ A and the 2nd @ 0.1 lb a.i/A
Mosquito Control	Liquid ULV Spray	Ground And Aerial	Non-agriculture Areas (Public health use); Refuse Waste Sites; Urban Areas; Wide Area and General Outdoor (Public health; Commercial, Institutional, Industrial Premises; Industrial Areas; FARM PREMISES; Cattle Feedlots; and Range Land	0.007 lb a.i/A; 26 applications per mosquito season with a minimum interval of 1-day
			Rural areas which includes agricultural crop areas	
Ant Mound Control	Liquid Spray	Ground	Non-agriculture Areas; Outdoors including: Recreational areas; and Commercial, Institutional, Industrial	0.84 lb a.i/A with no other information
Termite Control			For Urban and Rural Structures	0.77 lb a.i/A with no other information
Residential Turf and Ornamentals			Home and Garden	4.23 lb a.i/A @ 5-day intervals with no other information
Garden Vegetables				0.25 lb a.i/A; 6 Applications @ 5-day intervals
Garden Nut and Fruits				0.40 lb a.i/A; 5 Applications with no other information

2.4.4.2 National and California Usage Data for Permethrin

A national map showing the estimated poundage of permethrin **agricultural** uses across the United States is provided in **Figure 2.2**. The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website.
http://ca.water.usgs.gov/pnsp/pesticide_use_maps/compound_listing.php?year=02



Crops	Total pounds applied	Percent national use
corn	273339	48.05
lettuce	53782	9.45
alfalfa hay	41429	7.28
soybeans	38832	6.83
almonds	23627	4.15
pistachios	22576	3.97
sweet corn	19284	3.39
potatoes	16551	2.91
peaches	15420	2.71
tomatoes	12648	2.22

Figure 2.2. National permethrin agricultural use (pounds per square mile of agricultural land in county).

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[1], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide

[1] United States Depart of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.usda.gov/nass/pubs/estindx1.htm#agchem.

Regulation Pesticide Use Reporting (CDPR PUR) database[2]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for permethrin by county in this California-specific assessment were generated using CDPR PUR data. Seven years (1999-2006) of usage data were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all seven years. The units of area treated are also provided where available.

According to the CDPR PUR data, crops with high use (>1000 lb a.i./A, average) applied in California included alfalfa, almond, pistachio, walnut, broccoli, corn, peach, lettuce, spinach, onion, potato, residential (landscaping), artichoke, celery and tomato. Of these, the major uses were almond, pistachio and lettuce (>20,000 lb a.i./A). A summary of permethrin usage for all California use sites is provided below in **Tables 2.9** and **2.10**.

[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.

Table 2.9. Permethrin agricultural usage (Average data from 1999 to 2006).								
	Average Annual lbs Applied		*Average Annual Acreage Treated*		*Application Rate Data (Rate lb a.i/A)*			
Crop	*Lbs*	*% of Total*	*Acre*	*% of Total*	*AVG*	*95th %*	*99th %e*	*Average MAX*
(1) Alfalfa	**6,314**	**4.20%**	**53,820**	**6.90%**	**0.13**	**0.17**	**0.20**	**0.29**
(2) Nuts								
Almond	**21,975**	**14.62%**	**110,428**	**14.16%**	**0.19**	**0.33**	**0.49**	**1.01**
Pistachio	**33,063**	**22.00%**	**123,511**	**15.84%**	**0.25**	**0.35**	**0.38**	**1.48**
Walnut	**3,233**	**2.15%**	**14,065**	**1.80%**	**0.26**	**0.42**	**0.52**	**1.00**
(3) Avocado	**6**	**0.00%**	**31**	**0.00%**	**0.17**	**0.18**	**0.18**	**0.18**
(4) Cole Crops								
Broccoli	**1,066**	**0.71%**	**11,076**	**1.42%**	**0.30**	**0.66**	**0.76**	**0.98**
Cabbage	**715**	**0.48%**	**4,439**	**0.57%**	**0.15**	**0.18**	**0.26**	**0.44**
Cauliflower	**378**	**0.25%**	**3,947**	**0.51%**	**0.10**	**0.12**	**0.19**	**0.24**
Other Cole crops*	**93**	**0.06%**	**423**	**0.05%**	**0.15**	**0.21**	**0.22**	**0.22**
(5) Corn (grain + forage)	**7,198**	**4.79%**	**39,298**	**5.04%**	**0.17**	**0.27**	**0.56**	**0.84**
(6) Forest Timberland	**0**	**0.00%**	**216**	**0.03%**	**0.00**	**0.00**	**0.00**	**0.00**
(7) Fruits								
Cherry	**224**	**0.15%**	**1,198**	**0.15%**	**0.20**	**0.42**	**0.49**	**0.72**
Peach	**5,106**	**3.40%**	**21,763**	**2.79%**	**0.23**	**0.28**	**0.38**	**0.81**
Pear	**234**	**0.16%**	**927**	**0.12%**	**0.18**	**0.26**	**0.26**	**0.27**
Other Fruits**	**35**	**0.02%**	**246**	**0.03%**	**0.14**	**0.18**	**0.18**	**0.18**
(8) GARLIC	**117**	**0.08%**	**479**	**0.06%**	**0.18**	**0.22**	**0.22**	**0.22**
(9) Leafy Vegetables								
Brussels Sprout	**181**	**0.12%**	**1,851**	**0.24%**	**0.10**	**0.12**	**0.14**	**0.34**
Chicory	**331**	**0.22%**	**1,882**	**0.24%**	**0.18**	**0.20**	**0.70**	**0.81**
Endive (Escarole)	**250**	**0.17%**	**1,735**	**0.22%**	**0.22**	**0.24**	**0.27**	**0.43**
Lettuce (Head & Leaf)	**35,641**	**23.71%**	**245,614**	**31.49%**	**0.15**	**0.19**	**0.21**	**0.78**
Parsley	**205**	**0.14%**	**1,238**	**0.16%**	**0.34**	**0.44**	**0.44**	**0.44**
Spinach	**4,796**	**3.19%**	**31,056**	**3.98%**	**0.16**	**0.18**	**0.20**	**0.91**
Chard (Swiss)	**141**	**0.09%**	**896**	**0.11%**	**0.18**	**0.26**	**0.29**	**0.57**

Table 2.9. Permethrin agricultural usage (Average data from 1999 to 2006).								
	Average Annual lbs Applied		*Average Annual Acreage Treated*		*Application Rate Data (Rate lb a.i/A)*			
Crop	*Lbs*	*% of Total*	*Acre*	*% of Total*	*AVG*	*95th %*	*99th %e*	*Average MAX*
Other Leafy Vegetables	**87**	**0.06%**	**593**	**0.08%**	**0.27**	**0.46**	**0.57**	**0.59**
(10) Melons								
Cantaloupe	**777**	**0.52%**	**5,645**	**0.72%**	**0.16**	**0.20**	**0.21**	**0.23**
Cucumber	**234**	**0.16%**	**1,262**	**0.16%**	**0.18**	**0.21**	**0.21**	**0.22**
Melon	**327**	**0.22%**	**2,474**	**0.32%**	**0.17**	**0.20**	**0.21**	**0.21**
Pumpkin	**130**	**0.09%**	**763**	**0.10%**	**0.19**	**0.24**	**0.27**	**0.27**
Squash & Zucchini	**187**	**0.12%**	**1,001**	**0.13%**	**0.21**	**0.39**	**0.47**	**0.47**
Watermelon	**217**	**0.14%**	**1,128**	**0.14%**	**0.18**	**0.36**	**0.52**	**0.53**
Eggplant	**10**	**0.01%**	**62**	**0.01%**	**0.15**	**0.19**	**0.19**	**0.19**
(11) Nursery								
Christmas Tree	**1**	**0.00%**	**6**	**0.00%**	**0.10**	**0.11**	**0.11**	**0.11**
Flowering Plants (Indoors)	**257**	**0.17%**	**702**	**0.09%**	**0.27**	**0.64**	**0.77**	**1.29**
Plants in Containers (Indoors)	**290**	**0.19%**	**861**	**0.11%**	**0.24**	**0.50**	**0.70**	**0.97**
Plants for Transplant (Indoors)	**90**	**0.06%**	**774**	**0.10%**	**0.14**	**0.25**	**0.40**	**0.57**
Flowering Plants (Outdoors)	**512**	**0.34%**	**2,646**	**0.34%**	**0.15**	**0.28**	**0.43**	**0.87**
Plants in Containers (Outdoors)	**769**	**0.51%**	**4,114**	**0.53%**	**0.27**	**0.67**	**1.06**	**1.43**
Plants for Transplant (Outdoors)	**114**	**0.08%**	**697**	**0.09%**	**0.17**	**0.40**	**0.58**	**0.71**
(12) Onion & Fennel								
Fennel	**48**	**0.03%**	**375**	**0.05%**	**0.15**	**0.18**	**0.18**	**0.18**
Onion, Dry & Green	**1,895**	**1.26%**	**9,454**	**1.21%**	**0.24**	**0.28**	**0.37**	**0.42**
(13) Potato	**1,550**	**1.03%**	**7,935**	**1.02%**	**0.18**	**0.22**	**0.31**	**0.49**
(14) Residential: Landscaping	**9,745**	**6.48%**	**3**	**0.00%**	**0.15**	**0.17**	**0.17**	**0.17**
(15) Row Crops								
Artichoke (Globe)	**1,050**	**0.70%**	**4,744**	**0.61%**	**0.21**	**0.29**	**0.34**	**0.62**
Asparagus	**203**	**0.14%**	**1,319**	**0.17%**	**0.13**	**0.29**	**0.29**	**0.29**
Celery	**6,490**	**4.32%**	**40,995**	**5.26%**	**0.15**	**0.19**	**0.21**	**0.76**
Pepper	**516**	**0.34%**	**2,902**	**0.37%**	**1.37**	**2.94**	**3.05**	**3.17**
(16) Tomato and tomatillo	**3,506**	**2.33%**	**19,273**	**2.47%**	**0.17**	**0.21**	**0.33**	**0.47**

*	Other Cole Crops include: Chinese Cabbage (Bok Choy), Collard, Gailon, Kale Kohlrabi, Mustard (application rates not included), Rappini (Broccoli raab), and Turnip
**	Other Fruits include: Apple, Nectarine, Plum, and Prune
***	Other Leafy Vegetables include: Arrugula, Cardoon, Chervil, Chinese Greens, and Dandelion Green

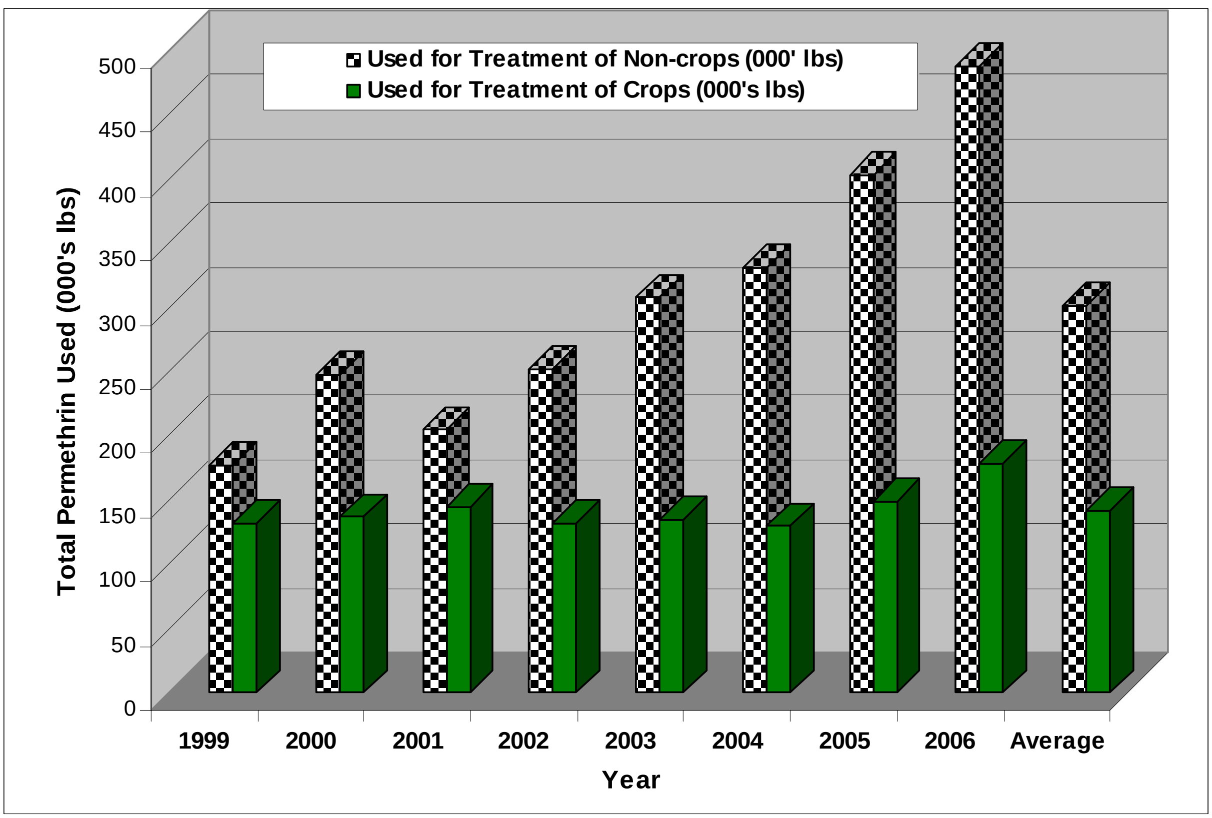
Of the non-agricultural uses, the structural pest control category is dominant, with 289,272 lb a.i. and 95.6%, followed by landscape maintenance with only 3.2%. Other uses are ≤0.4% of total.

Table 2.10. Permethrin non-agricultural usage (Average data from 1999 to 2006).		
Usage Sites	***Average Use (lbs a.i)***	***% Use of Total***
Structural Pest Control	289,272.0	95.6%
Landscape Maintenance	9,745.1	3.2%
Regulatory Pest control	1,172.6	0.4%
Rights of Ways	1,144.8	0.4%
Public Health	831.4	0.3%
Fumigation	202.3	0.1%
Animal Health	127.1	0.0%
All others*	22.6	0.0%

* Vertebrates control, uncultivated land, Research, and Lumber treatment

Figure 2.3 shows the total use (lbs) from 1999-2006 for agriculture and non-agriculture. It is noted that agricultural uses were relatively steady (around 100-150,000 lb) and that the increase in use mainly attributed to non-agricultural use which increased from around 150,000 to 450,000 lb).

Figure 2.3. Usage of permethrin in California from 1999 to 2006.



Furthermore, **Figure 2.4** shows the usage in various California counties. It is noted that urban areas have the highest share due to non-agricultural use (*i.e.* Los Angeles).

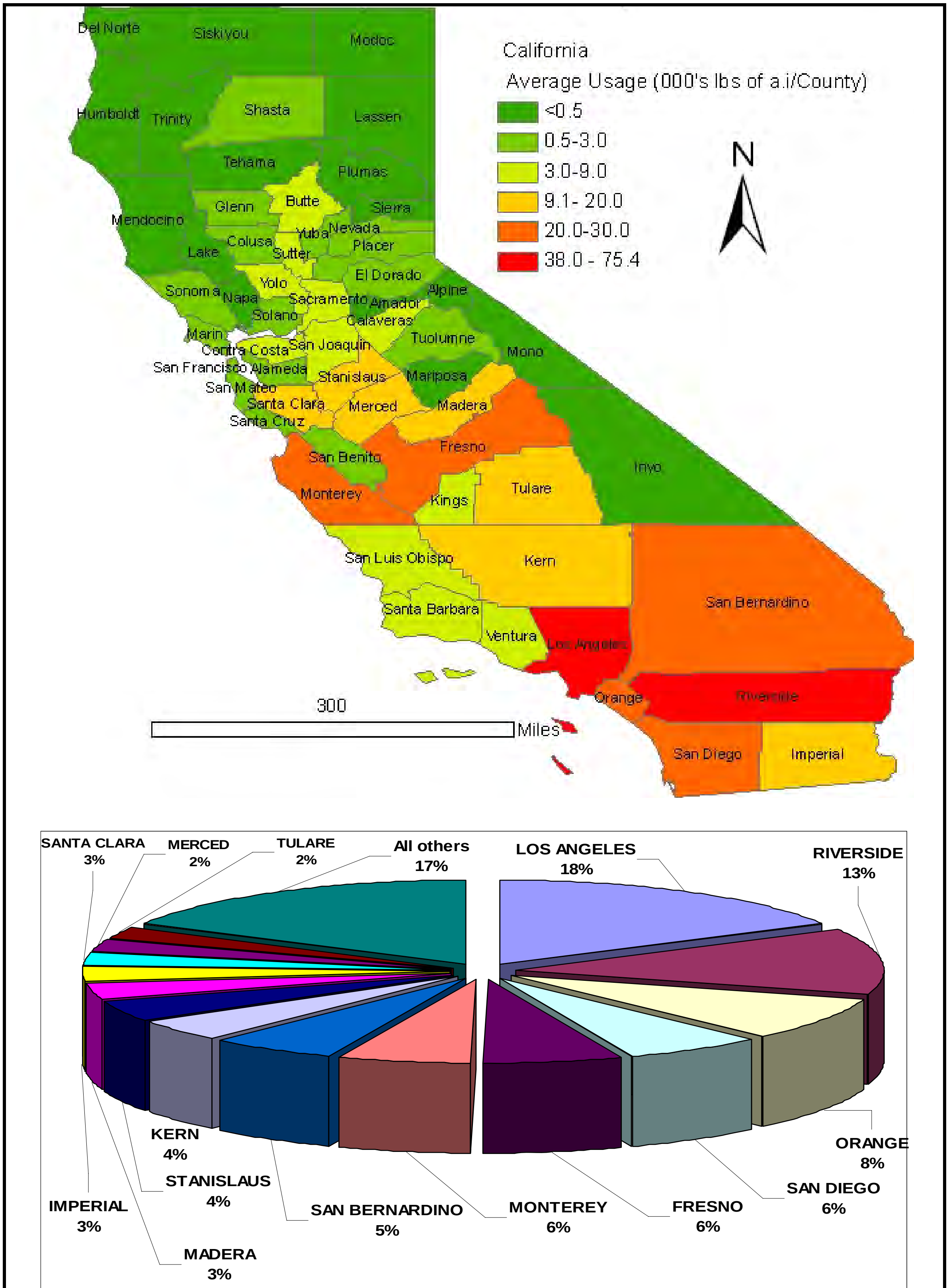


Figure 2.4. Breakdown of percentage usage of permethrin in California by county.

2.5 Assessed Species

Table 2.11 provides a summary of the current distribution, habitat requirements, and life history parameters for the listed species being assessed. More detailed life-history and distribution information can be found in **Attachments 1** and **3**. See **Figures 2.5, 2.6, 2.7, and 2.8** for maps of the current range and designated critical habitat, if applicable, of the CRLF, SFGS, CCR, SMHM, and BCB.

Table 2.11. Summary of current distribution, habitat requirements, and life history information for the assessed listed species.[1]

Assessed Species	Size	Current Range	Habitat Type	Designated Critical Habitat?	Reproductive Cycle	Diet
California red-legged frog (CRLF) (*Rana aurora draytonii*)	Adult (85-138 cm in length), Females – 9-238 g, Males – 13-163 g; Juveniles (40-84 cm in length)	Northern CA coast, northern Transverse Ranges, foothills of Sierra Nevada, and in southern CA south of Santa Barbara	Freshwater perennial or near-perennial aquatic habitat with dense vegetation; artificial impoundments; riparian and upland areas	Yes	<u>Breeding</u>: Nov. to Apr. <u>Tadpoles</u>: Dec. to Mar. <u>Young juveniles</u>: Mar. to Sept.	<u>Aquatic-phase</u>[2]: algae (tadpoles only), freshwater aquatic invertebrates and fish <u>Terrestrial-phase</u>: terrestrial invertebrates, small mammals, and frogs
San Francisco garter snake (SFGS) (*Thamnophis sirtalis tetrataenia*)	Adult (46-131 cm in length), Females – 227 g, Males – 113 g; Juveniles (18–20 cm in length)	San Mateo County	Densely vegetated freshwater ponds near open grassy hillsides; emergent vegetation; rodent burrows	No	<u>Oviparous Reproduction</u>[3] <u>Breeding</u>: Spring (Mar. and Apr.) and Fall (Sept. to Nov.) <u>Ovulation and Pregnancy</u>: Late spring and early summer <u>Young</u>: Born 3-4 months after mating	<u>Juveniles</u>: frogs (Pacific tree frog, CRLF, and bullfrogs depending on size) <u>Adults</u>: primarily frogs (mainly CRLFs; also bullfrogs, toads); to a lesser extent newts; freshwater fish and invertebrates; small mammals, reptiles, terrestrial invertebrates
California Clapper Rail (CCR) (*Rallus*	250 - 350 g	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma	Tidal marsh habitat	No	<u>Breeding</u>: Feb. - August <u>Nesting:</u> mid-March-Aug. <u>Lay Eggs:</u> March - July	Opportunistic feeders: freshwater and estuarine invertebrates,

Table 2.11. Summary of current distribution, habitat requirements, and life history information for the assessed listed species.[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
longirostris obsoletus)		counties			<u>Incubation</u>: 23 to 29 days; Leave nest: 35 to 42 days after hatch; Juveniles fledge at ten weeks and can breed during the spring after they hatch	seeds, worms, mussels, snails, clams, crabs, insects, and spiders; occasionally consume small birds and mammals, dead fish, up to 15% plant material
Salt marsh harvest mouse (SMHM) (*Reithrodontomys raviventris*)	Adult 8 – 14 g	Northern subspecies can be found in Marin, Sonoma, Napa, Solano, and northern Contra Costa counties. The southern subspecies occurs in San Mateo, Alameda, and Santa Clara counties with some isolation populations in Marin and Contra Costa counties.	Dense, perennial cover with preference for habitat in the middle and upper parts of the marsh dominated by pickleweed and peripheral halophytes as well as similar vegetation in diked wetlands adjacent to the Bay; may use abandoned bird nests for rearing sites	No	<u>Breeding:</u> March – November <u>Gestation period:</u> 21 – 24 days	Leaves, seeds, and plant stems; may eat insects; prefers "fresh green grasses" in the winter and pickleweed and saltgrass during the rest of the year; drinks both salt and fresh water
Bay checkerspot butterfly (BCB) (*Euphydryas editha bayensis*)	Adult butterfly - 5 cm in length	Santa Clara and San Mateo Counties [Because the BCB distribution is considered a metapopulation, any site with appropriate habitat in the vicinity of its historic range (Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara counties) should be considered potentially occupied by the butterfly (USFWS 1998, p. II-177)].	1) Primary habitat – native grasslands on large serpentine outcrops; 2) Secondary habitat – 'islands' of smaller serpentine outcrops with native grassland; 3) Tertiary habitat – non-serpentine areas where larval food plants occur	Yes	Larvae hatch in March – May and grow to the 4th instar in about two weeks. The larvae enter into a period of dormancy (diapause) that lasts through the summer. The larvae resume activity with the start of the rainy season. Larvae pupate once they reach a weight of 300 - 500 milligrams.	Obligate with dwarf plantain. Primary diet is dwarf plantain plants (may also feed on purple owl's-clover or exserted paintbrush if the dwarf plantains senesce before the larvae pupate). Adults feed on the nectar of a variety of plants found in association with

Table 2.11. Summary of current distribution, habitat requirements, and life history information for the assessed listed species.[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
					Adults emerge within 15 to 30 days depending on thermal conditions, feed on nectar, mate and lay eggs during a flight season that lasts 4 to 6 weeks from late February to early May	serpentine grasslands

[1] For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see **Attachments 1** and **3**
[2] For the purposes of this assessment, tadpoles and submerged adult frogs are considered "aquatic" because exposure pathways in the water are considerably different than those that occur on land.
[3] Oviparous = eggs hatch within the female's body and young are born live.

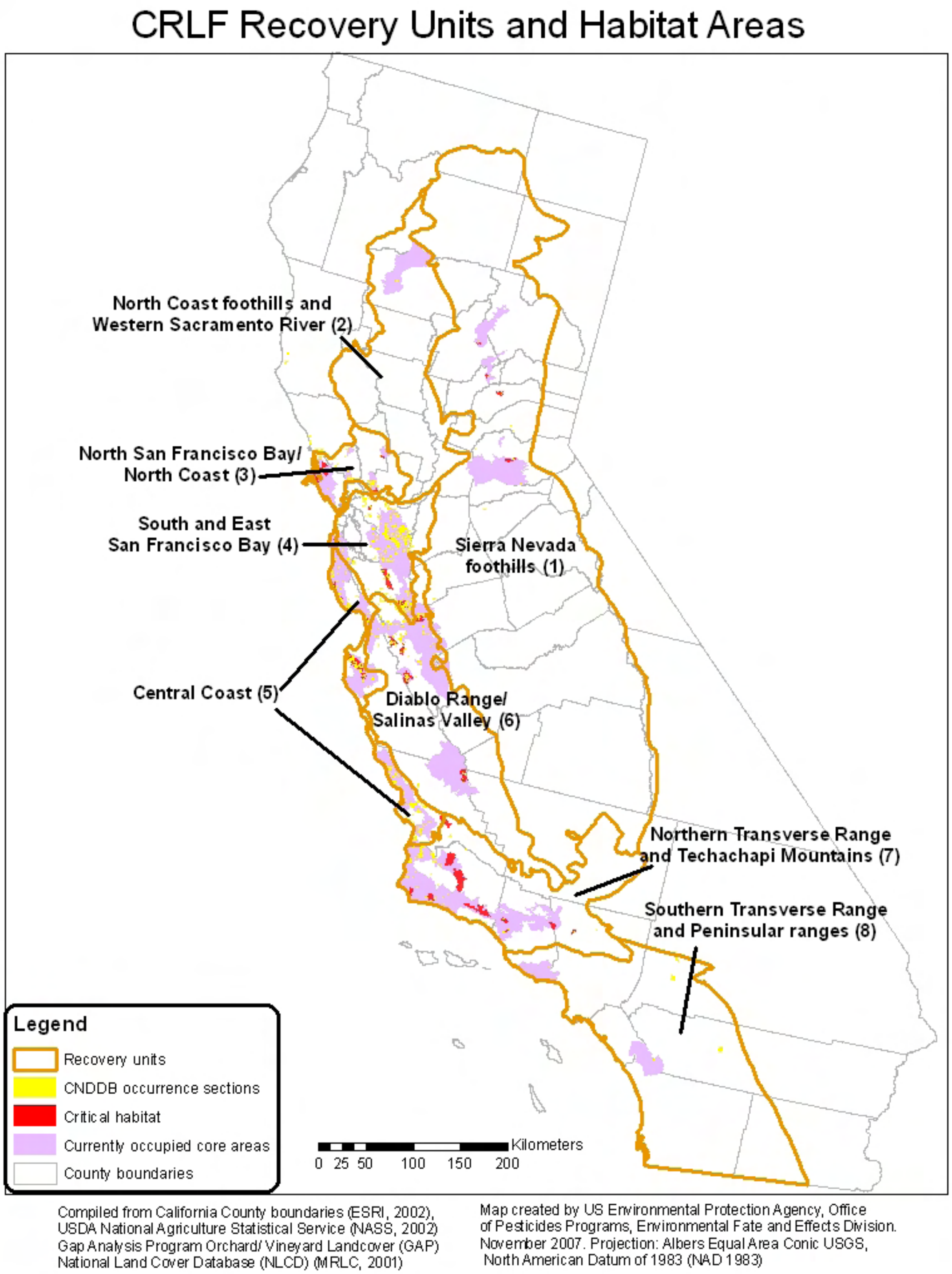


Figure 2.5. CRLF current range and designated critical habitat.

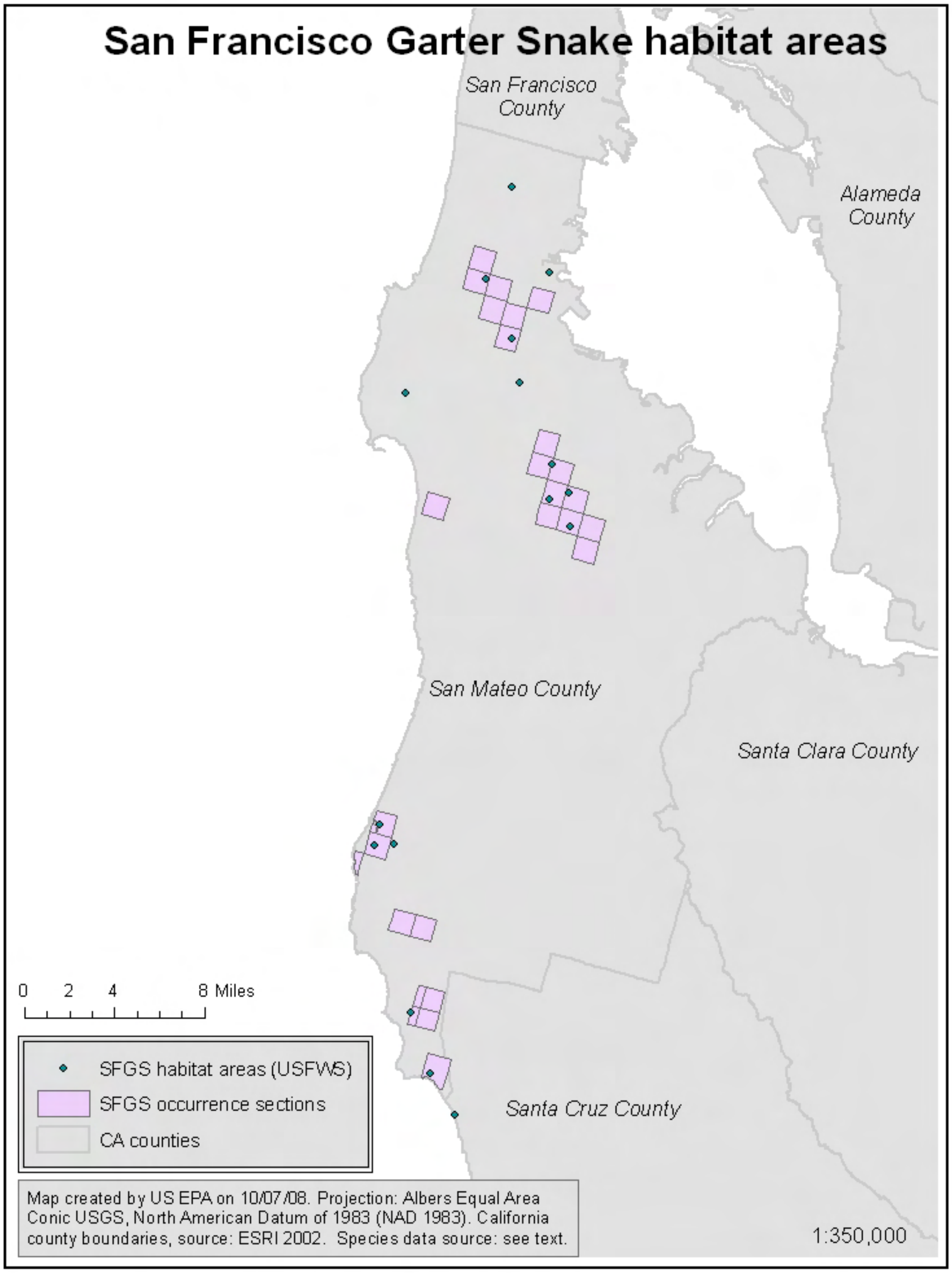


Figure 2.6. SFGS current range. Species location information obtained from USFWS Recovery Plan (1985), and from *Center for Biological Diversity (CBD) vs. EPA et al.* (Case No. 07-2794-JCS).

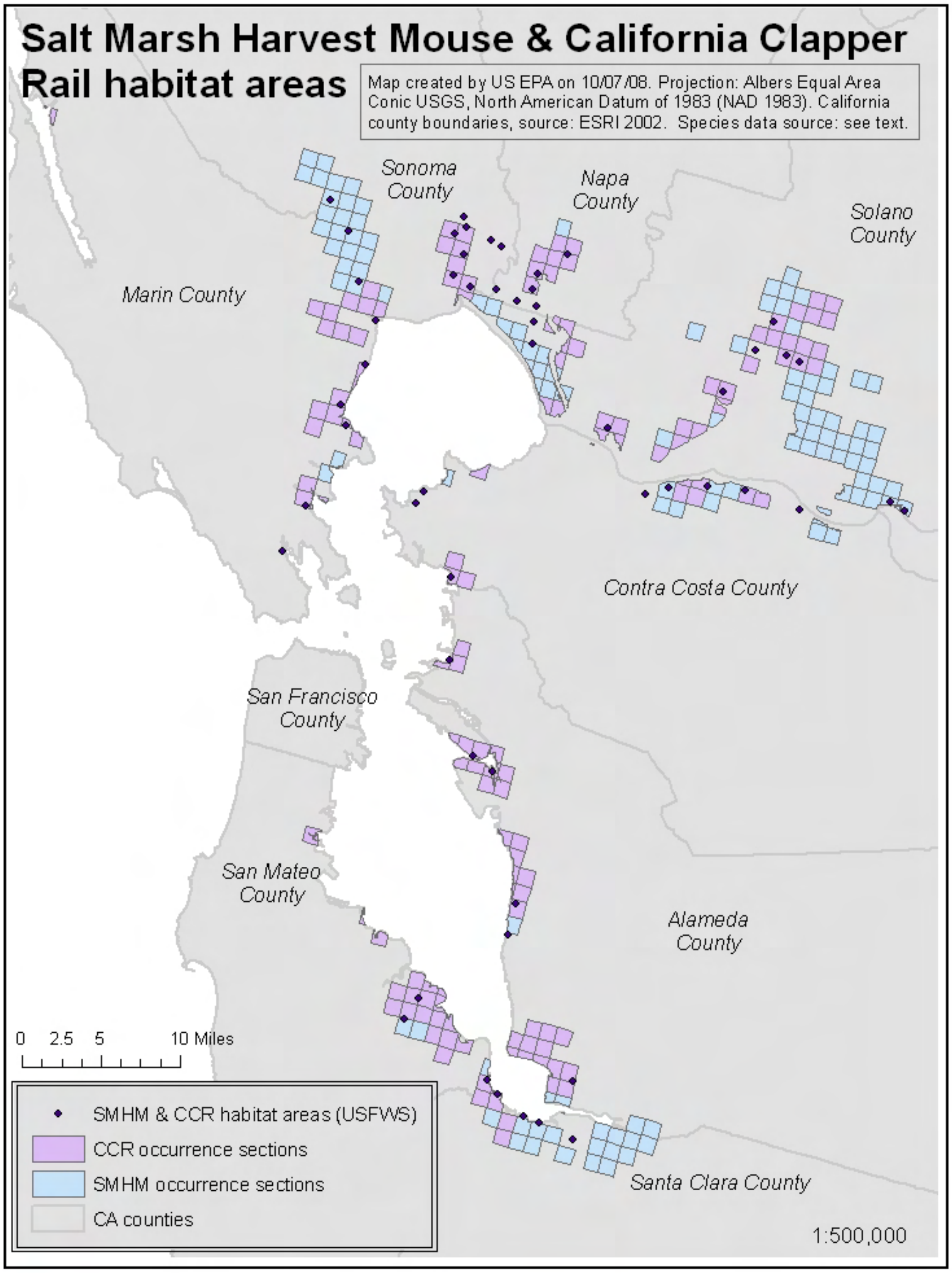


Figure 2.7. CCR and SMHM current range. Species location information obtained from USFWS Recovery Plan (1984), and from *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

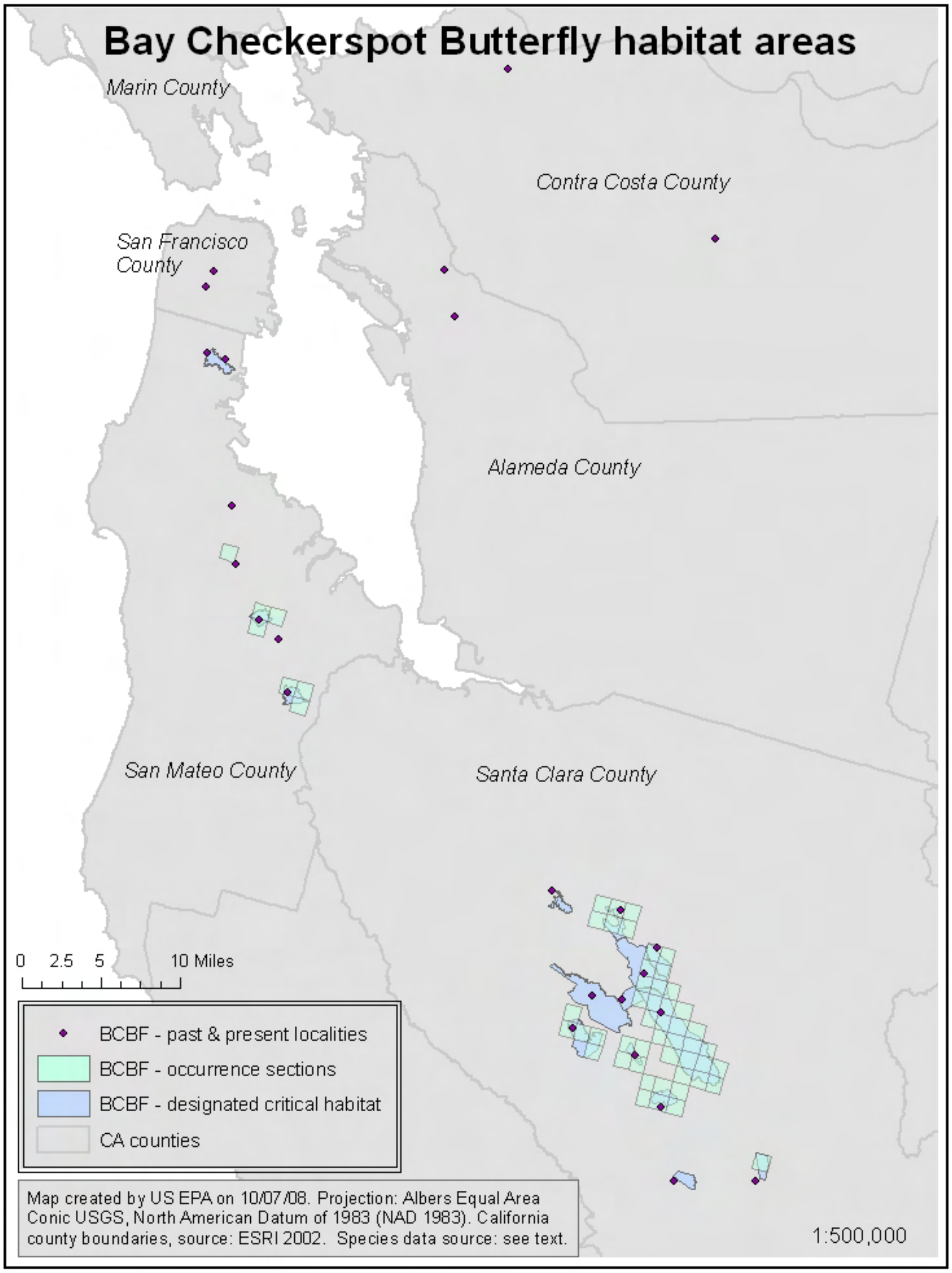


Figure 2.8. BCB current range and designated critical habitat. Species location information obtained from USFWS Recovery Plan (1998), and from *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS). Critical habitat information obtained from USFWS (2001).

2.6 Designated Critical Habitat

Critical habitat has been designated for the CRLF and BCB.

'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.' Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be 'essential to the conservation of the species.' Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. **Table 2.12** describes the PCEs for the critical habitats designated for the CRLF and BCB.

Table 2.12. Designated critical habitat PCEs for the CRLF and BCB. [1]

Species	PCEs	Reference
CRLF	Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond.	50 CFR 414.12(b), 2006
	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.	
	Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	
	Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	
	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	

Table 2.12. Designated critical habitat PCEs for the CRLF and BCB.[1]		
Species	**PCEs**	**Reference**
	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	
	Reduction and/or modification of food sources for terrestrial phase juveniles and adults	
	Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	
BCB	The presence of annual or perennial grasslands with little to no overstory that provide north/south and east/west slopes with a tilt of more than 7 degrees for larval host plant survival during periods of atypical weather (e.g., drought).	66 FR 21449 21489, 2001
	The presence of the primary larval host plant, dwarf plantain (*Plantago erecta*) (a dicot) and at least one of the secondary host plants, purple owl's-clover or exserted paintbrush, are required for reproduction, feeding, and larval development.	
	The presence of adult nectar sources for feeding.	
	Aquatic features such as wetlands, springs, seeps, streams, lakes, and ponds and their associated banks, that provide moisture during periods of spring drought; these features can be ephemeral, seasonal, or permanent.	
	Soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar soils (Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) that provide areas with fewer aggressive, nonnative plant species for larval host plant and adult nectar plant survival and reproduction.[2]	
	The presence of stable holes and cracks in the soil, and surface rock outcrops that provide shelter for the larval stage of the bay checkerspot butterfly during summer diapause.[2]	
[1] These PCEs are in addition to more general requirements for habitat areas that provide essential life cycle needs of the species such as, 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. [2] PCEs that are abiotic, including, 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.		

More detail on the designated critical habitat applicable to this assessment can be found in **Attachment 1** (for the CRLF) and **Attachment 3** (for the BCB). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of permethrin that may alter the PCEs of the designated critical habitat for the CRLF and BCB form the basis of the critical habitat impact analysis.

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 permethrin is expected to directly impact living organisms within the action area, critical habitat analysis for permethrin 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 permethrin is likely to encompass considerable portions of the United States based on the large array of agricultural and/or non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF, CCR, SFGS, SMHM, and BCB and their designated critical habitat (applicable to CRLF and BCB) within the state of California. Although the watershed for the San Francisco Bay extends northward into the very southwestern portion of Lake County, Oregon, and westward into the western edge of Washoe County, Nevada, the non-California portions of the watershed are small and very rural with little, if any, agriculture. Therefore, no use of permethrin is expected in these areas, and they are not considered as part of the action area applicable to this assessment.

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 permethrin. An analysis of labeled uses and review of available product labels was completed as described previously. Several of the currently labeled uses are special local needs (SLN) uses or are restricted to specific states and are excluded from this assessment. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the assessed species, the analysis indicates that, for permethrin, the following agricultural uses are considered as part of the federal action evaluated in this assessment:

- Alfalfa, nut trees, avocado, cole crops, corn, fruit trees, garlic, leafy vegetables, cucurbit vegetables, onion, potato, row crops, tomato/ tomatillo, ant mound treatment in agricultural areas (fruit trees), mosquito control of cropped areas

In addition, the following non-food and non-agricultural uses are considered:

- Nursery, turf, ant mound treatment (turf), mosquito control in non-agricultural fields, soil barrier treatment (fencerows, hedgerows and rangeland), residential turf and ornamental, perimeter treatment, termite treatment, garden vegetables, garden nuts and fruits, fire ants treatment, turf (granular formulation), garden vegetables (granular formulation)

Following a determination of the assessed uses, an evaluation of the potential “footprint” of permethrin use patterns is determined. This “footprint” represents the initial area of concern based on an analysis of available land cover data for the state of California. The initial area of concern is typically defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. However, in the case of permethrin, the overall conclusion of the analyses of use patterns is that they are so expansive in nature that there is no area in California from which the possibility of the occurrence of permethrin applications can be excluded. Therefore, the initial area of concern for permethrin is presumed to encompass the entire state of California.

Once the initial area of concern (i.e., the area directly affected by the federal action) is defined, the next step is to define the potential boundaries of the action area by determining the areas that would be indirectly affected by the federal action. This is done by evaluating 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.

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. Deriving the geographical extent of this portion of the action area is based on consideration of the types of effects that permethrin may be expected to have on the environment, the exposure levels to permethrin that are associated with those effects, and the best available information concerning the use of permethrin and its fate and transport within the state of California. Specific measures of ecological effect for the assessed species that define the action area include any direct and indirect toxic effect to the assessed species and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sub-lethal effects available in the effects literature. Therefore, the action area extends to a point where environmental exposures are below any measured lethal or sub-lethal 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.

Typically two methods are employed to define the areas indirectly affected by the federal action, and thus the total action area. These are the down stream dilution assessment for determining the extent of the affected lotic aquatic habitats (flowing water) and the spray drift assessment for determining the extent of the affected terrestrial habitats and lentic aquatic habitats (non-flowing water). However, as previously mentioned, 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, CCR, SFGS, SMHM, and BCB and their designated critical habitat *within the state of California*, and the initial action area has already been defined as the *entire state of California*. Therefore, in the case of permethrin, because LOC exceedances would be expected to occur on all land cover types throughout the state of California as a result of this federal action, the final full extent of the action area that is relevant for the assessed species cannot be extended beyond the boundaries of California and is assumed to encompass the entire state.

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, CCR, SFGS, SMHM, BCB, organisms important in the life cycle of the assessed species, and the PCEs of their designated critical habitat), the ecosystems potentially at risk (*e.g.,* waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of permethrin (*e.g.,* runoff, spray drift, *etc*.), and the routes by which ecological receptors are exposed to permethrin *(e.g.,* direct contact, *etc.)*.

2.8.1 Assessment Endpoints

Assessment endpoints for the CRLF, CCR, SFGS, SMHM, and BCB include direct toxic effects on the survival, reproduction, and growth of individuals, 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 assessed species. 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 sub-lethal effects used to define the action area. According 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.

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. As described in the Agency's Overview Document (U.S. EPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater (surrogate for aquatic-phase amphibians) and estuarine/marine fish, freshwater and estuarine/marine invertebrates, aquatic plants (non-vascular only; no data available for vascular aquatic plants), birds (surrogate for terrestrial-phase amphibians and reptiles), mammals, terrestrial invertebrates, and terrestrial plants (plants are only qualitatively evaluated due to lack of appropriate data). 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 permethrin.

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

A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect risks for each of the assessed species associated with exposure to permethrin is provided in **Table 2.13**.

Table 2.13. Taxa and assessment endpoints used to evaluate the potential for the use of permethrin to result in direct and indirect effects to the assessed listed species.

Taxa Used to Assess Direct and/or Indirect Effects to Assessed Species	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects
1. Freshwater Fish and Aquatic-phase Amphibians[1]	Direct Effect – -Aquatic-phase CRLF	Survival, growth, and reproduction of individuals via direct effects	1a. Bluegill sunfish LC_{50} 1b. Estimated bluegill sunfish chronic NOAEC (based on fathead minnow acute-to-chronic ratio)
	Indirect Effect (prey) -Aquatic-phase CRLF -SFGS -CCR	Survival, growth, and reproduction of individuals via indirect effects on aquatic prey food supply (*i.e.*, fish and aquatic-phase amphibians)	
2. Freshwater Invertebrates	Indirect Effect (prey) -Aquatic-phase CRLF -SFGS -CCR	Survival, growth, and reproduction of individuals via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	2a. Scud EC_{50} 2b. Estimated scud chronic NOAEC (based on fathead minnow acute-to-chronic ratio)
3. Estuarine/Marine Fish	Indirect Effect (prey) -CCR	Survival, growth, and reproduction of individuals via indirect effects on aquatic prey food supply (*i.e.*, estuarine/marine fish)	3a. Atlantic silverside LC_{50} 3b. Estimated Atlantic silverside chronic NOAEC(based on fathead minnow acute-to-chronic ratio)
4. Estuarine/Marine Invertebrates	Indirect Effect (prey) -CCR	Survival, growth, and reproduction of individuals via indirect effects on aquatic prey food supply (*i.e.*, estuarine/marine invertebrates)	4a. Stone crab EC_{50} 4b. Estimated stone crab chronic NOAEC (based on fathead minnow acute-to-chronic ratio)
5. Aquatic Plants (freshwater/marine)	Indirect Effect (food/habitat) -Aquatic-phase CRLF -CCR -SMHM -SFGS	Survival, growth, and reproduction of individuals via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	5a. Marine algae (*Skeletonema costatum*) EC_{50} 5b. No data available for quantitative evaluation of vascular aquatic plants
6. Birds, Terrestrial-phase Amphibians, and Reptiles[2]	Direct Effect -Terrestrial-phase CRLF -CCR -SFGS	Survival, growth, and reproduction of individuals via direct effects	6a. Bobwhite quail LC_{50} 6b. Mallard duck LD_{50} 6c. Mallard duck chronic NOAEC
	Indirect Effect (food/habitat from nests) -Terrestrial-phase CRLF -CCR -SFGS -SMHM [3]	Survival, growth, and reproduction of individuals via indirect effects on terrestrial prey (birds/frogs) and habitat[3]	
7. Mammals	Direct Effect	Survival, growth, and	7a. Laboratory rat acute LD_{50}

Table 2.13. Taxa and assessment endpoints used to evaluate the potential for the use of permethrin to result in direct and indirect effects to the assessed listed species.			
	-SMHM	reproduction of individuals via direct effects	7b. Laboratory mouse chronic NOAEL
	Indirect Effect (prey/habitat from burrows) -Terrestrial-phase CRLF -CCR -SFGS [4] -SMHM [5]	Survival, growth, and reproduction of individuals via indirect effects on terrestrial prey (mammals) and habitat	
8. Terrestrial Invertebrates	Direct Effect -BCB	Survival, growth, and reproduction of individuals via direct effects	8a. Honey bee acute contact LD_{50}
	Indirect Effect (prey) -Terrestrial-phase CRLF -CCR -SFGS -SMHM	Survival, growth, and reproduction of individuals via indirect effects on terrestrial prey (terrestrial invertebrates)	
9. Terrestrial Plants	Indirect Effect (food/habitat) (non-obligate relationship) -Terrestrial-phase CRLF -CCR -SFGS -SMHM	Survival, growth, and reproduction of individuals via indirect effects on food and habitat (*i.e.*, riparian and upland vegetation)	9a. No data available for quantitative evaluation
	Indirect Effect (food/habitat) (obligate relationship) -BCB		

[1] Freshwater fish are used as surrogates for aquatic-phase amphibians.
[2] Birds are used as surrogates for terrestrial phase amphibians and reptiles.
[3] The SMHM has been known to use abandoned birds nests for rearing sites.
[4] Successful SFGS breeding populations are typically found in areas where they can find shelter in rodent burrows.
[5] SMHM has been known to use nests built by Suisun shrews, after the young shrews have dispersed.

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 permethrin that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species 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 assessed species. 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 permethrin effects data are available.

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. Measures of ecological effect used to assess the potential for adverse modification to the critical habitat of the CRLF and BCB are described in **Table 2.14**.

Table 2.14. Summary of assessment endpoints and measures of ecological effect for primary constituent elements of designated critical habitat for CRLF and BCB.

Taxon Used to Assess Modification of PCE	**Assessed Listed Species Associated with the PCE**	**Assessment Endpoints**	**Measures of Ecological Effects**
1. Freshwater Fish and Aquatic-phase Amphibians[1]	Direct Effect – -Aquatic-phase CRLF	Survival, growth, and reproduction of individuals via direct effects	1a. Bluegill sunfish LC_{50} 1b. Estimated bluegill sunfish chronic NOAEC (based on fathead minnow acute-to-chronic ratio)
	Indirect Effect (prey) -Aquatic-phase CRLF	Modification of critical habitat via change in aquatic prey food supply (*i.e.*, fish and aquatic-phase amphibians)	
2. Freshwater Invertebrates	Indirect Effect (prey) -Aquatic-phase CRLF	Survival, growth, and reproduction of individuals via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	2a. Scud EC_{50} 2b. Estimated scud chronic NOAEC (based on fathead minnow acute-to-chronic ratio)
3. Aquatic Plants (freshwater/marine)	Indirect Effect (food/habitat) -Aquatic-phase CRLF	Modification of critical habitat via change in habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Marine algae (*Skeletonema costatum*) EC_{50} 3b. No data available for quantitative evaluation of vascular aquatic plants.
4. Birds, Terrestrial-phase Amphibians, and Reptiles[2]	Direct Effect -Terrestrial-phase CRLF	Survival, growth, and reproduction of individuals via direct effects	4a. Bobwhite quail LC_{50} 4b. Mallard duck LD_{50} 4c. Mallard duck chronic NOAEC
	Indirect Effect (food) -Terrestrial-phase CRLF	Modification of critical habitat via change in terrestrial prey (birds/frogs)	
5. Mammals	Indirect Effect (prey) -Terrestrial-phase CRLF	Modification of critical habitat via change in terrestrial prey (mammals)	5a. Laboratory rat acute LD_{50} 5b. Laboratory mouse chronic NOAEL
6. Terrestrial Invertebrates	Indirect Effect (prey) -Terrestrial-phase CRLF	Modification of critical habitat via change in terrestrial prey (terrestrial invertebrates)	6a. Honey bee acute contact LD_{50}
7. Terrestrial Plants	Indirect Effect (food/habitat) (non-obligate relationship) -Terrestrial-phase CRLF -BCB	Modification of critical habitat via change in food and habitat (*i.e.*, riparian and upland vegetation)	7a. No data available for quantitative evaluation.
	Indirect Effect (food/habitat) (obligate relationship) -BCB		

[1] Freshwater fish are used as surrogates for aquatic-phase amphibians.
[2] Birds are used as surrogates for terrestrial phase amphibians and reptiles.

2.9 Conceptual Model

2.9.1 Risk Hypotheses

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

The labeled use of permethrin within the action area may:

- directly affect the CRLF, CCR, SFGS, SMHM, and BCB by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect the CRLF, CCR, SFGS, SMHM, and BCB and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect the CRLF, CCR, SFGS, and SMHM and/or modify their designated critical habitat by reducing or changing the composition of the aquatic plant community in the species' current range, thus affecting primary productivity and/or cover;
- indirectly affect the CRLF, CCR, SFGS, SMHM, and BCB and/or modify their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;
- indirectly affect the CRLF, CCR, SFGS, and SMHM and/or modify their designated critical habitat by reducing or changing aquatic habitat in their current range (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- 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.

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the permethrin release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for permethrin effects on the CRLF, CCR, SFGS, SMHM, and BCB and their critical habitat in aquatic and terrestrial environments are shown in **Figures 2.9 and 2.10**, respectively. Although the conceptual models for direct/indirect effects and modification of designated critical habitat PCEs are shown on the same diagrams, the potential for direct/indirect effects and modification of PCEs will be evaluated separately in this assessment. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the CRLF, CCR, SFGS, SMHM, and BCB and modification to designated critical habitat is expected to be negligible.

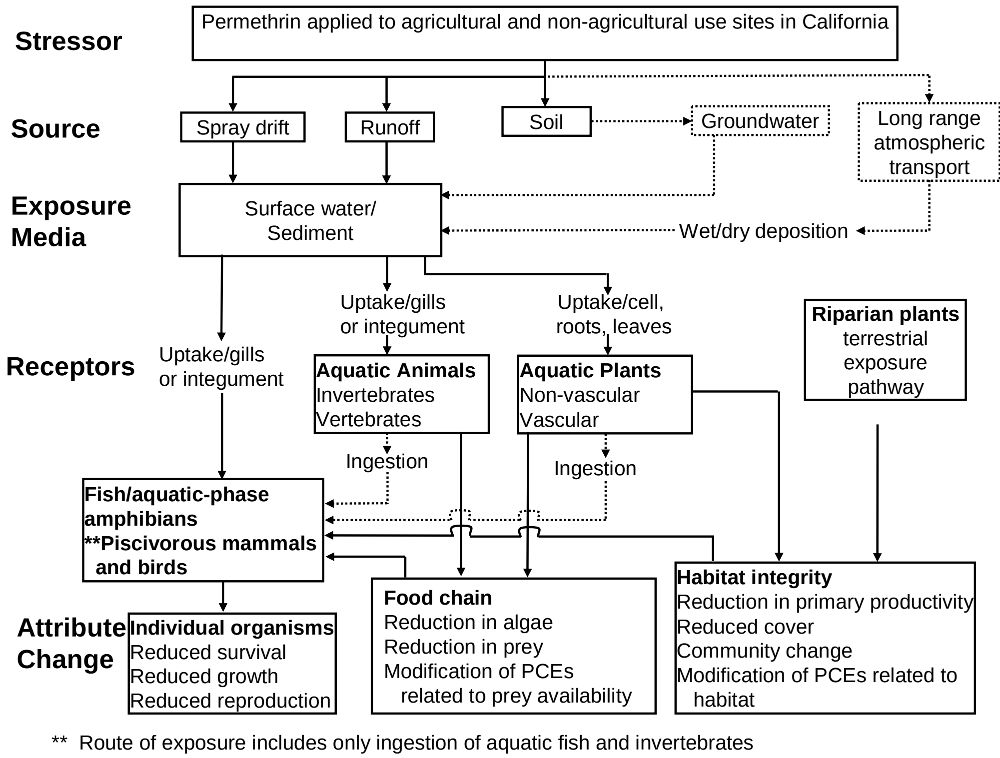


Figure 2.9. Conceptual model for permethrin effects on the assessed species and their critical habitat in aquatic environments.

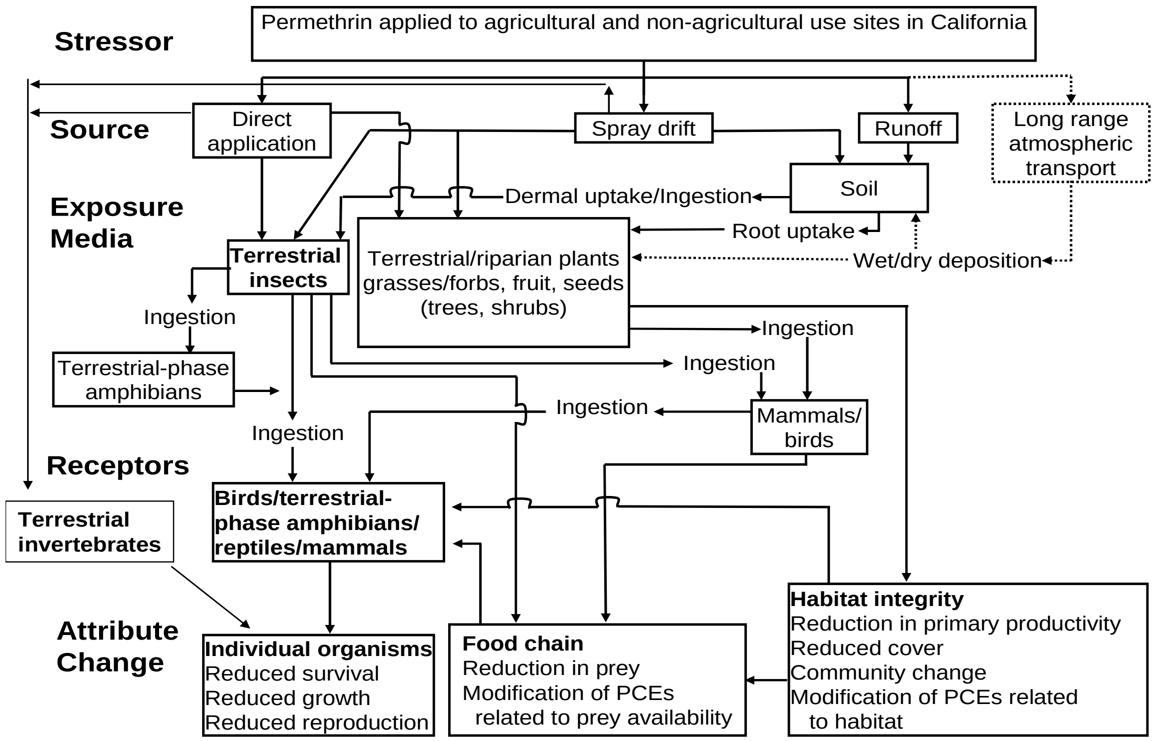


Figure 2.10. Conceptual model for permethrin effects on the assessed species and their critical habitat in terrestrial environments.

2.10 Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the CRLF, CCR, SFGS, SMHM, BCB, prey items, and habitat is estimated based on a taxon-level approach. In the following sections, the use, environmental fate, and ecological effects of permethrin are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (U.S. EPA, 2004), the likelihood of effects to individual organisms from particular uses of permethrin 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 permethrin along with available monitoring data indicate that runoff and spray drift are the principle potential transport mechanisms of permethrin to the aquatic and terrestrial habitats of the CRLF, CCR, SFGS, SMHM, and BCB. The major mechanisms of permethrin transport appear to be surface water runoff, runoff of eroded particles containing the pesticide, and spray drift. Because permethrin has a strong tendency to sorb to soil (based on the Kd/Koc values), the transport of permethrin from the field to water via runoff/erosion is most likely to occur with sediment. Permethrin exposure in water is likely to occur both in the water column and in the pore water/ benthic sediment. In this assessment, transport of permethrin through runoff and spray drift is considered in deriving quantitative estimates of permethrin exposure to the CRLF, CCR, SFGS, SMHM, BCB, their prey, and their habitats.

The limited atmospheric monitoring in California includes ambient air monitoring in Butte County (application) and Monterey County (ambient) in 1997 that coincided with the use of permethrin on lettuce and celery. There were samples above the LOQ in Butte County and detects (>LOD but <LOQ) in Monterey County. The LOD was 0.10 ug/ sample. In addition, permethrin was detected at trace levels to 4.3 ng/ m^3 in Lompoc, Santa Barbara County in 2000.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of permethrin using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/ EXAMS). The model used to predict terrestrial EECs on food items is T-REX. 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 (Aug 2007) to generate daily exposures and 1-in-10 year EECs of permethrin that may occur in surface water bodies adjacent to application sites receiving permethrin 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 permethrin. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10-year 60-day mean is used for assessing chronic exposure to fish; the 1-in-10-year 21-day mean is used for assessing chronic exposure for aquatic invertebrates.

Given the aquatic toxicity of permethrin and its likelihood of occurring in sediment, the Agency also considered the potential exposures resulting from benthic/sediment concentrations (EECs). Pore water concentrations are commonly used to predict toxicity of non-ionic substances in sediments and characterize exposure to organisms that spend time in or near sediments (Di Toro *et al.* 1991; USEPA 2003). PRZM/EXAMS estimates 1-in-10-year peak, 21-day mean, and 60-day mean EECs for pore water.

Exposure estimates for the terrestrial animals assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.3.1, 12/07/2006). This model incorporates the Kenega nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenega, 1972). For the purposes of this assessment, upper-bound Kenaga nomogram estimates reported by T-REX are used for derivation of the EECs for the terrestrial-phase CRLF, CCR, SFGS, SMHM, and BCB and their potential prey.

For granular applications of permethrin, acute exposure and risks to terrestrial wildlife are estimated with the conceptual approach and the LD_{50}/ft^2 method given in the model T-REX. Terrestrial EECs are calculated based on an estimation of loadings of pesticide per unit area (expressed in terms of mg a.i./ft^2) for a single application (multiple applications are not accounted for in this analysis); the available mass of pesticide per square foot is then compared to the acute oral dose for toxicity (LD_{50} values adjusted for body weight and percent body weight consumed) to derive risk quotients for birds and/or mammals. For chronic exposure to granular permethrin, estimation was done by considering direct ingestion of soil invertebrates that have bioconcentrated permethrin residues of granules in soil. This estimation of earthworm concentration was calculated using a fugacity-based (equilibrium partitioning) approach based on the work of Trapp and McFarlane (1995) and Mackay and Paterson (1981).

The T-REX model was used to estimate exposures and risks to avian and mammalian species resulting from permethrin seed treatment. T-REX approximates acute exposure from seed treatment using avian and mammalian Nagy doses (mg ai bw^{-1} day^{-1}), and also utilizes an approach analogous to the LD_{50}/ft^2 analyses done for granular applications. Chronic exposures are estimated based on the maximum seed application rate (mg a.i./kg seed), which can be compared directly to estimated dietary-based chronic dietary toxicity endpoints to estimate risks. The T-REX and fugacity-based models and methodologies, as well as the resulting measures of exposure, are described in greater detail in **Section 3.3**.

Birds are currently used as surrogates for terrestrial-phase amphibians and reptiles. However, amphibians and reptiles are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, amphibians and reptiles 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 and reptiles 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 and reptiles 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.

While the potential for bioaccumulation and magnification of permethrin up the food chain appears to be limited for reasons discussed later on in the document, there is some evidence of the potential for bioconcentration of permethrin in aquatic organisms; therefore, an additional exposure pathway that will be considered in this assessment is the consumption of contaminated fish or aquatic invertebrates that have bioconcentrated permethrin dissolved in water. The potential risk from this pathway will be evaluated and discussed further in **Section 5.2**. A laboratory derived bioconcentration factor (BCF) in fish will be multiplied by predicted water concentrations from PRZM/EXAMS to estimate concentrations of permethrin in aquatic organisms. These estimated tissue concentrations will be compared to toxicity values for various taxonomic groups that may eat aquatic organisms in order to evaluate potential risk. However, given the low solubility of permethrin, a moderate BCF, a high depuration rate, and the fact that permethrin is applied directly to the terrestrial environment, it is expected that exposure of terrestrial organisms (*e.g.,* frogs, birds, snakes, or mammals) to permethrin via consumption of contaminated aquatic organisms should be low relative to exposure via consumption of contaminated terrestrial food items.

EECs for terrestrial plants inhabiting dry and wetland areas are typically derived using TerrPlant (version 1.2.2, 12/26/2006), a model that uses estimates of pesticides in runoff and in spray drift to calculate EECs. However, in the case of permethrin, no acceptable terrestrial plant toxicity data were available to quantitatively evaluate risk, so this model was not run. Instead, risks are discussed qualitatively in **Section 5.2**.

For mosquito adulticide use, permethrin is applied as very small droplets to create a mist which remains suspended over the field to more efficiently target the mosquitoes. Therefore, the chemical is susceptible to drift towards an adjacent body of water. To determine the deposition of the pesticide to adjacent bodies of water, the spray drift model AGDISP (version 8.15) was used. The outputs of interest from AGDISP in this case are the application efficiency (fraction of the material that deposits in the target area under the aircraft), and the fraction of the material that deposits in the designated area or the standard pond. The later is obtained via the "toolbox" Deposition Assessment. These results were subsequently used as input parameters in PRZM/ EXAMS to model the degradation and partitioning in sediment for water bodies that may be exposed to drift from mosquito adulticide. Estimates of application efficiency were also used to adjust application rates input into T-REX for exposure estimates for terrestrial wildlife resulting from mosquito adulticide uses (**Section 3.3**).

To estimate exposure related to releases of permethrin to domestic wastewater treatment, the Agency relied on the Office of Pollution Prevention and Toxics (OPPT) model, Exposure and Fate Assessment Screening Tool (E-FAST, version 2.0, 2007). From this model, the Agency used the "Down-the-Drain" module, which is designed for releases to domestic wastewater treatment. It is suitable for all the sources of permethrin that could potentially be exposed through a "down-the-drain" scenario (permethrin containing products, such as over the counter drugs, prescribed drugs, pre-treated clothing, products for the treatment of clothes and pet products or shampoos). The model provides screening level estimate concentrations of chemicals in surface water that may result from household uses and the disposal of consumer products into wastewater using a few simple input parameters (production volume and fraction of the chemical removed during wastewater treatment).

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, CCR, SFGS, SMHM, and BCB. **Table 2.15** identifies the taxa used to assess the potential for direct and indirect effects from the uses of permethrin for each listed species assessed here. 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 and SFGS makes the assumption that toxicity of permethrin to birds is similar to or less than the toxicity to terrestrial-phase amphibians and reptiles (this also applies to potential prey items). The same assumption is made for fish and aquatic-phase CRLF (again, this also applies to potential prey items).

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 assessed species and their designated critical habitat are associated with impacts to survival, growth, and fecundity, and do not include the full suite of sub-lethal effects used to define the action area. According 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.

Table 2.15. Taxa used in the analyses of direct and indirect effects for the assessed listed species.

Listed Species	Birds [a]	Mammals	Terr [b] Plants [c]	Terr [b] Inverts [d]	FW [e] Fish [f]	FW [e] Inverts [d]	Estuarine /Marine Fish	Estuarine /Marine Inverts [d]	Aquatic Plants
CRLF	Direct Indirect (prey)	Indirect (prey)	Indirect (habitat)	Indirect (prey)	Direct Indirect (prey)	Indirect (prey)	N/A[g]	N/A[g]	Indirect (food/ habitat)
CCR	Direct Indirect (prey)	Indirect (prey)	Indirect (prey and habitat)	Indirect (prey)	Indirect (prey)	Indirect (prey)	Indirect (prey)	Indirect (prey)	Indirect (habitat)
SMHM	Indirect (rearing sites)	Direct Indirect (rearing sites)	Indirect (food, habitat)	Indirect (prey)	N/A[g]	N/A[g]	N/A[g]	N/A[g]	Indirect (habitat)
SFGS	Direct Indirect (prey)	Indirect (prey and habitat)	Indirect (habitat)	Indirect (prey)	Indirect (prey)	Indirect (prey)	N/A[g]	N/A[g]	Indirect (habitat)
BCB	N/A[c]	N/A[c]	Indirect (food/ habitat) [h]	Direct	N/A[g]	N/A[g]	N/A[g]	N/A[g]	N/A[g]

[a] Birds are used as surrogates for terrestrial-phase amphibians and reptiles.
[b] Terr = Terrestrial
[c] No acceptable plant data were available for quantitative use, so analyses were performed only qualitatively.
[d] Inverts = Invertebrate
[e] FW = Freshwater
[f] Fish are used as aquatic-phase amphibians.
[g] Not applicable
[h] Obligate relationship

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 permethrin, and the likelihood of direct and indirect effects to the CRLF, CCR, SFGS, SMHM, and BCB 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 permethrin 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) (**APPENDIX D**).

For this listed species assessment, listed species LOCs are used for comparing RQ values for acute and chronic exposures of permethrin directly to the CRLF, CCR, SFGS, SMHM, and BCB. If estimated exposures directly to the assessed species of permethrin 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 assessed species due to effects to prey, the listed species LOCs are also used. If estimated exposures to the prey of the assessed species of permethrin resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is a “may affect.” If the RQ being considered also exceeds the non-listed species acute risk LOC, then the effects determination is a LAA. If the acute RQ is between the listed species LOC and the non-listed acute risk species LOC, then further lines of evidence (*e.g.* probability of individual effects, species sensitivity distributions) are considered in distinguishing between a determination of NLAA and a LAA. If the RQ being considered for a particular use exceeds the non-listed species LOC for plants, the effects determination is “may affect”. Specifically, any exceedances of the listed species LOC for dicots would also result in an LAA for the BCB due to its obligate relationship with dicots. Further information on LOCs is provided in **APPENDIX D**.

2.10.2 Data Gaps

2.10.2.1 Fate and Transport Data

The environmental fate database is substantially complete. At this time, there are no listed environmental fate data gaps.

2.10.2.2 Ecotoxicity Data

Neither acceptable acute nor acceptable chronic toxicity data for reptiles and amphibians are available for quantitative use for permethrin; therefore, surrogate data are used for estimating toxicity to these taxonomic groups. In addition, although it is recognized that assuming a uniform acute-to-chronic ratio (ACR) across taxonomic groups involves considerable uncertainty, a fathead minnow acute-to-chronic ratio was used to estimate chronic toxicity values for freshwater fish (and subsequently, aquatic-phase amphibians), freshwater invertebrates, estuarine/marine fish, and estuarine/marine invertebrates because no chronic toxicity data are available for the most acutely sensitive freshwater fish species, the chronic toxicity data available for freshwater invertebrates are less sensitive than the most sensitive acute toxicity value, no definitive chronic endpoints have been determined for estuarine/marine fish, and the chronic toxicity data available for estuarine/marine invertebrates are less sensitive than the most sensitive acute toxicity value, respectively (see the “Effects Assessment” section; **Section 4**).

No sediment toxicity studies with permethrin have been submitted to the Agency for quantitative evaluation of risk to benthic organisms. Although exposure of aquatic invertebrates to permethrin in the benthic compartment could be estimated using pore water EECs from PZM/EXAMS, risk estimates could not be generated exclusively for benthic organisms because they are a function of the magnitude of expected exposure as well as toxicity. Instead, for reasons discussed in the “Uncertainties” section of the document (**Section 6.2.1**), quantitative risk estimates made in this assessment for aquatic invertebrates based on toxicity data from water only-exposure studies and water column EECs are expected to be inclusive and sufficiently protective of all aquatic invertebrates for the purposes of this assessment, regardless of the aquatic compartment they typically inhabit; when risks were identified for freshwater and estuarine/marine invertebrates, it was assumed to apply to both benthic and water column-dwelling invertebrates.

Lastly, no acceptable aquatic vascular plant data or terrestrial plant toxicity data are available for quantitative use for permethrin.

3. Exposure Assessment

Permethrin is formulated in various ways (*e.g.* liquid, water dispersible granules, wettable powder, emulsifiable concentrate, liquid, dust, and Ready-to-Use [RTU] formulations). Applications include ground, aerial, granular and ULV, band treatment, incorporated treatment, various sprayers (low-volume, hand held, directed), and spreaders for granular applications. Risks from ground boom and aerial applications are considered in this assessment because they are expected to result in the highest off-target levels of permethrin due to generally higher spray drift levels. Ground boom and aerial modes of application tend to use lower volumes of application applied in finer sprays than applications coincident with sprayers and spreaders and thus have a higher potential for off-target movement via spray drift.

3.1 Label Application Rates and Intervals

Permethrin labels may be categorized into two types: labels for manufacturing uses (including technical grade permethrin and its formulated products) and end-use products. While technical products, which contain permethrin of high purity, are not used directly in the environment, they are used to make formulated products, which can be applied in specific areas to control insects. The formulated product labels legally limit permethrin's potential use to only those sites that are specified on the labels.

This assessment considered the recent mitigation described in the permethrin RED. The mitigation includes reduction in application rates for numerous uses and label language on buffers and spray drift requirements. Buffer zones of 25 and 150 ft are required for ground and aerial applications, respectively. The use of Medium or coarser spray nozzles for ground and non-ULV aerial applications, according to ASAE (S572) is required. Also, restrictions on the boom height are imposed for both ground and aerial applications. Currently registered agricultural and non-agricultural uses of permethrin within California include alfalfa, nut trees, avocado, cole crops, corn, fruit trees, garlic, leafy vegetables, cucurbit vegetables, onions, potato and turnip, row crops, nursery and forestry. In addition, the following non-agricultural uses are included: adulticide (mosquito control), barrier treatment, outdoor perimeter surface spray, ant control (ant mounds), soil treatment and others. The uses being assessed are summarized in **Table 3.1**. A summary of important mitigation measures that affect exposure are included in **APPENDIX C**, **"**Permethrin Post-RED Mitigation Measures and Non-Agriculture Use."

Table 3.1. Permethrin use, scenarios, and application information.									
CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**% DRIFT/ APP. EFFICIEN-CY[1]**	**IPSCND[2]**	**DATE OF 1st APP (day-month)**	**CROP-PING PERIOD**
Agricultural Use Patterns									
Alfalfa	Alfalfa hay and seed crops	CA alfalfa	0.20	5	30	3.9/95	2	01-02	All year
Nut Trees	Pistachio	CA almond	0.3	3	10	3.9/95	1	01-06	Aug – Sept
Avocado	Avocado	CA avocado	0.20	4	7	3.9/95	3	01-02	All year
Cole crop	Broccoli	CA cole crop	0.20	4	5	3.9/95	2	07-01	Jan – Mar
Corn	Corn (pop)	CA corn	0.2	3	5	3.9/95	1	01-05	Apr – Sept
Corn	Corn (sweet)	CA corn	0.2	4	3	3.9/95	1	01-05	Apr – Sept
Forestry	Softwood (conifer), hybrid cottonwood/ poplar	CA Forestry	0.20	N/S, Assumed to be 10	N/S, Assumed to be 5	3.9/95	1	01-02	All year
Fruit tree	Pear	CA fruit tree	1@0.4 and 1@0.25	2	10	3.9/95	1	15-02	All year
Fruit tree	Peach	CA fruit tree	0.25	3	10	3.9/100	1	15-02	All year
Garlic	Garlic	CA garlic	0.20	4	10	3.9/95	3	15-03	Oct – Jul
Leafy vegetables	Major leafy vegetables[4]	CA lettuce	0.2	4	7	3.9/95	3	07-01	Feb – May
Leafy vegetables	Minor leafy vegetables[5]	CA lettuce	0.2	10	3	3.9/95	3	07-01	Feb – May
Cucurbit vegetables	Major cucurbit vegetables[6]	CA melons	0.2	6	7	3.9/95	1	15-05	May – Aug
Cucurbit vegetables	Minor cucurbit vegetables[7]	CA melons	0.24	8	N/S, assumed to be 7	3.9/95	1	15-05	May – Aug

Table 3.1. Permethrin use, scenarios, and application information.									
CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**% DRIFT/ APP. EFFICIEN-CY[1]**	**IPSCND[2]**	**DATE OF 1st APP (day-month)**	**CROP-PING PERIOD**
Nursery	X-mass trees, Nursery stock and Pine seed orchard[8]	CA nursery	0.4	6	28	3.9/95	1	01-03	Mar – Nov
Nursery	Pine seed orchard (current label low rate) [8]	CA nursery	0.75	6	28	3.9/95	1	01-03	Mar – Nov
Nursery	Pine seed orchard (current label high rate) [8]	CA nursery	1.6	6	28	1.0/99	1	01-03	Mar – Nov
Onion	Onion	CA onion	1@0.1 and 3@0.3	4	7	1.0/99	2	15-03	Jan – Jun
Onion	Fennel	CA onion	0.2	10	3	3.9/95	2	15-03	Jan – Jun
Potato	Potato	CA potato	0.2	4	10	3.9/95	1	15-03	Feb – Jun
Row Crops	Celery, artichoke, asparagus, pepper	CA row crop	0.2	5	7	3.9/95	1	15-01	Jan – Apr
Row Crops	Rhubarb, field grown roses	CA row crop	0.2	10	5	3.9/95	1	15-01	Jan – Apr
Tomato	Tomato	CA tomato	0.2	3	7	3.9/95	1	01-03	Mar – Sep
Tomato	Tomatillo	CA tomato	0.2	6	N/S, assumed to be 7	3.9/95	1	01-03	Mar – Sep
Turf	Golf course, recreational areas	CA turf	0.87	6	N/S, Assume 7	1.0/99	3	01-06[3]	All year
Ant mound treatment [9]	Agricultural fruit trees	CA fruit	0.84	4	7	1.0/99	3	01-01	All year
Non-Agricultural Use Patterns									
Mosquito control – Pre-CFR 2005-1	Northern Recreational areas	CA turf	0.007	26	1	51.4/44.9	3	01-06[3]	All year
Mosquito control – Post-CFR 2005-1	Northern Recreational areas	CA turf	0.007	26	1	22.8/2.0	3	01-06[3]	All year

Table 3.1. Permethrin use, scenarios, and application information.

CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	% DRIFT/ APP. EFFICIEN-CY[1]	IPSCND[2]	DATE OF 1st APP (day-month)	CROP-PING PERIOD
Mosquito control – Pre-CFR 2005-1	Northern Agricultural Areas (metfile W93193.dvf)	CA alfalfa	0.007	26	1	51.4/44.9	3	01-06[3]	All year
Mosquito control – Post-CFR 2005-1	Northern Agricultural Areas (metfile W93193.dvf)	CA alfalfa	0.007	26	1	22.8/2.0	3	01-06[3]	All year
Mosquito control – Pre-CFR 2005-1	Central Agricultural Areas (metfile W23232.dvf)	CA alfalfa	0.007	26	1	51.4/44.9	3	01-06[3]	All year
Mosquito control – Post-CFR 2005-1	Central Agricultural Areas (metfile W23232.dvf)	CA alfalfa	0.007	26	1	22.8/2.0	3	01-06[3]	All year
Ant mound Treatment [9]	Non-agricultural areas, turf, recreational areas	CA turf	0.84	4	7	1.0/99	3	01-01	All year
Soil Barrier Treatment	Fencerows and Hedgerows	CA range-land-hay	0.01	10	N/S, assumed to be 7	1.0/99	1	01-01[1]	All year
Soil Barrier Treatment	Range Land	CA range-land-hay	0.1	10	N/S, assumed to be 7	1.0/99	1	01-01[1]	All year
Residential Turf and Ornamentals	Home & Garden	CA residential [10]	4.23	N/S, assumed to be 3	5	1.0/99	1	01-04	All year
Perimeter Treatment	Urban & Rural Structures	CA residential [10]	1.43	N/S, assumed to be 4	N/S, assumed to be 90	1.0/99	1	15-03	All year
Termite Treatment	Urban & Rural Structures	CA residential [10]	0.77	1	None	1.0/99	1	01-02	All year
Garden Vegetables	Home & Garden	CA residential [10]	0.25	6	3	1.0/99	1	15-04	All year
Garden Nuts and Fruits	Home & Garden	CA residential [10]	0.4	5	N/S, assumed to be 10	1.0/99	1	01-04	All year
Garden Nuts and Fruits	Home & Garden	CA residential [10]	0.4	5	10	1.0/98.6	1	01-04	All year

Table 3.1. Permethrin use, scenarios, and application information.									
CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	% DRIFT/ APP. EFFICIEN-CY[1]	IPSCND[2]	DATE OF 1st APP (day-month)	CROP-PING PERIOD
Barrier Treatment	Urban & Rural Structures	CA residential [10]	1@0.08 and 3@0.10	2	N/S, assumed to be 7	1.0/99	1	15-03	All year
Fire Ants Treatment (Granular formulation)	Home & Garden	CA residential [10]	1.00	N/S, assumed to be 4	N/S, assumed to be 7	0.0/1.0	1	01-04	All year
Turf (Granular formulation)	Home & Garden	CA residential [10]	0.33	N/S, assumed to be 3	N/S, assumed to be 7	0.0/1.0	1	01-04	All year
Garden Vegetables(Granular formulation)	Home & Garden	CA residential [10]	0.27	6	3	0.0/1.0	1	01-05	All year

[1]Drift values calculated with AgDRIFT in Tier 1 mode according to 150 ft and 25 ft buffers for aerial, air blast and ground spray applications as directed by product labels. Application Efficiencies were 95% for aerial, 98.6% for airblast and 99% for ground, and 100% for granular ground application.
[2]Flag indicating the disposition of pesticide remaining on foliage after harvest; 1 - pesticide remaining on foliage is converted to surface application, 2 - remaining pesticide on foliage is completely removed, 3- remaining pesticide on foliage is retained as surface residue and continues to undergo decay. Assumptions were made in the absence of specific use information.
[3]Application assumed in the summer.
[4] Lettuce, Brussel sprouts, orach, spinach, New Zealand spinach.
[5] Chinese amaranth, cardoon, celetuce, Swiss chard, chervil chicory, leafy chrysanthemum, corn salad, garden and upland cress, dandelion, dock (scorrel), parsley, purslane (winter and garden), roquette (arugula).
[6] Cucumber, cantaloupe, eggplant, pumpkin, squash, watermelon.
[7] Melons, melons (bitter, balsam pear), citron melon, melons (honeydew, mango, musk and winter "Casaba/ Crenshaw/ Honeydew/ Persian").
[8] The first run covers Christmass trees and nursery stock (0.2 lb a.i/A rate) and the Registrant corrected low rate of pine seed orchards (0.4 lbs a.i. /A). The second run covers the current label low rate (0.75 lbs a.i. /A) while the third run covers the highest rate in the current label (1.6 lb a.i. /A). As per SRRD, the language in the label is to be corrected soon.
[9] Assuming mound application for 80 mounds per acre, reference http://edis.ifas.ufl.edu/UW242 .
[10] Two Scenarios run separately, CA residential and CA Impervious Surfaces with Post Processing of daily time series to obtain 1:10 years EECs.
[11] In the absence of label number of applications and/ or interval between applications, a reasonable high end value was assumed.
[12] CFR 2005-1 imposes various restrictions in the adulticide labels (additional details below), but, at this time, not all the labels have been modified to comply with the CFR. Pre- and Post-CFR 2005-1 runs were calculated.

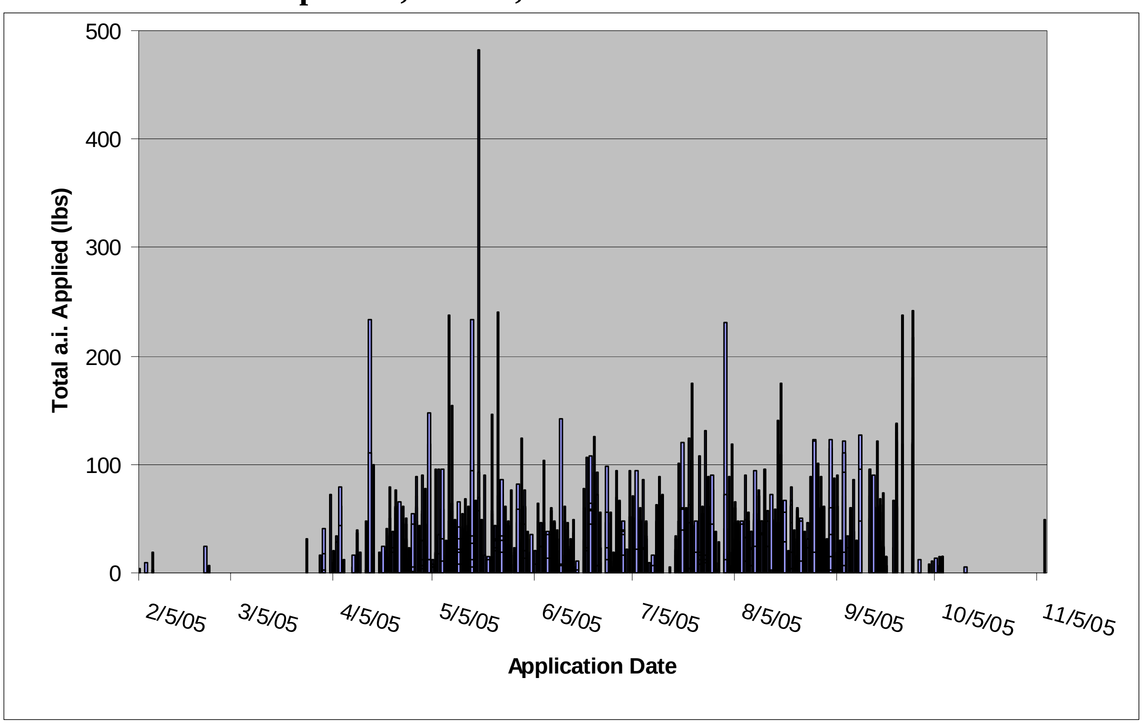
3.2 Aquatic Exposure Assessment

3.2.1 Modeling Approach

Aquatic exposures are quantitatively estimated for all of assessed uses using scenarios that represent high exposure sites for permethrin use. Each of these sites represents a 10 hectare field that drains into a 1-hectare pond that is 2 meters deep and has no outlet. Exposure estimates generated using the standard pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that make these water bodies more or less vulnerable than the standard surrogate pond. Static water bodies that have larger ratios of drainage area to water body volume would be expected to have higher peak EECs than the standard pond. These water bodies will be either shallower or have large drainage areas (or both). Shallow water bodies tend to have limited additional storage capacity, and thus, tend to overflow and carry pesticide in the discharge whereas the standard pond has no discharge. As watershed size increases beyond 10 hectares, at some point, it becomes unlikely that the entire watershed is planted to a single crop, which is all treated with the pesticide. Headwater streams can also have peak concentrations higher than the standard pond, but they tend to persist for only short periods of time and are then carried downstream. Specific uncertainties related to the aquatic and terrestrial modeling are provided in **Section 6.1** Exposure Assessment Uncertainties.

Use-specific management practices for all of the assessed uses of permethrin were utilized for modeling, including application rates, number of applications per year, application intervals, buffer widths and resulting spray drift values modeled from AgDRIFT and AGDISP, and the first application date for each use. The date of first application was developed based on several sources of information including data provided by BEAD, a summary of individual applications from the CDPR PUR data, and Crop Profiles maintained by the USDA. A sample of the distribution of permethrin applications to pistachios from the CDPR PUR data for 2005 used to pick a June 1 application date is shown in **Figure 3.1**. Multiple application dates were simulated between the 5th of May and the 5th of October (30 simulations) and resultant EECs were almost the same. This is expected because of the fact that applications shown in **Figure 3.1** lies within a rainfall scarce period.

Figure 3.1. Summary of application of permethrin to pistachios, a major crop use pattern, in 2005, from CDPR PUR data.



The modeling of the “residential” use patterns requires two PRZM scenarios (CA residential and CA impervious). Both scenarios are run separately. In order to obtain suitable EECs for these use patterns, post-processing of the output data from PRZM/ EXAMS is needed. The *NAME*_TS.out file, which contains the time series of the water column and the sediment concentrations is extracted, and the water column concentrations from each scenario is copied and pasted into an EXCEL file that estimates the actual EECs for the use patterns. The intention is to couple the edge of field concentrations from the impervious scenario with the edge of field concentrations from the residential scenario to generate weighted concentrations for areas of a certain impervious cover.

Equilibrium Partitioning

Permethrin, like other pyrethroids, is a lipophilic compound that can adsorb readily to particulate and sediment (mean Koc = 76,800 L/kg). Due to its soil binding properties and persistence in anaerobic aquatic environments (anaerobic aquatic metabolism half-life ranges from 113 to 175 days, respectively), sediment can act as a reservoir for permethrin, thereby increasing its toxic exposure in the benthos of aquatic systems.

To evaluate the potential for exposure to permethrin in this aquatic compartment relative to permethrin dissolved in the water column, PRZM/EXAMS has been employed to generate exposure estimates. The basis for this estimation is grounded in the Agency's Equilibrium Partitioning Sediment Guidelines (ESG) under the Clean Water Act [CWA Section 304(a)(2)] and the equilibrium partitioning theory (EqP). The EqP theory holds that a nonionic compound in the sediment partitions between sediment organic carbon, interstitial (pore) water and benthic organisms (Di Toro *et al.*, 1991, USEPA, 2003). At equilibrium, if the concentration in any phase is known, then the concentration in the other phases can be predicted through the organic/ carbon soil partition coefficient. Since the EXAMS model is capable of employing the equilibrium partitioning theory in order to predict concentrations of nonionic chemicals in pore water through the use of a chemical's k_{oc}, EFED has estimated permethrin sediment exposure to benthic organisms by calculating pore water exposure values using the PRZM/EXAMS model. Exposure estimates for permethrin dissolved in the pore water relative to the water column, and any associated uncertainties will be discussed and characterized qualitatively in the "Uncertainties" section of the document (**Section 6.2.1**).

Adulticide Use

Permethrin is used in certain instances to control adult mosquitoes, black flies, and midges in residential and recreational areas such as, but not limited to parks, campsites, woodlands, athletic fields, golf courses, garden playgrounds, recreational areas, etc. Some of these use sites could involve exposure to various types of bodies of water. Furthermore, permethrin may be applied as an adulticide to a number of crops.

Mosquito adulticides are more efficacious if they come into contact with insects in flight. For that reason, mosquito abatement using permethrin (as well as other mosquito adulticides) is typically applied via aerial spray methods with very fine droplets or mists, to prevent immediate deposition of the pesticide. The modeling approach for this type of use includes calculations of spray drift using the AGricultural DISPersal model (AGDISP v. 8.15). This model/ computer program estimates the deposition of the pesticide to the treated area, and, by means of its toolbox "deposition assessment," to the adjacent bodies of water (*i.e.* the standard pond), the value of spray drift is obtained. In other words, AGDISP estimates the application efficiency and downwind deposition or spray block deposition (to the water body, equivalent to the spray drift). AGDISP provides a better prediction of spray drift under circumstances where a mosquito adulticide is used.

Down-the-drain Assessment

The issue of household wastewaters releases of permethrin was first raised by Tri-TAC[4], a technical advisory group, comprised by public and private wastewater professionals focusing on regulatory issues of interest to POTWs in California. In a letter at the time, Tri-TAC asked the California Department of Pesticide Regulation to require registration of pre-treated clothing. They raised concerns that clothes pretreated with permethrin may cause adverse water quality impacts.

In order to address the issue of permethrin release to domestic wastewater, the Agency relied on the Office of Pollution Prevention and Toxics (OPPT) consumer exposure model, Exposure and Fate Assessment Screening Tool (E-FAST, v. 2.0) (USEPA, 2007). The Down-the-Drain module of E-FAST v.2.0 is specifically designed to address all sources of permethrin that could potentially be disposed to domestic wastewater from a "down-the-drain" application. This model provides screening-level estimate of chemical residues in surface water that may result from household uses and the disposal of these consumer products into wastewater. The module uses input parameters that include the annual production volume of the pesticide and takes into account the fraction of the chemical removed during wastewater treatment. The model assumes that in a given year, the entire production volume of the chemical is parceled out on a daily per capita basis to the US population and converted to a mass release per capita (*e.g.* g/person/day). This mass is diluted into the average daily volume of wastewater released per person per day to arrive to an estimated concentration in wastewater prior to entering a treatment facility. The chemical (permethrin) concentration in untreated wastewater is then reduced by the fraction removed during wastewater treatment before release into a river or stream. The remaining chemical is discharged into surface water, where it is assumed that it is instantaneously diluted, with no further removal. A Stream Dilution Factor is the volume of the receiving stream flow divided by the volume of the wastewater released from the Publicly Owned Treatment Works (POTW). For ecological effects, surface water concentrations are based on the following flows:

SF_{1Q10} – Single day of lowest flow over a 10-year period (appropriate for acute surface water concentrations to compare with concentrations of concern for aquatic life).
And,
SF_{30Q5} – Thirty consecutive days of lowest flow over a 5-year period (appropriate for chronic surface water concentrations to compare with the concentrations of concern for aquatic life).

The underlying equations used by the 'down-the-drain' module are:

[4] Tri-TAC is a jointly sponsored by the California Association of Sanitation Agencies, the California Water Environment Association and the League of California Cities. According to the letter, the constituency base for Tri-TAC serves most of the sewered population of California.

$$H_R = \frac{PV}{Pop} \times 1000\ g/kg \times CF1, \quad \text{where,}$$

H_R = daily per capita release
PV = production volume
Pop = 2003 U.S. resident population (2.908×10^8 persons) (U.S. Bureau of the Census, 2004-2005)
CF1 = conversion factor – year/365 days

$$SWC = \frac{H_R \times 1/Q_H \times (1\text{-}WWT) \times CF2}{SDF}, \quad \text{where,}$$

SWC = surface water concentration
SDF = stream dilution factor
CF2 = conversion factor 10^6 ug/g

For SWC_{median} (median time averaged SWC), the stream dilution factor (SDF) is the 50th percentile SDF, while for SWC_{high} (high end time averaged SWC), the SDF is the 10th percentile value.

3.2.2 Model Inputs

3.2.2.1 Agricultural and Non-Agricultural Uses Modeling Inputs

Permethrin is an insecticide used on a wide variety of food and non-food crops. Permethrin environmental fate data used for generating model parameters is listed in **Table 2.2**. The input parameters for PRZM and EXAMS appear in **Table 3.2**.

Table 3.2. Summary of PRZM/ EXAMS environmental fate data used for aquatic exposure inputs for permethrin listed species assessment for the CRLF and SF Bay species.

Fate Property	Value (unit)[2]	MRID (or source)
Molecular Weight	391.30 g/mole	Extoxnet data base http://extoxnet.orst.edu/pips/permethr.htm Accessed 05/01/08
Henry's Law constant	1.4×10^{-6} atm-m^3/mol	Calculated with s=0.0055 mg/L and VP=1.5×10^{-8} mmHg
Vapor Pressure	1.48×10^{-8} mmHg	MRID 42109801
Solubility in Water	0.055 mg/L	Open lit.[1] Wollerton, 1987, as cited in Laskowski, 2002. Set to 10x the solubility limit of 0.0055 mg/L
Photolysis in Water	80 days	MRID 40242801; Additional information reviewed 02/24/89: Tett. Lett. 35.3045.1976: J. Ag. Food Chem. 26(3):590, 1978
Aerobic Soil Metabolism Half-lives	111 days	MRID 42410002; three times the available value of 37 days

Table 3.2. Summary of PRZM/ EXAMS environmental fate data used for aquatic exposure inputs for permethrin listed species assessment for the CRLF and SF Bay species.		
Fate Property	**Value (unit)[2]**	**MRID (or source)**
Hydrolysis	0	Permethrin is stable to hydrolysis at pH 7
Aerobic Aquatic Metabolism (water column)	48.2 days	MRID 43938201; Upper 90% confidence interval for n≥2 ($t_{½}$ = 38 and 43 days; mean = 40.5; std. dev. = 3.536 days)
Anaerobic Aquatic Metabolism (benthic)	239.4 days	MRID 43982001; Upper 90% confidence interval for n≥2 ($t_{½}$ = 175 and 113 days; mean = 144 days; std. dev. = 43.841 days)
K_{OC}	76,800	MRID 41868001; Average value
Application rate and frequency	Refer to **Table 3.1**	Maximum label rates; calculated by dividing maximum allowed application per season by application rate from maximum label application
Application intervals	Refer to **Table 3.1**	Label information
Application date	Refer to **Table 3.1**	Metadatafiles and label
Chemical Application Method (CAM)	2	2 = linear foliar based on crop canopy
Application Efficiency	0.95, 0.99	For aerial and ground applications, respectively
Spray Drift Fraction[1]	0.039; 0.01	For aerial and ground applications, respectively
Application type and depth of incorporation	aerial or ground app, 0.0 in.	Label information
FEXTRC (foliar extraction)	0.5	Agency guidance[2]
UPTKF (Uptake factor)	0	Agency guidance[2]
PLVKRT (Volatilization rate from foliage)	0	Agency guidance[2]
PLDKRT (Foliage pesticide half-life)	0 $days^{-1}$	Agency guidance[2]

1 – Spray drift not included in final EEC due to edge-of-field estimation approach
2 – Inputs determined in accordance with EFED "*Guidance for Chemistry and Management Practice Input Parameters for Use in Modeling the Environmental Fate and Transport of Pesticides*" dated February 28, 2002

Table 3.1 provides the application date, the disposition of pesticide remaining on foliage after harvest (IPSCND), the percent drift, and the application efficiency utilized for each crop or scenario. The percent drift was determined by means of the model AgDRIFT (except for the adulticide applications, where AGDISP was used). As indicated in **Table 3.2**, all input parameters were selected according to current guidance. For the aerobic and anaerobic aquatic metabolism, two values were available and the 90% upper confidence interval was calculated. For the aerobic soil metabolism, to account for the uncertainty related to the fact that only one value was available, 3x the value was used as input to the model. In order to obtain pore water EECs, the "Write Benthic pore water concentrations" option of the PE5.pl shell is activated.

3.2.2.2 Adulticide Uses Modeling Inputs

For the adulticide use, most of the labels available for permethrin have new specifications on various parameters that may affect the exposure to adjacent bodies of water. This was done after PR Notice 2005-1 was issued. According to the PR Notice, certain restrictions in the droplet size are required. Explicit droplet size specifications appear in the new labels. Furthermore, the altitude of aerial applications is also specified. Prior to the issue of the PR Notice and the EFED RED Chapter in 2006, the labels did not have specifications about the interval between applications or the number of applications per year, or the boom or release height. A buffer zone of 100 ft to protect the bodies of water appeared in the old labels. It was proven in the RED Chapter that the 100 ft buffer zone did not affect substantially the exposure. The sample label selected for modeling was BIOMIST® 4+4 ULV. It contains 4.00% permethrin and 4.00% piperonyl butoxide (PBO). Only aerial applications were modeled because it appears that they bring more exposure. The maximum application rate is 0.007 lb a.i./A/application and 0.18 lb a.i./A/year (equivalent to 26 applications per year). This same number of applications was utilized for the modeling of both Pre- and Post-PR Notice 2005-1 because 26 is the maximum number of applications allowed in PRZM/ EXAMS. BIOMIST® 4+4 ULV is a ready to use adulticide; the flow rate for an application rate of 0.007 lb a.i./A is 3.0 fl oz product/A. According to the label, the spray equipment must be adjusted so that the $D_{V0.5}$ is less than 60 µm (half of the volume is contained in droplets smaller than 60 µm). In addition, the label specifies that the $D_{V0.9}$ is smaller than 115 µm, meaning that 90% of the volume is contained in droplets smaller than 115 µm. It has previously been shown (in previous assessments) that the exposure to an adjacent pond decreases with increasing boom height; therefore, the lowest boom height allowed in the label was selected. For aerial applications, the altitude or boom height is specified at 75-300 ft. A boom height of 75 ft was selected. The wind speed is specified at greater than 1 mph (to avoid temperature inversions). Furthermore, air temperatures should be greater than 50°F when conducting all types of applications. A boom height of 25 ft was selected to represent the labels issued prior to PR Notice 2005-1 (**Table 3.3**).

Two scenarios were modeled, CA turf (to represent uses such as parks, golf courses and recreational areas) and CA alfalfa with the recommended metfile and with metfile w23232.dvf (representative of crop uses). The temperature and relative humidity were selected to simulate those conditions where mosquitoes grow (85°F and 90% relative humidity). A wind speed of 10 mph was selected. The spray material was “oil” and its specific gravity is 0.867 (information that was obtained from the MSDS for the product). A low evaporation rate was assumed and the volatile fraction was kept at a minimum. The spray volume was 0.0234 gal/A (obtained from the label (3.0 oz/A). No canopy was assumed (more suitable to estimate the deposition). Generally, the remaining input parameters in AGDISP were kept at their default value (unless otherwise specified). In order to obtain the level of drift, the toolbox “Deposition Assessment” was utilized. The dimensions of the standard pond are entered in the toolbox, and the return is the “effective” application rate on the standard pond. By dividing the output of the toolbox by the application rate of the product, the fraction of drift is obtained. This is the input value utilized in PRZM/EXAMS.

Table 3.3 shows the input parameters utilized in AGDISP and **Table 3.4** shows the input parameters for PRZM/ EXAMS specifically used for the adulticide modeling.

Table 3.3. Input parameters for AGDISP for permethrin.

Parameter	**Value**
Aircraft type	Air tractor AT-401, fixed wing
Swath width	60 ft
Wing semispan	24.5 ft
Swath displacement	0 ft
Propeller rpm	2000, propeller rad. 4.5 ft
Fixed wing	1 engine
Flight lines	20
Flight speed	120 mph
Boom height	75 ft
Number of nozzles	42
Vortex decay rate	1.25 mph
Aircraft drag coefficient	0.1
Propeller efficiency	0.8
Ambient pressure	29.91 in Hg
Planform area	294 ft^2
Nozzle spacing (even)	0.78 ft
Wind speed	10 mph
Wind direction	90°, perpendicular to flight path
Surface roughness	0.0075 ft
Canopy roughness	0.07 ft (grass)
Stability	Overcast
Relative humidity	90%
Temperature	85°F
Droplet type	User defined
$D_{v0.1}$	16.44
$D_{v0.5}$	61.24
$D_{v0.9}$	140.89
Relative span	2.03
<141 µm	90.03%
Spray material	Oil
Specific gravity	0.867
Active fraction	0.04
Nonvolatile fraction	0.96
Spray volume	0.0234 gal/A
Evaporation rate	1 μm^2/°C/sec
Buffer zone	N/A
Downwind water body width	208.7
Average depth	6.6 ft ~ 2 m

For the most part, the input parameters in PRZM/EXAMS for adulticide use are the same as the ones mentioned in **Table 3.2**, except the ones mentioned in **Table 3.4**.

Table 3.4. PRZM/EXAMS input parameters for permethrin use as adulticide.			
Parameter	**Value & Units**		**Source**
Label Specifications	Before PR Notice 2005-1	After PR Notice 2005-1	
Initial ave. deposition	0.0036 lb/A	0.0016 lb/A	AGDISP
Spray drift fraction	0.514	0.228	AGDISP
Application efficiency	0.449	0.020	AGDISP
Application rate	0.007 lb a.i./A = 0.0079 kg a.i./ha		Product label
Number of applications	26		Product label
Interval between applications	1 day		Product label
Date of first application	01-06		Close to summertime, period of highest insect pressure
PRZM scenario	CATurfRLF.txt		PE5.pl
Metfile	W23234.dvf		PE5.pl
PRZM scenario	CAalfalfa_WirrigOP.txt		PE5.pl
Metfile	W93193.dvf		PE5.pl
PRZM scenario	CAalfalfa_WirrigOP.txt		PE5.pl
Metfile	w23232.dvf		Alternate metfile

3.2.2.3 Down-the Drain Modeling Inputs

Removal of Permethrin – Information on the degree of removal of permethrin from wastewater at POTWs is scarce. The EPA's National Risk Management Research Laboratory keeps a Treatability database with information on the removal of certain chemicals.[5] The removals of permethrin from three pesticide manufacturers in the pretreatment systems, employing granular activated carbon and resin adsorption were 52%, 75% and 94%. For permethrin, granular carbon and resin adsorption is considered the best technology economically achievable (USEPA, 1993, as cited in TriTAC letter). Since the values of removal varied widely depending on the removal techniques, as described earlier, The Agency used best available data in risk assessment.

Production Volume – The production volume is an estimate of the mass of a chemical that may be discharged annually in the USA to wastewater by consumers. The production volume of permethrin for the specific uses included in the "down-the-drain" assessment was based on unpublished marketing data, partly from the U.S. Food and Drug Administration, and partly from Confidential Business Information (CBI) provided by the registrants. Available, but sensitive marketing data indicated that on the average

[5] Information on the database at www.epa.gov/NRMRL/treat.htm .

basis about 60,900 kg a.i. permethrin per year are used for pet products, products to treat clothes, pretreated clothing, over the counter (OTC) drugs and prescribed drugs. Aproximately 10% of this value is related to OTC and prescribed drugs.

Bioconcentration Factor – The value of 610X, that represents the maximum one for whole fish, was utilized.

3.2.3 Results

3.2.3.1 Agricultural, Non-Agricultural, and Adulticide Applications

The water column EECs generated by PRZM/ EXAMS for the various scenarios and application practices considered in this assessment are listed in **Table 3.5**. An example output from PRZM/ EXAMS is available in **APPENDIX E**. For the agricultural use patterns, the peak water column EECs ranged from 0.162 ppb for CA onion (application rate 1 lb a.i./A/season) to 5.50 ppb (the solubility limit for permethrin) for CA nursery (application rate 1.6x6 lb a.i./A-pine seed orchard-high rate). Two other possible scenarios for CA nursery (pine seed orchard-low rate and Christmas trees), yielded high peak EECs (5.50 ppb), but the 21- and 60-day values were lower than for the pine seed orchard-high rate. For the non-agricultural patterns, the peak EECs ranged from 0.0447 ppb for barrier treatment (fencerows and hedgerows, application rate 0.01x10 lb a.i.A), to 5.50 for residential turf and ornamentals (application rate 4.23x3 lb a.i./A). It appears that there is a correlation between the application rate and the peak EECs within the same crop scenario (not linear). There is some correlation between the peak EECs and the application rates for different scenarios if all results are considered, but there is a high variability (*e.g.* at an application rate of 0.2x2 lb a.i./A, the peak EEC is 0.527 ppb for fennel (CA onion scenario), and 4.74 ppb for forestry).

The pore water EECs for the various scenarios and application practices are listed in **Table 3.6**. The pore water EECs ranged from 0.00364 ppm for barrier treatment to 1.62 ppb for nursery-pine seed orchard-high rate. The pore water EECs were invariably smaller than the corresponding water column EECs, but the degree appears to be variable. In most instances, the pore water EECs were relatively steady with time (*e.g.* for CA tomato scenario (at an application rate of 0.2x6 lb a.i./A), the peak pore water EEC is 0.0492 ppb, the 21-day value is 0.0487 ppb, and the 60-day value is 0.0475 ppb – a variation of only 3%, compared to the peak EEC).

Table 3.5. Water column EECs (µg/L) for permethrin uses in California.

Use pattern	Application Rate lb a.i./A	Date of First Application	Peak EEC	21-day average EEC	60-day average EEC
Agricultural Use Patterns					
Alfalfa Hay and seed crops	0.2x5	01-02	0.437	0.0967	0.0853
Nut Trees	0.3x3	01-06	0.629	0.159	0.114

Table 3.5. Water column EECs (µg/L) for permethrin uses in California.					
Use pattern	Application Rate lb a.i./A	Date of First Application	Peak EEC	21-day average EEC	60-day average EEC
Avocado	0.2x4	01-02	0.660	0.149	0.112
Cole Crops	0.2x4	07-01	0.908	0.287	0.235
Corn (pop)	0.2x3	01-05	0.465	0.152	0.106
Corn (sweet)	0.2x4	01-05	0.582	0.203	0.142
Forestry	0.2x10	01-02	4.74	1.17	0.910
Fruit Trees (Pear)	0.4+0.25	15-02	0.504	0.113	0.0776
Fruit trees (others)	0.25x3	15-02	0.759	0.119	0.0693
Garlic	0.2x4	15-03	0.479	0.145	0.116
Major leafy vegetables	0.2x4	07-01	1.56	0.402	0.319
Minor leafy vegetables	0.2x10	07-01	3.54	0.980	0.772
Major cucurbit vegetables	0.2x6	15-05	0.441	0.141	0.115
Minor cucurbit vegetables	0.24x8	15-05	0.557	0.198	0.179
X-mass trees, Nursery stock and Pine seed orchard	0.4x6	01-03	5.50[1]	1.18	0.849
Pine seed orchard (current label low rate)	0.75x6	01-03	5.50[1]	2.22	1.59
Pine seed orchard (current label high rate)	1.6x6	01-03	5.50[1]	4.58	3.15
Onion	0.1+0.3x3	15-03	0.162	0.0447	0.0294
Fennel	0.2x10	15-03	0.527	0.271	0.193
Potato and Turnip (root crop)	0.2x4	15-03	0.414	0.101	0.0765
Row crops 1 [2]	0.2x5	15-01	0.648	0.216	0.173
Row crops 2 [3]	0.2x10	15-01	1.09	0.389	0.331
Tomato	0.2x3	01-03	0.414	0.105	0.0634
Tomatillo	0.2x6	01-03	0.447	0.145	0.120
Golf course, recreational areas Turf	0.87x6	01-06	0.571	0.204	0.175

Table 3.5. Water column EECs (µg/L) for permethrin uses in California.					
Use pattern	**Application Rate lb a.i./A**	**Date of First Application**	**Peak EEC**	**21-day average EEC**	**60-day average EEC**
Ant mound Treatment in Agricultural fruit trees	0.84x4	01-01	0.539	0.179	0.126
Non-Agricultural Use Patterns					
Northern Recreational areas Pre-CFR 2005-1	0.007x26	01-06	0.496	0.385	0.268
Northern Recreational areas Post-CFR 2005-1	0.007x26	01-06	0.221	0.171	0.119
Northern Agricultural Areas Pre-CFR 2005-1	0.007x26	01-06	0.452	0.342	0.223
Northern Agricultural Areas Post-CFR 2005-1	0.007x26	01-06	0.200	0.151	0.0982
Central Agricultural Areas Pre-CFR 2005-1	0.007x26	01-06	0.472	0.361	0.242
Central Agricultural Areas Post-CFR 2005-1	0.007x26	01-06	0.208	0.159	0.106
Ant mound Treatment in turf	0.84x4	01-01	0.598	0.191	0.146
Fencerows and Hedgerows Soil Barrier Treatment	0.01x10	01-01	0.0447	0.00932	0.00714
Range land Soil Barrier Treatment	0.1x10	01-01	0.448	0.0932	0.0715
Residential Turf and Ornamentals	4.23x3	01-04	5.50[1]	1.166	0.616
Residential Perimeter Treatment	1.43x4	15-03	1.814	0.325	0.206
Residential Termite Treatment	0.77x1	01-02	0.454	0.077	0.042
Home Garden Vegetables	0.25x6	15-04	0.329	0.089	0.046
Home Garden Nuts and Fruits (ground treatment)	0.40x5	01-04	0.506	0.095	0.063
Garden Nuts and Fruits (Air blast treatment)	0.40x5	01-04	0.506	0.095	0.063

Table 3.5. Water column EECs (µg/L) for permethrin uses in California.					
Use pattern	**Application Rate lb a.i./A**	**Date of First Application**	**Peak EEC**	**21-day average EEC**	**60-day average EEC**
Residential Barrier Treatment	0.09+0.10	15-03	0.195	0.030	0.016
Home Garden Fire Ants Treatment (Granular)	1x4	01-04	1.534	0.253	0.130
Residential Turf (Granular formulation)	0.33x3	01-04	0.505	0.076	0.038
Home Garden Vegetables(Granular formulation)	0.27x6	01-05	0.413	0.053	0.029

[1]Limited by the solubility of permethrin in water.
[2] Row crops 1 includes: Celery, artichoke, asparagus and pepper
[3] Row crops 2 includes: Rhubarb and field grown roses

Table 3.6. Pore water EECs (µg/L) for permethrin uses in California.					
Use Pattern	Application Rate lb a.i./A	Date of First Application	Peak EEC	21-day average EEC	60-day average EEC
Agricultural Use Patterns					
Alfalfa Hay and seed crops	0.2x5	01-02	0.0435	0.0428	0.0418
Nut Trees	0.3x3	01-06	0.0503	0.0497	0.0480
Avocado	0.2x4	01-02	0.0484	0.0479	0.0465
Cole Crops	0.2x4	07-01	0.123	0.123	0.120
Corn (pop)	0.2x3	01-05	0.0532	0.0526	0.0507
Corn (sweet)	0.2x4	01-05	0.0709	0.0701	0.0676
Forestry	0.2x10	01-02	0.480	0.476	0.466
Fruit Trees (Pear)	0.4+0.25	15-02	0.0310	0.0307	0.0298
Fruit trees (others)	0.25x3	15-02	0.0266	0.0264	0.0257
Garlic	0.2x4	15-03	0.0541	0.0540	0.0536
Major leafy vegetables	0.2x4	07-01	0.164	0.163	0.160
Minor leafy vegetables	0.2x10	07-01	0.398	0.395	0.388
Major cucurbit vegetables	0.2x6	15-05	0.0473	0.0462	0.0438
Minor cucurbit vegetables	0.24x8	15-05	0.0741	0.0723	0.0689
X-mass trees, Nursery stock and Pine seed orchard	0.4x6	01-03	0.431	0.426	0.418
Pine seed orchard (current label low rate)	0.75x6	01-03	0.809	0.800	0.785
Pine seed orchard (current label high rate)	1.6x6	01-03	1.62	1.60	1.57
Onion	0.1+0.3x3	15-03	0.0129	0.0127	0.0123
Fennel	0.2x10	15-03	0.0767	0.0760	0.0737
Potato and Turnip (root crop)	0.2x4	15-03	0.0306	0.0302	0.0294
Row crops 1 [2]	0.2x5	15-01	0.0850	0.0843	0.0827
Row crops 2 [3]	0.2x10	15-01	0.168	0.167	0.163

Table 3.6. Pore water EECs (µg/L) for permethrin uses in California.					
Use Pattern	**Application Rate lb a.i./A**	**Date of First Application**	**Peak EEC**	**21-day average EEC**	**60-day average EEC**
Tomato	0.2x3	01-03	0.0252	0.0249	0.0243
Tomatillo	0.2x6	01-03	0.0492	0.0487	0.0475
Golf course, recreational areas	0.87x6	01-03	0.0815	0.0805	0.0783
Ant mound Treatment in Agricultural fruit trees	0.84x4	01-01	0.0581	0.0514	0.0510
Non-Agricultural Use Patterns					
Northern Recreational areas Pre-CFR 2005-1	0.007x26	01-06	0.116	0.115	0.111
Northern Recreational areas Post-CFR 2005-1	0.007x26	01-06	0.0515	0.0509	0.0494
Northern Agricultural Areas Pre-CFR 2005-1	0.007x26	01-06	0.0896	0.0873	0.0823
Northern Agricultural Areas Post-CFR 2005-1	0.007x26	01-06	0.0394	0.0384	0.0361
Central Agricultural Areas Pre-CFR 2005-1	0.007x26	01-06	0.101	0.0991	0.0944
Central Agricultural Areas Post-CFR 2005-1	0.007x26	01-06	0.0442	0.0434	0.0413
Ant mound Treatment in turf	0.84x4	01-01	0.0671	0.0666	0.0657
Fencerows and Hedgerows Soil Barrier Treatment	0.01x10	01-01	0.00364	0.00361	0.00354
Range land Soil Barrier Treatment	0.1x10	01-01	0.0364	0.0361	0.0355
Residential Turf and Ornamentals	4.23x3	01-04	NA	NA	NA
Residential Perimeter Treatment	1.43x4	15-03	NA	NA	NA
Residential Termite Treatment	0.77x1	01-02	NA	NA	NA
Home Garden Vegetables	0.25x6	15-04	NA	NA	NA

Table 3.6. Pore water EECs (µg/L) for permethrin uses in California.					
Use Pattern	Application Rate lb a.i./A	Date of First Application	Peak EEC	21-day average EEC	60-day average EEC
Home Garden Nuts and Fruits (ground treatment)	0.40x5	01-04	NA	NA	NA
Garden Nuts and Fruits (Air blast treatment)	0.40x5	01-04	NA	NA	NA
Residential Barrier Treatment	0.09+0.10	15-03	NA	NA	NA
Home Garden Fire Ants Treatment (Granular)	1x4	01-04	NA	NA	NA
Residential Turf (Granular formulation)	0.33x3	01-04	NA	NA	NA
Home Garden Vegetables(Granular formulation)	0.27x6	01-05	NA	NA	NA
NA = Not Available					

3.2.3.2 "Down-the-Drain" Assessment

The "down-the-drain" model results are presented in **Table 3.7**. As expected, the higher concentrations are related to the lower level of removal. The acute concentrations ranged from 0.09 ppb for a level of removal of 94% (highest value) to 0.71 ppb for a level of removal of 52% (lowest value). The chronic concentrations ranged from 0.05 to 0.39 ppb and the dilution factor is 1.80. As indicated earlier (**Section 3.2.1**), the SF_{1Q10} flow is related to the acute concentrations and the SF_{30Q5} flow is related to the chronic concentrations.

Table 3.7. Surface water concentrations modeled by E-FAST.		
Level of Removal	Acute Concentration/ppb [1]	Chronic Concentration/ppb[2]
52%	0.71	0.39
75%	0.37	0.21
94%	0.09	0.05

[1] SF_{1Q10} (Dilution Factor=1.00): Single day of lowest flow over a 10-year period (appropriate for acute surface water concentrations to compare with concentrations of concern for aquatic life).
[2] SF_{30Q5} ((Dilution Factor=1.80): Thirty consecutive days of lowest flow over a 5-year period (appropriate for chronic surface water concentrations to compare with the concentrations of concern for aquatic life).

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. Included in this assessment are permethrin data from the USGS NAWQA program (http://water.usgs.gov/nawqa) and data from the California Department of Pesticide Regulation (CDPR). In addition, air monitoring data for permethrin are summarized.

Permethrin has a limited set of surface water monitoring data relevant to the CRLF assessment. No surface water monitoring studies which specifically targeted permethrin use (application period and/or sites) were available for analysis as part of this assessment. Generally, targeted monitoring data are collected with a sampling program designed to capture, both spatially and temporally, the maximum use of a particular pesticide. Because none of the available regional monitoring studies were designed specifically for permethrin, they are considered 'non-targeted.' Typically, sampling frequencies employed in 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 application times and/or areas limit the utility of these data in estimating exposure concentrations for risk assessment. Monitoring data can be used to set lower bounds on the occurrence in the environment, since concentrations were at least as high as those found in the monitoring studies. For these reasons, baseline risk assessments rely on model-generated values for estimating acute and chronic exposure values, and the non-targeted monitoring data are typically used for qualitative characterizations.

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 August 22, 2008 and all data for the State of California were evaluated. A total of 52 sediment and 2148 surface water samples were analyzed for cis- (all samples) and trans-permethrin (sediment samples only). Of these samples, 2 (3.8 %) sediment samples had positive detections, one of cis- and one of trans-permethrin in the San Joaquin-Tulare Basin area. In addition, 23 (1.1%) surface water samples had positive detections of cis-permethrin. The maximum surface water concentration detected was 0.146 µg/L in a Culvert discharge to Mustang C A Monte Vista Ave. Reported levels of detection (LODs) were approximately 5-10 ug/kg for sediment samples, and 0.005-0.15 µg/L for water samples.

3.2.4.2 USGS NAWQA Groundwater Data

Ground water monitoring data from the United States Geological Survey (USGS) NAWQA program was accessed on August 22, 2008 and all data for the State of California were evaluated. A total of 689 ground samples were analyzed for cis-permethrin. Of these samples, 0 (0.0%) had positive detections of permethrin. Reported levels of detection (LODs) were approximately 0.005 µg/L.

3.2.4.3 California Department of Pesticide Regulation (CPR) Data

Surface water monitoring data were accessed from the California Department of Pesticide regulation (CDPR) and all data with analysis for permethrin were extracted. A total of 2,216 samples were analyzed for permethrin (1957 surface waters, 259 sediment). Of these, 10 surface water samples (0.5%) and 64 sediment samples (25%) had positive detections of permethrin. The maximum surface water concentration was 0.195, µg/L in Alisal Slough (Reclamation Ditch), Moffett Street *ca.* 0.15 mi SE of Airport Boulevard, Monterey. The quantitation limits were variable. The maximum sediment concentration was 0.188 ug/kg, in Kaseberg Creek at Caragh Road, Placer.

3.2.4.4 Atmospheric Monitoring Data

There is limited atmospheric monitoring in California. Ambient air monitoring was conducted in Butte County (application) and Monterey County (ambient) in 1997 as per request of the California Department of Pesticide Regulation. Ambient samples were taken in populated areas of Monterey County that coincided with the use of permethrin on lettuce and celery. The LOQ was 0.33 ug/sample (equivalent to 0.015 ug/m^3 for sampling performed for 24 hours at 15 L/min). The LOD was 0.10 ug/sample. Of 24 application samples in Butte County, three were above the LOQ. Of the 115 ambient samples collected in Monterey County, six were reported as detected (>LOD but <LOQ) and 109 samples were below the LOD.

In addition, samples were taken in Lompoc, an agricultural city in Santa Barbara County downwind from the agricultural area. Monitoring occurred in 2000 for a total of 31 pesticides, including permethrin. Permethrin was detected at trace levels to 4.3 ng/m^3 (highest 1-day air concentration).

3.3 Terrestrial Animal Exposure Assessment

3.3.1 Terrestrial Animal Exposure Modeling- Spray Applications

A primary concern with permethrin is that birds and mammals may be exposed shortly after application through oral or dietary exposure to vegetative plant material or insects when foraging in the treated fields for nesting material or food. Therefore, for permethrin spray applications, estimation of pesticide concentrations in wildlife food items focuses on quantifying possible dietary ingestion of residues on vegetative matter and insects. The EFED terrestrial exposure model T-REX (T-REX, Version 1.3.1, dated December 7, 2006) simulates a one-year time period and is used to estimate exposures and risks to avian (surrogate for terrestrial-phase amphibians and reptiles) and mammalian species. Input values for avian and mammalian toxicity as well as chemical application and foliar dissipation half-life data are required to run the model. The model provides estimates of exposure concentrations and risk quotients (RQs). Specifically, the model provides estimates of concentrations (upper-bound and mean) of chemical residues on the surface of different types of foliage and insects that may be dietary sources of exposure to avian, mammalian, reptilian, or terrestrial-phase amphibian receptors. The surface residue concentration (ppm) is estimated by multiplying the application rate (pounds active ingredient per acre) by a value specific to each food item (termed the Hoerger-Kenaga estimates). For multiple applications, the EEC is determined by adding the mass on the surface immediately following the application to the mass of the chemical still present on the surfaces on the day of application (determined based on first order kinetics using the foliar half-life as the rate constant). The Hoerger-Kenaga estimates and a more detailed discussion of the methodology implemented by T-REX can be found at http://www.epa.gov/oppefed1/models/terrestrial/.

T-REX is also used to calculate EECs for terrestrial insects exposed to permethrin via spray applications. Dietary-based EECs calculated by T-REX for small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates (units of a.i./g) are used to bound an estimate of exposure to terrestrial invertebrates. Available acute contact toxicity data for bees exposed to permethrin (in units of µg a.i./bee), are converted to µg a.i./g (of bee) by multiplying by 1 bee/0.128 g. The EECs are later compared to the adjusted acute contact toxicity data for bees in order to derive RQs for terrestrial invertebrates. For the purposes of this assessment, upper-bound Kenaga nomogram estimates reported by T-REX have been used for derivation of the EECs for the terrestrial-phase CRLF, CCR, SFGS, SMHM, and BCB and their potential prey (**Table 3.8**). Details on the measures of exposure for evaluating direct and indirect effects to the assessed species are discussed further in **Section 3.3.4** below.

Although the multitude of labels that exist for permethrin allow for many types of spray or liquid application (e.g., foliar spray, chemigation, soil incorporation, soil surface spray, air-blast, band spray, and seed treatment), it is expected that foliar spray applications will result in the highest levels of exposure to non-target wildlife feeding on the forage items considered in T-REX; a review of the existing agricultural labels for permethrin has revealed that maximum rates of application for other methods are the same or lower. While the primary area of concern for exposure of terrestrial wildlife to permethrin extends from agricultural uses, there are other labeled uses of permethrin that cannot be discounted and have also been considered in this assessment. These uses include foliar spray applications for: turf; forestry; nurseries; mosquito control; ant mound treatment; soil barrier treatment for fencerows, hedgerows, range land, and urban and rural structures; residential turf and ornamentals; perimeter treatment for urban and rural structures; termite treatment for urban and rural structures; and home and garden vegetables, nuts and fruits.

In addition to the aforementioned spray applications considered in this assessment, permethrin can also be applied as a seed treatment and a granular formulation. These application types have also been considered due to uniqueness of application (i.e., seed treatment) and/or potential to result in an intense short-term acute exposure (i.e., consumption of granules). The approach for assessing exposure and risk resulting from these uses will be discussed in the subsequent sections. At this time, exposure to terrestrial wildlife resulting from dust formulations for home and garden use has not been assessed due the expected low potential for exposure to wildlife relative to the other uses considered, and due to the lack of specifications regarding application rate on the labels.

While most of the spray applications for the various permethrin uses considered in this assessment are expected to be applied directly to various terrestrial wildlife forage items and can be modeled using T-REX according to standard practice, permethrin used for mosquito control is applied as an Ultra-Low Volume (ULV) aerosol targeting flying insects via application to air columns rather than direct application to foliage. Therefore, the normal T-REX assumptions regarding direct application to foliage and rates of deposition on foliage and various food items are not appropriate for permethrin adulticide uses and will likely result in an overestimation of EECs for terrestrial organisms. Therefore, for the purposes of appropriately estimating risk to terrestrial animals resulting from permethrin use for mosquito control, the AGricultural DISPersal model (AGDISP) was used as described in the “Aquatic Exposure Assessment” section (**Section 3.2**) of this document to estimate deposition of permethrin in the treated area. In particular, AGDISP estimated the application efficiency (fraction of applied; 0.449 and 0.020 for Pre- and Post- implementation of RED mitigation measures, respectively) that could be used to adjust the maximum labeled application rate for mosquito adulticides so as to be more representative of the actual rate that reaches foliage and other various food items. The “adjusted application rate” based on application efficiency estimated by AGDISP was the rate that was entered into T-REX for estimating exposure and risk of terrestrial animals resulting from permethrin mosquito adulticide use.

Use specific input values, including number of applications, application rate, foliar half-life and application interval are provided in **Table 3.8**. The maximum number of applications per year, the minimum application intervals, and the maximum application rates for each crop selected as the representative crop for a “Crop Category” were derived from the product labels, whereas the foliar half-life of 15.4 days was based on data for permethrin in Willis and McDowell (1987). An example output from T-REX is available in **APPENDIX F**. Please refer to **Table 3.1** for details regarding which uses are covered under each “Use Category.”

The data from Willis and McDowell (1987) used to calculate the foliar dissipation half-life entered into T-REX meet the basic EFED criteria for deeming half-life data acceptable for use in ecological risk assessments. Assuming the available data were normally distributed, the foliar half-life of 15.4 days calculated as per EFED guidance represents the 90% upper confidence limit of the mean half-life for all crops that had half-life estimates based on total residues (internal plus dislodgeable residues). Although data on all available crops were considered, half-lives based on dislodgeable residues alone were not considered for permethrin because the compound has a high octanol/water partition coefficient (reported $K_{OW}=1.26\times10^6$; log P=6.1; Laskowski, 2002) and is expected to bind strongly to plants. Therefore, the three half-lives available based on total residues (i.e., half-lives of 13.9 (soybeans), 12.6 (peaches), and 6.3 (peaches)) are expected to provide more realistic estimates of exposure, whereas half-lives based on dislodgeable residues alone will likely underestimate exposure concentrations.

As stated previously, the model was run for agricultural uses with the maximum single application rate and number of applications as proposed on the labels; however, it should be noted that in some instances this approach resulted in an exceedance of the maximum label-recommended seasonal application rate. Specifically, the maximum label-recommended seasonal application rates of 0.65 (vs. modeled 0.8), 1.0 (vs. modeled 1.2), and 0.18 (vs. modeled 0.2) lb a.i./A for the use of permethrin on fruit trees (pear), onion (onion), and as a soil barrier treatment (urban and rural structures), respectively, are below the modeled seasonal rates. However, this approach was taken in order to be as conservative as possible; T-REX has no current provisions that allow for an automated process by which to vary application rates within a given season or year, and using an application rate estimated by dividing the maximum seasonal application rate by the maximum number of applications would result in an underestimate of predicted peak residues.

Table 3.8. Input parameters used in T-REX v1.3.1 and upper-bound Kenega Nomogram dietary- and dose-based estimated environmental concentrations (EECs) for birds and mammals for the maximum permethrin foliar spray application scenarios.

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Dose-based EECs (mg/kg-bw)			Dietary-based EECs (mg/kg-diet)
			Avian Classes and Body Weights		Mammalian Classes and Body weight	
			20g	100g	15 g	
Alfalfa (Alfalfa)	**0.2, 30, 5**	**Short Grass**	73.7	42.0	61.7	64.7
		Tall Grass	33.8	19.3	28.3	29.7
		Broadleaf plants, Small Insects	41.5	23.6	34.7	36.4
		Fruits, Pods, Seeds, Lg Insects	4.6	2.6	3.9	4.0
Nut Trees (Pistachio)	**0.3, 10, 3**	**Short Grass**	167.6	95.6	140.3	147.2
		Tall Grass	76.8	43.8	64.3	67.5
		Broadleaf plants, Small Insects	94.3	53.8	78.9	82.8
		Fruits, Pods, Seeds, Lg Insects	10.5	6.0	8.8	9.2
Avocado (Avocado)	**0.2, 7, 4**	**Short Grass**	144.9	82.6	121.3	127.2
		Tall Grass	66.4	37.9	55.6	58.3
		Broadleaf plants, Small Insects	81.5	46.5	68.2	71.6
		Fruits, Pods, Seeds, Lg Insects	9.1	5.2	7.6	8.0
Cole Crops (Broccoli)	**0.2, 5, 4**	**Short Grass**	161.0	91.8	134.8	141.4
		Tall Grass	73.8	42.1	61.8	64.8
		Broadleaf plants, Small Insects	90.6	51.6	75.8	79.5
		Fruits, Pods, Seeds, Lg Insects	10.1	5.7	8.4	8.8
Corn (Pop corn)	**0.2, 5, 3** [3]	**Short Grass**	133.2	75.9	111.5	116.9
		Tall Grass	61.0	34.8	51.1	53.6
		Broadleaf plants, Small Insects	74.9	42.7	62.7	65.8
		Fruits, Pods, Seeds, Lg Insects	8.3	4.7	7.0	7.3
Corn (Sweet corn)	**0.2, 3, 4**	**Short Grass**	180.6	103.0	151.2	158.6
		Tall Grass	82.8	47.2	69.3	72.7
		Broadleaf plants, Small Insects	101.6	57.9	85.1	89.2

Table 3.8. Input parameters used in T-REX v1.3.1 and upper-bound Kenega Nomogram dietary- and dose-based estimated environmental concentrations (EECs) for birds and mammals for the maximum permethrin foliar spray application scenarios.						
Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Dose-based EECs (mg/kg-bw)			Dietary-based EECs (mg/kg-diet)
			Avian Classes and Body Weights		Mammalian Classes and Body weight	
			20g	100g	15 g	
		Fruits, Pods, Seeds, Lg Insects	11.3	6.4	9.5	9.9
Forestry (Cottonwood)	0.2, 5 [4], 10 [4]	Short Grass	242.7	138.4	203.2	213.1
		Tall Grass	111.2	63.4	93.1	97.7
		Broadleaf plants, Small Insects	136.5	77.8	114.3	119.9
		Fruits, Pods, Seeds, Lg Insects	15.2	8.6	12.7	13.3
Fruit Trees (Pear) [5]	0.4, 10, 2	Short Grass	179.0	102.1	149.9	157.2
		Tall Grass	82.1	46.8	68.7	72.1
		Broadleaf plants, Small Insects	100.7	57.4	84.3	88.4
		Fruits, Pods, Seeds, Lg Insects	11.2	6.4	9.4	9.8
Fruit Trees (Peach)	0.25, 10, 3	Short Grass	139.7	79.7	116.9	122.6
		Tall Grass	64.0	36.5	53.6	56.2
		Broadleaf plants, Small Insects	78.6	44.8	65.8	69.0
		Fruits, Pods, Seeds, Lg Insects	8.7	5.0	7.3	7.7
Garlic & Potatoes (Garlic & Potatoes)	0.2, 10, 4	Short Grass	125.9	71.8	105.4	110.6
		Tall Grass	57.7	32.9	48.3	50.7
		Broadleaf plants, Small Insects	70.8	40.4	59.3	62.2
		Fruits, Pods, Seeds, Lg Insects	7.9	4.5	6.6	6.9
Major Leafy Vegetables (Lettuce)	0.2, 7, 4	Short Grass	144.9	82.6	121.3	127.2
		Tall Grass	66.4	37.9	55.6	58.3
		Broadleaf plants, Small Insects	81.5	46.5	68.2	71.6
		Fruits, Pods, Seeds, Lg Insects	9.1	5.2	7.6	8.0
Minor Leafy Vegetables [6]	0.2, 3, 10	Short Grass	320.6	182.8	268.4	281.5
		Tall Grass	147.0	83.8	123.0	129.0
		Broadleaf plants, Small Insects	180.4	102.9	151.0	158.4
		Fruits, Pods, Seeds, Lg Insects	20.0	11.4	16.8	17.6
Major Cucurbits (Cucumber)	0.2, 7, 6	Short Grass	171.7	97.9	143.8	150.8
		Tall Grass	78.7	44.9	65.9	69.1
		Broadleaf plants, Small Insects	96.6	55.1	80.9	84.8
		Fruits, Pods, Seeds, Lg Insects	10.7	6.1	9.0	9.4
Minor Cucurbits (Melons)	0.24, 7 [4], 8	Short Grass	223.2	127.3	186.9	196.0
		Tall Grass	102.3	58.3	85.6	89.8
		Broadleaf plants, Small Insects	125.6	71.6	105.1	110.2
		Fruits, Pods, Seeds, Lg Insects	14.0	8.0	11.7	12.3
Nursery (Pine Seed Orchard-Reduced) [7]	0.4, 28, 6	Short Grass	152.5	87.0	127.7	133.9
		Tall Grass	69.9	39.9	58.5	61.4
		Broadleaf plants, Small Insects	85.8	48.9	71.8	75.3
		Fruits, Pods, Seeds, Lg Insects	9.5	5.4	8.0	8.4
Nursery (Pine	1.6, 28, 6	Short Grass	610.1	347.9	510.8	535.7

Table 3.8. Input parameters used in T-REX v1.3.1 and upper-bound Kenega Nomogram dietary- and dose-based estimated environmental concentrations (EECs) for birds and mammals for the maximum permethrin foliar spray application scenarios.

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Dose-based EECs (mg/kg-bw)			Dietary-based EECs (mg/kg-diet)
			Avian Classes and Body Weights		Mammalian Classes and Body weight	
			20g	100g	15 g	
Seed Orchard-Maximum)		Tall Grass	279.6	159.5	234.1	245.5
		Broadleaf plants, Small Insects	343.2	195.7	287.3	301.3
		Fruits, Pods, Seeds, Lg Insects	38.1	21.8	31.9	33.5
Onions (Onion) [5]	0.3, 7, 4	Short Grass	217.4	124.0	182.0	190.9
		Tall Grass	99.6	56.8	83.4	87.5
		Broadleaf plants, Small Insects	122.3	69.7	102.4	107.4
		Fruits, Pods, Seeds, Lg Insects	13.6	7.8	11.4	11.9
Onions (Fennel)	0.2, 3, 10	Short Grass	320.6	182.8	268.4	281.5
		Tall Grass	147.0	83.8	123.0	129.0
		Broadleaf plants, Small Insects	180.4	102.9	151.0	158.4
		Fruits, Pods, Seeds, Lg Insects	20.0	11.4	16.8	17.6
Row Crops (Celery)	0.2, 7, 5	Short Grass	160.4	91.5	134.3	140.9
		Tall Grass	73.5	41.9	61.6	64.6
		Broadleaf plants, Small Insects	90.2	51.5	75.5	79.2
		Fruits, Pods, Seeds, Lg Insects	10.0	5.7	8.4	8.8
Row Crops (Rhubarb)	0.2, 5, 10	Short Grass	242.7	138.4	203.2	213.1
		Tall Grass	111.2	63.4	93.1	97.7
		Broadleaf plants, Small Insects	136.5	77.9	114.3	119.9
		Fruits, Pods, Seeds, Lg Insects	15.2	8.7	12.7	13.3
Tomato (Tomato)	0.2, 7, 3	Short Grass	123.7	70.5	103.5	108.6
		Tall Grass	56.7	32.3	47.5	49.8
		Broadleaf plants, Small Insects	69.6	39.7	58.2	61.1
		Fruits, Pods, Seeds, Lg Insects	7.7	4.4	6.5	6.8
Tomato (Tomatillos)	0.2, 7 [4], 6	Short Grass	171.7	97.9	143.8	150.8
		Tall Grass	78.7	44.9	65.9	69.1
		Broadleaf plants, Small Insects	96.6	55.1	80.9	84.8
		Fruits, Pods, Seeds, Lg Insects	10.7	6.1	9.0	9.4
Turf (Golf Course and Recreational Areas)	0.87, 7 [4], 6 [4]	Short Grass	747.0	426.0	625.4	655.9
		Tall Grass	342.4	195.2	286.6	300.6
		Broadleaf plants, Small Insects	420.2	239.6	351.8	369.0
		Fruits, Pods, Seeds, Lg Insects	46.7	26.6	39.1	41.0
Ant Mound Treatments (Non-ag, Turf, Recreational, &Ag. Fruit Trees)	0.84, 7 [4], 4 [4]	Short Grass	608.6	347.1	509.5	534.4
		Tall Grass	279.0	159.1	233.5	244.9
		Broadleaf plants, Small Insects	342.4	195.2	286.6	300.6
		Fruits, Pods, Seeds, Lg Insects	38.0	21.7	31.9	33.4
Adulticide	0.003 [8], 1[9], 52 [9]	Short Grass	16.8	9.6	14.1	14.8

Table 3.8. Input parameters used in T-REX v1.3.1 and upper-bound Kenega Nomogram dietary- and dose-based estimated environmental concentrations (EECs) for birds and mammals for the maximum permethrin foliar spray application scenarios.						
Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Dose-based EECs (mg/kg-bw)			Dietary-based EECs (mg/kg-diet)
			Avian Classes and Body Weights		Mammalian Classes and Body weight	
			20g	100g	15 g	
(Mosquito Control Pre-CFR 2005-1)		Tall Grass	7.7	4.4	6.5	6.8
		Broadleaf plants, Small Insects	9.5	5.4	7.9	8.3
		Fruits, Pods, Seeds, Lg Insects	1.1	0.6	0.9	0.9
Adulticide (Mosquito Control Post-CFR 2005-1) [10]	0.00014 [8], 1, 26	Short Grass	0.6	0.3	0.5	0.5
		Tall Grass	0.3	0.2	0.2	0.2
		Broadleaf plants, Small Insects	0.3	0.2	0.3	0.3
		Fruits, Pods, Seeds, Lg Insects	0.04	0.02	0.03	0.03
Soil Barrier Treatment (Fencerows & Hedgerows)	0.01, 7 [4], 10	Short Grass	9.7	5.5	8.1	8.5
		Tall Grass	4.4	2.5	3.7	3.9
		Broadleaf plants, Small Insects	5.5	3.1	4.6	4.8
		Fruits, Pods, Seeds, Lg Insects	0.6	0.3	0.5	0.5
Soil Barrier Treatment (Range Land)	0.1, 7 [4], 10	Short Grass	96.8	55.2	81.0	85.0
		Tall Grass	44.4	25.3	37.1	39.0
		Broadleaf plants, Small Insects	54.5	31.1	45.6	47.8
		Fruits, Pods, Seeds, Lg Insects	6.1	3.5	5.1	5.3
Residential Turf and Ornamentals (Home and Garden)	4.23, 5, 3 [4]	Short Grass	2817	1606	2358	2473
		Tall Grass	1291	736	1081	1134
		Broadleaf plants, Small Insects	1584	904	1326	1391
		Fruits, Pods, Seeds, Lg Insects	176	100	147	155
Perimeter Treatment (Urban and Rural Structures)	1.43, 90 [4], 4 [4]	Short Grass	397.8	226.8	333.0	349.3
		Tall Grass	182.3	104.0	152.6	160.1
		Broadleaf plants, Small Insects	223.8	127.6	187.3	196.5
		Fruits, Pods, Seeds, Lg Insects	24.9	14.2	20.8	21.8
Termite Treatment (Urban and Rural Structures)	0.77, N/A, 1	Short Grass	210.5	120.0	176.2	184.8
		Tall Grass	96.5	55.0	80.8	84.7
		Broadleaf plants, Small Insects	118.4	67.5	99.1	104.0
		Fruits, Pods, Seeds, Lg Insects	13.2	7.5	11.0	11.6
Garden Vegetables (Home and Garden)	0.25, 3, 6	Short Grass	300.4	171.3	251.5	263.7
		Tall Grass	137.7	78.5	115.3	120.9
		Broadleaf plants, Small Insects	169.0	96.3	141.5	148.4
		Fruits, Pods, Seeds, Lg Insects	18.8	10.7	15.7	16.5
Garden Nuts and Fruits (Home and Garden)	0.4, 10 [4], 5	Short Grass	269.9	153.9	225.9	237.0
		Tall Grass	123.7	70.5	103.6	108.6
		Broadleaf plants, Small Insects	151.8	86.6	127.1	133.3
		Fruits, Pods, Seeds, Lg Insects	16.9	9.6	14.1	14.8
Soil Barrier	0.1, 7 [4], 2	Short Grass	47.3	27.0	39.6	41.5

Table 3.8. Input parameters used in T-REX v1.3.1 and upper-bound Kenega Nomogram dietary- and dose-based estimated environmental concentrations (EECs) for birds and mammals for the maximum permethrin foliar spray application scenarios.						
Use Category[1]	**App Rate (lbs a.i./A), Interval (Days), # of Apps[2]**	**Dietary Category**	**Dose-based EECs (mg/kg-bw)**			**Dietary-based EECs (mg/kg-diet)**
			Avian Classes and Body Weights		**Mammalian Classes and Body weight**	
			20g	**100g**	**15 g**	
Treatment (Urban and Rural Structures) [5]		**Tall Grass**	21.7	12.4	18.1	19.0
		Broadleaf plants, Small Insects	26.6	15.2	22.3	23.4
		Fruits, Pods, Seeds, Lg Insects	3.0	1.7	2.5	2.6

[1] Please refer to **Table 3.1** for details regarding which uses are covered under each "Use Category."
[2] The maximum number of applications per year, the minimum application intervals, and the maximum application rates for each use selected as the representative use for a "Use Category" were derived from the product labels and used to model EECs, whereas the foliar half-life of 15.4 days used for modeling was based on data for permethrin in Willis and McDowell (1987). For foliar dissipation, 3 foliar half-life measurements on two crops based on total residues were available. Assuming these values are distributed normally, the value which represents the one tail upper 90% confidence limit of the mean half-lives is 15.4 days.
[3] The label actually allows up to six applications, but the maximum seasonal rate is set at 0.6 lb a.i.A. Therefore, only 3 applications can be made in a season if applying at the maximum single application rate of 0.2 lb a.i./A.
[4] Assumed. Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.
[5] The maximum label-recommended seasonal application rates of 0.65 (vs. modeled 0.8), 1.0 (vs. modeled 1.2), and 0.18 (vs. modeled 0.2) lb a.i./A for the use of permethrin on fruit trees (pear), onion (onion), and as a soil barrier treatment (urban and rural structures), respectively, are below the modeled seasonal rates.
[6] For a list of which crops were modeled for this "Crop Category", please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document.
[7] This reduced exposure scenario represents what one registrant has claimed to be the maximum intended use scenario for the application of permethrin to pine seed orchards. However, the label could be interpreted to allow for the modeled maximum exposure scenario for pine seed orchards (4 applications of a maximum single application rate of 1.6 lb a.i./A with a 28-day interval).
[8] Permethrin as a mosquito adulticide is applied to an air column, not directly to foliage. Therefore, the maximum application rate allowed on the labels (0.007 lb a.i./A) was multiplied by the AGDISP estimated application efficiency (fraction of applied deposited in treated area; 0.449 and 0.020 for Pre- and Post-implementation of RED mitigation measures, respectively) in order to determine the application rate representative of the applied amount to foliage and other various wildlife food items.
[9] The labels pre-implementation of RED mitigation measures had no restrictions on the application interval or number of applications made per year for mosquito adulticide applications. For the sake of being protective, a one day application interval and a maximum of 52 applications were assumed.
[10] Dependence on this scenario for reaching conclusions regarding exposure and risk from mosquito adulticide applications should be done with caution because not all labels have been revised based on mitigation measures. Currently, there are still no specifications on some of the labels for the maximum number of applications or minimum application interval. The revised labels are to have a minimum of a 1-day interval and a maximum of 26 applications.

3.3.2 Terrestrial Animal Exposure Modeling- Granular Applications

There is potential for exposure of birds and mammals to granular permethrin by direct ingestion of granules. They also may be exposed by other routes, such as incidental ingestion of contaminated soil, dermal contact with treated granular surfaces and soil during activities in the treated areas, preening activities, and ingestion of drinking water contaminated with pesticide. It should be noted, however, that the primary route of exposure to permethrin granules will be via the oral route because it is not volatile and it is not expected to appreciably absorb through the skin relative to absorption via the gut following direct consumption (the estimated conservative dermal absorption factor is 15%; refer to the Health Effects Division's chapter for the Reregistration Eligibility Decision Document (RED) for permethrin (Dated April 4th 2006; DP Barcode D324993)). Therefore, ingestion of granules and consumption of terrestrial invertebrates that have bioconcentrated pesticide residues were considered as routes of exposure in this assessment.

Although a bird's or mammal's habitat is not limited to a square foot, there is presumably a direct correlation between the concentration of a pesticide in the environment (mg/ft^2) and the chance that an animal will be exposed to a concentration that could adversely affect its survival. For granular applications of permethrin, acute exposure and risks to terrestrial wildlife are estimated with the conceptual approach and the LD_{50}/ft^2 method given in the model T-REX. Terrestrial EECs are calculated based on an estimation of loadings of pesticide per unit area (expressed in terms of mg a.i./ft^2) for a single application (multiple applications are not accounted for in this analysis), assuming that 100% of the application was present on the surface of the soil. This approach compares the available mass of pesticide per square foot to the acute oral dose for toxicity (LD_{50} values adjusted for body weight and percent body weight consumed) to derive risk quotients for mammals. However, because definitive LD_{50} (as well as LC_{50}) values were not established for birds (there were no treatment-related mortalities or sub-lethal effects in any of the acute oral studies), the LD_{50} ft^{-2} analysis was not performed for them and acute risk to birds based on granular applications of permethrin was presumed to be low. Further description of the mg/ft^2 index can be found in the T-REX User's Guide at http://www.epa.gov/oppefed1/models/terrestrial/, and in U.S. EPA (1992 and 2004).

For these analyses, the maximum single application rate of all uses within a given category of uses (*i.e.,* Nuts, Corn, Residential Categories) was modeled to estimate exposure and risk for the entire category. It was also assumed that granules are applied via broadcast equipment and that 100% of the granules are unincorporated. Terrestrial EECs estimated using the LD_{50} ft^{-2} for granular uses are presented below in **Table 3.9**.

Table 3.9. Terrestrial estimated environmental concentrations (EECs) for mammals generated using T-REX v1.3.1 and the LD_{50} f^{t-2} analysis for the maximum granular permethrin application scenarios. [1,2]

Use Category [3]	Modeled Application Rate (lb ai/A)	EEC (mg/ft^2)
Nuts	**0.30**	3.12
Corn and Sod & Golf Turf[4]	**0.2**	2.08
Residential	**1.00**	10.41

[1] The LD_{50} ft^{-2} analysis was only performed for mammals because definitive LD_{50} values were not established for birds.
[2] Only single applications of granules are accounted for using this analysis performed by T-REX.
[3] Please refer to **Table 2.5** for details regarding which uses are covered under each "Use Category."
[4] The two "Use Categories" for granular uses on "Corn" and on "Sod and Golf Turf" have been considered together for the LD_{50} ft^{-2} analysis since they share the same use parameters (*ie.,* rate, # of applications, and interval).

EFED has no standard methodology for assessing chronic risk to terrestrial organisms from granular applications. The chronic exposure estimation and risk characterization for terrestrial wildlife (birds and mammals) in this risk assessment considers granular routes of exposure including direct ingestion of soil invertebrates that have bioconcentrated permethrin residues of granules in soil. In addition, exposure and risk to terrestrial soil-dwelling invertebrates resulting from granular permethrin were also considered using the methodology described below.

The estimation of earthworm (the model invertebrate) concentration was calculated using a fugacity-based (equilibrium partitioning) approach based on the work of Trapp and McFarlane (1995) and Mackay and Paterson (1981). Earthworms dwelling within the soil are exposed to contaminants in both soil pore water and via the ingestion of soil (Belfroid et al. 1994). Soil concentrations of permethrin were calculated based on a depth of 7.6 cm (three inches; a chemical concentration averaged over a 7.6 cm soil depth was used to reflect a concentration across the earthworm occupied area of soil), the maximum application rate, number of applications, and the minimum interval for each use selected as the representative use for a “Use Category”, and a 1-acre terrestrial environment. In order to determine the maximum soil concentration *under a multiple application scenario with a uniform application rate and interval throughout*, a measure of dissipation in surface soil (the aerobic soil metabolism half-life of 111 days for permethrin used in the PRZM/EXAMS modeling; three times the single available value of 37 days) and the following equations were used:

$$C_{\text{soil}_{\max}} = \sum_{i=1}^{n} C_{\text{soil}_i} * e^{(-k*T)}$$

where,

$C_{soil\ max}$ = the maximum concentration of chemical found in bulk soil under a multiple application scenario (mg/kg)
n = the maximum number of applications
T = the time in days from the i[th] application until the final application
k = soil degradation rate constant = calculated assuming first order kinetics with the following equation = ln(0.5) / ((aerobic soil metabolism half-life)(-1))
$C_{soil\ i}$ = concentration in soil resulting from the i[th] application of a pesticide (mg/kg)

$$= \qquad C_{\text{soil}_i} = \frac{application\ rate}{soil\ depth \times soil\ density} = \frac{AR \times CF_1 \times CF_2}{z \times CF_3 \times \rho_{soil}}$$

where,

$C_{soil\ i}$ = concentration in soil immediately following a single application (mg/kg)
AR = application rate (lb a.i./acre)
z = soil depth (cm)
ρ_{soil} = soil bulk density (g/cm^3)
CF_1 = conversion factor, 453582.4 mg = 1 lb
CF_2 = conversion factor, 1 acre = 40468730 cm^2
CF_3 = conversion factor, 0.001 kg = 1 g

The concentration of permethrin in earthworms was calculated as a combination of uptake from soil pore water and gastrointestinal absorption from ingested soil:

$$C_{earthworm} = [(C_{soil\ max})(Z_{earthworm}/Z_{soil})]+[(C_{soil\ water})(Z_{earthworm}/Z_{water})]$$

where,

$C_{soil\ max}$ = the maximum concentration of chemical found in bulk soil under a multiple application scenario
$Z_{earthworm}$ = the fugacity capacity of chemical in earthworms = (lipid)(K_{ow})($\rho_{earthworm}$)/H
Z_{soil} = fugacity capacity of chemical in soil = (K_d)(ρ_{soil})/H
Z_{water} = fugacity capacity of chemical in water = 1/H

$C_{soil\ water}$	=	concentration of chemical in soil water = $C_{soil\ max}/K_{bw}$
K_{bw}	=	bulk soil-to-water partitioning coefficient = $(\rho_{soil})(K_d)+\theta+(\varepsilon-\theta)(K_{aw})$
K_{aw}	=	air-to-water partitioning coefficient = H/RT
H	=	Henry's Constant specific to permethrin = 1.4×10^{-6} atm-m^3/mol
R	=	universal gas constant =8.31 Joules-m^3/mol-^{o}K
T	=	temperature ^{o}K =assumed to be 298 ^{o}K
K_{oc}	=	pesticide organic carbon/ water partitioning coefficient = 76,800L/kg
K_d	=	soil partitioning coefficient for permethrin = (K_{oc} * 0.02 (assumed fraction of soil organic carbon))
ρ_{soil}	=	bulk density of soil =assumed to be 1.3 g/cm^3
θ	=	volumetric fraction of the soil =assumed to be 0.30
ε	=	volumetric total porosity of the soil = (1-(ρ_{soil} /partical densitiy of 2.65 mineral soils)
lipid	=	fraction of lipid in organism = 0.01 (Cobb et al. 1995)
K_{ow}	=	the octanol to water partitioning coefficient for permethrin =1.26×10^6
$\rho_{earthworm}$	=	the density of the organism g/cm^3 = assumed to be 1 g/cm^3

Table 3.10 summarizes the model inputs and exposure estimates (i.e., earthworm concentrations in ppm) for insectivorous birds, insectivorous mammals, and terrestrial invertebrates, based on granular permethrin applications.

Table 3.10. Fugacity model input parameters and exposure estimates for avian, mammalian, and terrestrial invertebrate receptors.

Parameter	**Use Category**[1]		
	Nuts **(0.3 lb a.i./A, 3 apps, 10-day interval)**	**Corn and Sod & Golf Turf**[2] **(0.20 lb a.i./A, 4 apps, 3-day interval)**	**Residential** **(1.00 lb a.i./A, 4 apps, 7-day interval)**[3]
$C_{soil\ max}$ (mg/kg @ 7.6 cm depth)	0.9604	0.8826	4.2548
Earthworm Concentration ($C_{earthworm}$) (mg/kg)	12.1199	11.1377	53.6928
K_d (L/kg)	1536	1536	1536
Z_{water} (1/H or moles/Pa-m^3)	7.14×10^5	7.14×10^5	7.14×10^5
Z_{soil} (($K_{\cdot}\cdot\rho_{soil}$)/H)	1.43×10^9	1.43×10^9	1.43×10^9
$Z_{earthworm}$ ((lipid$\cdot K_{ow}\cdot\rho_{earthworm}$)/H)	9.00×10^9	9.00×10^9	9.00×10^9
ρ_{soil} (g/cm^3)	1.3	1.3	1.3
$\rho_{earthworm}$ (g/cm^3)	1	1	1
θ (unitless)	0.3	0.3	0.3
ε (unitless)	0.509434	0.509434	0.509434
K_{aw} (H/RT)	5.65×10^{-10}	5.65×10^{-10}	5.65×10^{-10}
K_{bw} (($\rho_{soil}\cdot$Kd)+θ+(ε-θ)(K_{aw}))	1997.1	1997.1	1997.1

Table 3.10. Fugacity model input parameters and exposure estimates for avian, mammalian, and terrestrial invertebrate receptors.			
Parameter	**Use Category[1]**		
	Nuts (0.3 lb a.i./A, 3 apps, 10-day interval)	**Corn and Sod & Golf Turf[2]** (0.20 lb a.i./A, 4 apps, 3-day interval)	**Residential** (1.00 lb a.i./A, 4 apps, 7-day interval)[3]

[1] Please refer to **Table 2.5** for details regarding which uses are covered under each "Use Category."

[2] The two "Use Categories" for granular uses on "Corn" and on "Sod and Golf Turf" have been considered together for the fugacity model analysis since they share the same use parameters (*ie.*, rate, # of applications, and interval).

[3] The application interval and number of applications for the residential uses of granular permethrin (based on use parameters for Fire Ant Mound treatment) were assumed. Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.

Chronic risks for birds and mammals that consume terrestrial soil-dwelling invertebrates as the majority of their diet were estimated based on comparison of the concentration of permethrin in earthworm tissue ($C_{earthworm}$) with chronic toxicity values for birds and mammals. In addition to dietary estimates for birds and mammals, residue concentrations in terrestrial invertebrates were converted to daily oral doses for mammals based on the fraction of body weight consumed as estimated through mammalian allometric relationships, and were then compared with chronic oral toxicity values for mammals. Lastly, the concentration of permethrin in earthworms, used as a surrogate for all terrestrial soil-dwelling invertebrates, was compared to the most sensitive acute contact LD_{50} value for terrestrial invertebrates in order to evaluate the potential for risk to this taxonomic group resulting from granular permethrin use. A detailed description of the fugacity model and methodology used to estimate chronic exposure and risk for granular applications of permethrin is presented in **APPENDIX G**.

3.3.3 Terrestrial Animal Exposure Modeling- Seed Treatments

Similar to granular permethrin, there is potential for exposure of birds and mammals to seeds treated with permethrin by direct ingestion. Birds and mammals may also be exposed via other routes, such as incidental ingestion of soil contaminated via seed treatment, dermal contact with treated seed surfaces and contaminated soil during activities in the treated areas, preening activities, and ingestion of drinking water contaminated with pesticide from seed treatments. However, as discussed previously, these routes of exposure are expected to pose lower risks relative to direct ingestion of treated seed and have not been evaluated in this assessment.

The terrestrial exposure model T-REX (T-REX, Version 1.3.1, dated December 7, 2006) was used to estimate exposures and risks to avian and mammalian species resulting from permethrin seed treatment. T-REX estimates potential doses to terrestrial wildlife from seed treatment applications only for small birds (20 grams) and mammals (15 grams). T-REX approximates acute exposure from seed treatment using avian and mammalian Nagy doses (mg ai bw^{-1} day^{-1}), and also utilizes an approach analogous to the LD_{50}/ft^2 analyses done for granular applications, in which acute exposure is estimated in terms of available pesticide (mg ai ft^{-2}). Chronic exposures are estimated based on the maximum seed application rate (mg a.i./kg seed), which can be compared directly to estimated dietary-based chronic dietary toxicity endpoints to estimate risks. It is important to note that these analyses are predicated on conservative assumptions; it is assumed that all seeds are available for ingestion (despite that seeds are often planted rather than scattered) and that the animals are actively foraging only on treated seed. Please consult the T-REX User's Guide at http://www.epa.gov/oppefed1/models/terrestrial/ for further description of the seed treatment analyses performed by T-REX. T-REX model input values and results for permethrin seed treatments are summarized in **Table 3.11** below.

Table 3.11. Estimated terrestrial wildlife exposure from permethrin used as a seed treatment using T-REX v1.3.1.

Use Category[1]	Maximum Seeding Rate (lbs/acre)[2]	Application Rate (lb a.i./A)[2]	Max. Seed App. Rate (mg a.i./kg seed)	Avian Nagy Dose (mg a.i./kg-bw/day)	Mammalian Nagy Dose (mg a.i./kg-bw/day)	Available A.I. (mg a.i./ft^2)
Cole Crops	**6.8**	**0.0021284**	**313**	79.22	66.32	0.02221
Corn	**18**	**0.0056340**	**313**	79.22	66.32	0.05879
Melons	**2**	**0.0006260**	**313**	79.22	66.32	0.00653
Peppers and Tomatoes	**0.3**	**0.0000939**	**313**	79.22	66.32	0.00098

[1] Please refer to **Table 2.7** for details regarding which uses are covered under each "Use Category."

[2] These rates were assumed. Please refer to the "Use Characterization" section (**Section 2.4.4**) of the document for an explanation.

3.3.4 Terrestrial Animal Exposure Modeling- Summary of the Measures of Exposure for Evaluating Direct and Indirect Effects to Terrestrial Wildlife

3.3.4.1 Measures of Exposure for Direct Effects

For the purposes of evaluating direct exposure and effects to the BCB, larvae for the BCB were considered 'small insects' in this assessment, while the adults of this species were considered 'large insects'. Therefore, the potential for direct exposure and effects specifically to the BCB resulting from permethrin spray applications was evaluated by considering the lowest available acute contact toxicity endpoint for terrestrial invertebrates along with the T-REX estimated EECs for small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) insects. The potential for direct exposure and effects specifically to the BCB resulting from granular permethrin applications was not quantitatively evaluated based on EECs generated using the fugacity-based approach because those EECs are expected to be representative of soil-dwelling invertebrates that actively move and feed in soil (although BCB larvae are found in the soil, they are in dormancy and are generally found in very rocky, dry soils, which the EECs from the fugacity model may not be representative of).

In addition, the potential for direct exposure of the BCB resulting from seed treatments was not quantitatively evaluated.

Direct exposure of the SMHM in terrestrial environments was evaluated based on dose- and dietary-based EECs estimated using various approaches (*i.e.*, T-REX for foliar spray applications, T-REX $LD_{50}ft^{-2}$ analysis for granular applications, T-REX seed treatment analysis, and the fugacity-based model for insectivorous wildlife) for small mammals (15 g) consuming a variety of dietary items. All estimated EECs (*i.e.*, EECs for short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, seeds, and soil dwelling invertebrates) were considered relevant for evaluation of direct effects because the SMHM has been known to feed on leaves, seeds, plant stems, insects, and grasses.

Direct acute dietary-based or dose-based estimates of exposure were not derived for the terrestrial-phase CRLF, CCR, or SFGS because the acute avian effects data show no treatment-related mortality to the mallard duck and bobwhite quail at the highest tested level of permethrin in the sub-acute dietary and acute oral avian studies. However, direct chronic exposure of the terrestrial-phase CRLF was evaluated based on the dietary-based EECs estimated using various approaches (*i.e.*, T-REX for foliar spray applications and the fugacity-based model for insectivorous wildlife) for birds consuming small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates, or soil-dwelling invertebrates because, those are the only relevant dietary items that have been identified as potential terrestrial-phase CRLF food sources for which the available screening-level models can estimate EECs (see more on refined model T-HERPS in the “Risk Description” section of the chapter (**Section 5.2**)).

Direct chronic exposure of the SFGS in terrestrial environments was evaluated based on the dietary-based EECs estimated using various approaches (*i.e.,* T-REX for foliar spray applications and the fugacity-based model for insectivorous wildlife) for birds consuming small invertebrates (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates, or soil-dwelling invertebrates, because those are the only relevant dietary items that have been identified as a potential SFGS food source for which the available screening-level models can estimate EECs (see more on refined model T-HERPS in the “Risk Description” section of the chapter (**Section 5.2**)).

Direct chronic exposure of juvenile and adult CCR in terrestrial environments was evaluated based on the dietary-based EECs estimated using various approaches (*i.e.*, T-REX for foliar spray applications, T-REX seed treatment analysis, and the fugacity-based model for insectivorous wildlife) for birds consuming a variety of dietary items. All estimated EECs (*i.e.*, EECs for short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, seeds, and soil dwelling invertebrates) were considered relevant for evaluation because the CCR has been observed feeding on seeds, worms, insects, and plant material.

3.3.4.2 Measures of Exposure for Indirect Effects

Dietary-based and dose-based exposures of terrestrial-phase CRLF potential prey (mammals, amphibians, and invertebrates) are assessed when possible using small mammals (15 g) which consume short grass, small birds (20g; they represent terrestrial-phase amphibians that it may consume) which consume small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates, and small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of any prey items that may be exposed to granular permethrin (15 g mammals, terrestrial-phase amphibians, and invertebrates) or seed treatments (15 g mammals) were assessed when possible according to methods described above in **Sections 3.3.2** and **3.3.3** above, respectively.

Dietary-based and dose-based exposures of CCR potential prey (birds, mammals, and invertebrates) are assessed when possible using small mammals (15 g) and small birds (20 g) which consume short grass, and small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of any prey items that may be exposed to granular permethrin (15 g mammals, 20 g birds, and invertebrates) or seed treatments (15 g mammals and 20 g birds) were assessed when possible according to methods described above in **Sections 3.3.2** and **3.3.3** above, respectively.

Dietary-based and dose-based exposures of potential SFGS prey (mammals, amphibians, reptiles, and invertebrates) are assessed when possible using small mammals which consume short grass (15 g; they serve as prey items and provide burrows for habitat), small birds (20 g; they represent terrestrial-phase amphibians and reptiles that it may consume) which consume small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates, and small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of any prey items that may be exposed to granular permethrin (15 g mammals, terrestrial-phase amphibians, reptiles, and invertebrates) or seed treatments (15 g mammals) were assessed when possible according to methods described above in **Sections 3.3.2** and **3.3.3** above, respectively.

Dietary-based and dose-based exposures of taxonomic groups that may help to provide suitable habitat for the SMHM are assessed when possible using small mammals (15 g; they may provide nesting sites) and small birds (20 g; they may provide nesting sites) which consume short grass. Dietary-based exposures of potential SMHM prey (insects) are assessed using small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of any prey items that may be exposed to granular permethrin (invertebrates), or exposure of taxonomic groups that may help to provide suitable habitat for the SMHM to granular permethrin (15 g mammals and 20 g birds) or seed treatments (15 g mammals and 20 g birds) were assessed when possible according to methods described above in **Sections 3.3.2** and **3.3.3** above.

Acute dietary-based or dose-based estimates of exposure were not derived for avian, terrestrial-phase amphibian, or reptilian prey of the terrestrial-phase CRLF, CCR, SFGS, or SMHM because the acute avian effects data show no treatment-related mortality to both the mallard duck and bobwhite quail at the highest tested level of permethrin in the sub-acute dietary and acute oral avian studies.

3.4 Terrestrial Plant Exposure Assessment

Exposure to terrestrial plants was not quantitatively evaluated for this risk assessment due to the lack of acceptable terrestrial plant toxicity data. Instead, potential risks to plants are discussed qualitatively within the "Risk Description" section of the document (**Section 5.2**).

4. Effects Assessment

This assessment evaluates the potential for permethrin to directly or indirectly affect the CRLF, CCR, SFGS, SMHM, and BCB or modify their designated critical habitat. As previously discussed in **Section 2.8**, assessment endpoints for the effects determination for each assessed species include direct toxic effects on the survival, reproduction, and growth, as well as indirect effects, such as reduction of the prey base or modification of its habitat. In addition, potential modification of critical habitat is assessed by evaluating effects to the PCEs, which are components of the critical habitat areas that provide essential life cycle needs of each assessed species. Direct effects to the aquatic-phase CRLF are based on toxicity information for freshwater fish, while effects to terrestrial-phase amphibians (terrestrial-phase CRLF) and reptiles (SFGS) are based on avian toxicity data, given that birds are generally used as a surrogate for terrestrial-phase amphibians and reptiles.

As described in the Agency's Overview Document (U.S. EPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater (surrogate for aquatic-phase amphibians) and estuarine/marine fish, freshwater and estuarine/marine invertebrates, aquatic plants (non-vascular only; no data available for vascular aquatic plants), birds (surrogate for terrestrial-phase amphibians and reptiles), mammals, terrestrial invertebrates, and terrestrial plants (plants are only qualitatively evaluated due to lack of appropriate data). 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 permethrin.

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) (U.S. EPA, 2004). Open literature data presented in this assessment were obtained from ECOTOX information obtained on March 30, 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 listed 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.*, survival, reproduction, and growth) identified in **Section 2.8**. The effects determinations rely on endpoints that are relevant to the assessment endpoints of survival, growth, or reproduction. Endpoints such as behavior modifications are likely to be only qualitatively evaluated, because quantitative relationships between modifications and reduction in species survival, reproduction, and/or growth are not available.

Although the full suite of sub-lethal endpoints potentially available in the effects literature (regardless of their significance to the assessment endpoints) are often considered to define the action area for other chemicals, in the case of permethrin, LOC exceedances are expected to occur on all land cover types throughout the state of California as a result of this federal action and the final full extent of the action area is assumed to encompass the entire state. Therefore, for this assessment, toxicity data from the open literature were only considered for inclusion if: the effects were evaluated on the basis of relevant routes of exposure that could be reliably interpreted in the context of existing risk assessment exposure assumptions; the endpoints were clearly more sensitive than existing registrant-submitted measures of effect for a given taxonomic group; the data could fill critical data gaps (*e.g.,* terrestrial plant data); the data could present a toxicity profile for under-represented taxa (*e.g.,*toxicity data for amphibians or reptiles); the data provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk for a given taxonomic group. For a comprehensive consideration of all potential sub-lethal effects resulting from exposure to permethrin please refer to the detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sub-lethal endpoints, that can be found in **APPENDIX H**. Citations of all open literature studies, including those 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 B. APPENDIX B** 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 listed species risk assessment. **APPENDIX I** also includes a summary of the human health effects data for permethrin, available from the HED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin (Dated April 4th 2006; DP Barcode D324993).

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 permethrin. A summary of the available aquatic and terrestrial ecotoxicity information, use of the probit dose response relationship, and the incident information for permethrin are provided in **Sections 4.1** through **4.4**, respectively.

As previously stated in **Section 2.2**, although trans-DCVA, 3-PBalcohol and 3-PBA are major degradation products of permethrin that occur as a result of the ester bond breakage, data on the toxicity of these degradates were not available for this review. However, evaluation of the chemical moiety of the degradates suggest little or no similarity to the active parent compound, and the cleavage of the ester linkages during degradation of the parent structure is expected to result in a significantly decreased toxicity of those degradates relative to the parent. These conclusions are in agreement with HED's approach of considering only the parent as the residue of concern for purposes of tolerance expression and risk assessment (HED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin; Dated April 4th 2006; DP Barcode D324993). Therefore, no analysis on degradates is included in this assessment.

Also covered in **Section 2.2**, 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. No product data have been submitted to the Environmental Fate and Effects Division to evaluate the potential for differences in toxicity between technical grade permethrin and permethrin formulated with multiple active ingredients. In addition, due to the numerous products containing multiple active ingredients, the extensive body of open literature on these products, and the limited amount of time for review, multiple active ingredient product mixture data from the ECOTOX open literature database were not extracted and reviewed in time for this assessment. For a comprehensive consideration of all data available for multiple active ingredient products containing permethrin and the potential for altered/enhanced toxicity, please refer to a listing of all available references for studies identified by ECOTOX in **APPENDIX B**. Instead, the Agency is relying on the available mammalian toxicity data for mixtures of permethrin submitted to the Agency and reviewed by the Health Effects Division (HED) to inform this assessment. The HED analysis of the acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in **APPENDIX A**. A qualitative discussion of implications of the available pesticide mixture effects data involving permethrin on the confidence of risk assessment conclusions for the CRLF, CCR, SFGS, SMHM, and BCB is addressed as part of the uncertainty analysis for this effects determination.

4.1 Toxicity of Permethrin to Aquatic Organisms

Table 4.1 summarizes the most sensitive aquatic toxicity endpoints, 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, CCR, SFGS, SMHM, and BCB is presented below. Additional information is provided in **APPENDIX J**.

Table 4.1. Aquatic toxicity profile for permethrin.					
Assessment Endpoint	**Purity (% a.i.)**	**Surrogate Species**	**Toxicity Value Used for Quantitative Risk Estimates (µg a.i./L)**	**Effects**	**Reference/Acceptability**
Freshwater Fish and Aquatic-phase Amphibians[a]					
Survival	Technical	Bluegill Sunfish (*Lepomis macrochirus*)	LC_{50} = 0.79	Mortality	MRID 00042128 / Supplemental
Reproduction and Growth	N/A [b]	Bluegill Sunfish (*Lepomis macrochirus*)	NOAEC = 0.0515	N/A [b]	Estimated [c]
Freshwater Invertebrates					
Survival	100	Scud (*Hyalella azteca*) [d]	EC_{50} = 0.0212	Mortality	Anderson *et al.*2006 (ECOTOX Ref. # 90039)
Reproduction and Growth	N/A [b]	Scud (*Hyalella azteca*)	NOAEC = 0.0014	N/A [b]	Estimated [e]
Estuarine/Marine Fish					
Survival	93	Atlantic Silverside (*Menidia menidia*)	LC_{50} = 2.2	Mortality/Immobilization	MRID 40228401 / Supplemental
Reproduction and Growth	N/A [b]	Atlantic Silverside (*Menidia menidia*)	NOAEC = 0.1434	N/A [b]	Estimated [f]
Estuarine/Marine Invertebrates					
Survival	93	Stone Crab (*Menippe mercenaria*)	EC_{50} = 0.018	Mortality/Immobilization	MRID 40228401 / Supplemental
Reproduction and Growth	N/A [b]	Stone Crab (*Menippe mercenaria*)	NOAEC = 0.0012	N/A [b]	Estimated [g]
Aquatic Non Vascular Plants					
Survival and Growth	NR[h]	Marine algae (*Skeletonema costatum*)	EC_{50} = 68	Growth (Based on cell counts and absorbance)	Walsh and Alexander 1980 (ECOTOX Ref. # 5297)
Aquatic Vascular Plants					
Survival and Growth	No acceptable data identified				

[a] Freshwater fish are used as a surrogate for aquatic-phase amphibians because no acceptable data for quantitative use currently exist for permethrin toxicity to aquatic-phase amphibians.
[b] N/A = Not available.
[c] The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate a bluegill sunfish (*Lepomis macrochirus*) chronic toxicity value because it is the most acutely sensitive freshwater fish species and no chronic toxicity data are available for it.
[d] Toxicity value is based on 96-hours of water-only exposure.
[e] The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate a scud (*Hyalella azteca*) chronic toxicity value because the chronic toxicity data available for freshwater invertebrates are less sensitive than the most sensitive acute toxicity value (the most sensitive LOAEC from all of the available chronic studies with freshwater invertebrates equals 0.084 µg a.i./L).
[f] The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate an Atlantic Silverside (*Menidia menidia*) chronic toxicity value because there currently are no definitive chronic endpoints determined for the estuarine/marine fish taxonomic group (effects were seen at the lowest concentration tested in the only chronic study available; NOAEC < 10 µg a.i./L).
[g] The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate a stone crab (*Menippe mercenaria*) chronic toxicity value because the chronic toxicity data available for mysids are less sensitive than the most sensitive acute toxicity value (based on the only chronic study available for estuarine/marine invertebrates the LOAEC = 0.024 µg a.i./L; the acute EC_{50} for stone crabs was reported to be 0.018 µg a.i./L) and because the chronic study was not performed using the most acutely sensitive estuarine/marine invertebrate.
[h] The formulation was reported to be Pounce® but the percent active ingredient was not reported.

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

Table 4.2. Categories of acute toxicity for aquatic animals.

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

4.1.1 Toxicity to Freshwater Fish

A summary of acute and chronic freshwater fish data, including data from the open literature, is provided below in **Sections 4.1.1.1** through **4.1.1.3**.

4.1.1.1 Freshwater Fish: Acute Exposure (Mortality) Studies

The acute toxicity studies available to the Agency demonstrate that permethrin can be classified as very highly toxic to freshwater fish, with LC_{50} values ranging from 0.79 to 72 µg a.i./L for a number of different species (refer to **APPENDIX J** for details). The studies also demonstrate that both the technical grade active ingredient and formulated permethrin share a very similar range of toxicity, with LC_{50} values ranging from 0.79 to 17.0 µg a.i./L for permethrin TGAI, and from 2.3 to 72.0 µg a.i./L for formulated permethrin. The most sensitive acute LC_{50} value of 0.79 µg a.i./L (MRID 00042128) for bluegill sunfish (*Lepomis macrochirus*) will be used to quantitatively estimate acute risk to freshwater fish. Since no acute mortality studies with aquatic-phase amphibians in the open literature have been identified as acceptable for quantitative use within the context of this risk assessment, the most sensitive LC_{50} value of 0.79 µg a.i./L for freshwater fish will also be used to estimate acute risk to aquatic-phase amphibians.

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

Only a single acceptable life-cycle study on fathead minnows (*Pimephales promelas*) was available to the Agency to evaluate the effects of chronic exposure to permethrin (95.7% a.i.) on freshwater fish (MRID 00110666). The study demonstrated that chronic exposure to concentrations as low 0.41 µg a.i./L has the potential to cause reproductive toxicity. A significant reduction in the number of surviving fry at 0.41 µg a.i./L relative to the controls was observed (8% vs. 85-95% survival). However, no other adverse effects were noted on growth or number of eggs produced. Therefore, the NOAEC and LOAEC for this study are 0.30 µg a.i./L and 0.41 µg a.i./L, respectively. Although this study is considered acceptable, a fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a bluegill sunfish chronic toxicity value because it is the most acutely sensitive freshwater fish species and no chronic toxicity data are available for it. The estimated chronic NOAEC value for the bluegill sunfish was calculated as follows:

$$\frac{\text{Acute fathead}}{\text{Chronic fathead}} = \frac{\text{Acute bluegill}}{\text{Chronic bluegill}}$$

Where, the acute fathead value is based on the geometric mean (4.602 µg a.i./L) of the three acute LC_{50} values available for fathead minnows exposed to permethrin, the chronic fathead minnow NOAEC is 0.30 µg a.i./L as described above, and the acute bluegill sunfish LC_{50} is 0.79 µg a.i./L as described previously.

Therefore,

$$\frac{4.602\ \mu g\ a.i./L}{0.30\ \mu g\ a.i./L} = \frac{0.79\ \mu g\ a.i./L}{X}$$

And,

Estimated bluegill NOAEC = (0.30 x 0.79) / 4.602 = 0.0515 µg a.i./L

This estimated NOAEC of 0.0515 µg a.i./L for bluegill sunfish will be used to quantitatively estimate chronic risk to freshwater fish. Since no chronic studies with aquatic-phase amphibians in the open literature have been identified as acceptable for quantitative use within the context of this risk assessment, the estimated NOAEC of 0.0515 µg a.i./L for freshwater fish will also be used to estimate chronic risk to aquatic-phase amphibians.

4.1.1.3 Freshwater Fish: Sub-lethal Effects and Additional Open Literature Information

No additional acceptable studies from the open literature were identified for freshwater fish that: established more sensitive acute or chronic endpoints than existing data; filled critical data gaps; presented a toxicity profile for under-represented taxa (*e.g.*, toxicity data for amphibians); or provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk.

4.1.2 Toxicity to Freshwater Invertebrates

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 **4.1.2.4**.

4.1.2.1 Freshwater Invertebrates: Acute Exposure (Mortality) Studies

The acute toxicity studies available to the Agency demonstrate that permethrin can be classified as slightly toxic to very highly toxic to freshwater invertebrates, with EC_{50} values ranging from 0.039 to <25,000 µg a.i./L. The studies also demonstrate that while the technical grade active ingredient can be classified as highly toxic to very highly toxic, with EC_{50} values ranging from 0.039 to 210 µg a.i./L, formulated permethrin is classified as slightly toxic to very highly toxic, with EC_{50} values ranging from 0.76 to <25,000 µg a.i./L.

In addition to the standard acute guideline studies mentioned above for freshwater invertebrates, an additional study examining the effects of acute exposure of *Daphnia* ephippia to permethrin was submitted (MRID 00110662). In this study, ephippia were exposed to permethrin TGAI at levels ranging from 0.001 to 100 mg a.i./L for 48 hours. After the exposure period, the eggs were rinsed and allowed to hatch in uncontaminated tap water. Time from exposure to hatching ranged from 4-5 days. The EC_{50} value for number of first instars hatched was calculated twice based on two runs of the experiment, and were reported as 34 µg a.i./L and 108 µg a.i./L.

4.1.2.2 Freshwater Invertebrates*:* Acute Exposure (Mortality) Studies- Open Literature

In addition to the aforementioned acute mortality studies with freshwater invertebrates, an additional study was identified in the open literature which reported a more sensitive EC50 value (Anderson et al, 2006; ECOTOX Ref. # 90039). This study was conducted to determine the toxicity of permethrin to the baetid mayfly *Procloeon sp.*, the amphipod *Hyalella azteca*, and the midge *Chironomus dilutus*. The determined 48-h (*Procloeon sp.*) and 96-h (*H. azteca* and *C. dilutus*) EC_{50} values for the mayfly, amphipod, and midge were 0.0896, 0.0212, and 10.45 µg a.i./L, respectively. Specifically, the estimated EC_{50} value for Hyalella is of interest because it is more sensitive than the most sensitive toxicity value from the other studies available to the Agency. Although this EC_{50} is the most sensitive toxicity value available for freshwater invertebrates, it was estimated based on static, nominal test concentrations, and therefore, still likely underestimates toxicity. In addition, it should be noted that although *Hyalella* is considered a benthic organism, this toxicity study was performed using water-only exposures. This study has been reviewed and is considered acceptable for quantitative use within the context of this risk assessment; subsequently, the most sensitive acute EC_{50} value of 0.0212 µg a.i./L (Anderson et al, 2006; ECOTOX Ref. # 90039) for amphipods, or scuds (*Hyalella azteca*), will be used to quantitatively estimate acute risk to freshwater invertebrates.

4.1.2.3 Freshwater Invertebrates: Chronic Exposure (Growth/Reproduction) Studies

There are a total of two chronic exposure studies with permethrin involving freshwater invertebrates. These two guideline life-cycle studies with waterfleas (*Daphnia magna*) report NOAEC values ranging from 0.039 to 0.28 µg a.i./L. The first study (MRID 43745701; used TGAI-98.6% a.i.) reported the NOAEC and LOAEC as 0.039 and 0.084 µg a.i./L, respectively, based on 14% and 4% reductions in the number of young produced per female and length, respectively. Decreased adult survival was also observed at 0.34 µg a.i./L. In the second life cycle study (EPA Beltsville TN 2420, 1979; used TGAI-94.4% a.i.), total production of young per adult and adult survival were decreased by 13% and 4%, respectively, at 0.56 µg a.i./L. The NOAEC was reported as 0.28 µg a.i./L.

Although these studies are considered acceptable/supplemental, the previously described fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a scud (*Hyalella azteca*) chronic toxicity value because the chronic toxicity data available for freshwater invertebrates are less sensitive than the most sensitive acute toxicity value (the most sensitive LOAEC from all of the available chronic studies with freshwater invertebrates equals 0.084 µg a.i./L) and because the chronic studies were not conducted with the most acutely sensitive freshwater invertebrate. The estimated chronic NOAEC value for scuds (*Hyalella azteca*) was calculated in the same manner as for freshwater fish, but the acute toxicity value for scuds was used instead of the acute bluegill $LC_{50.}$

$$\frac{\text{Acute fathead}}{\text{Chronic fathead}} = \frac{\text{Acute scud}}{\text{Chronic scud}}$$

Where, the acute fathead value is based on the geometric mean (4.602 µg a.i./L) of the three acute LC_{50} values available for fathead minnows exposed to permethrin, the chronic fathead minnow NOAEC is 0.30 µg a.i./L as described above, and the acute scud EC_{50} is 0.0212 µg a.i./L as described previously.

Therefore,

$$\frac{4.602\ \mu g\ a.i./L}{0.30\ \mu g\ a.i./L} = \frac{0.0212\ \mu g\ a.i./L}{X}$$

And,

Estimated scud NOAEC = (0.30 x 0.0212) / 4.602 = 0.0014 µg a.i./L

This estimated NOAEC of 0.0014 µg a.i./L for scuds will be used to quantitatively estimate chronic risk to freshwater invertebrates.

4.1.2.4 Freshwater Invertebrates: Sub-lethal Effects and Additional Open Literature Data

No additional acceptable studies from the open literature, beyond the one already discussed, were identified for freshwater invertebrates that: established more sensitive acute or chronic endpoints than existing data; filled critical data gaps; presented a toxicity profile for under-represented taxa (*e.g.,* toxicity data for amphibians); or provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk.

4.1.3 Toxicity to Estuarine/Marine Fish

A summary of acute and chronic estuarine/marine fish data, including data published in the open literature, is provided below in **Sections 4.1.3.1** through **4.1.3.3**.

4.1.3.1 Estuarine/Marine Fish: Acute Exposure (Mortality) Studies

The acute toxicity studies available to the Agency demonstrate that permethrin can be classified as highly toxic to very highly toxic to estuarine/marine fish, with LC_{50} values ranging from 2.2 to >300 µg a.i./L. The studies also demonstrate that while the technical grade active ingredient can be classified as very highly toxic, with LC_{50} values ranging from 2.2 to 7.8 µg a.i./L, formulated permethrin is classified as highly toxic to estuarine/marine fish with a single reported LC_{50} value of >300 µg a.i./L. The most sensitive acute LC_{50} value of 2.2 µg a.i./L (MRID 40228401) for Atlantic silversides (*Menidia menidia*) will be used to quantitatively estimate acute risk to estuarine/marine fish.

4.1.3.2 Estuarine/Marine Fish: Chronic Exposure (Growth/Reproduction) Studies

Only a single early life-stage study with sheepshead minnows (*Cyprinodon variegatus*) was available to the Agency to evaluate the effects of chronic exposure to permethrin (93% a.i.) on estuarine/marine fish (NR 1994). The study demonstrated that chronic exposure to concentrations as low 10 µg a.i./L has the potential to cause reduced survival. However, a NOAEC could not be established because effects were seen at the lowest tested concentration of 10 µg a.i./L (NOAEC < 10µg a.i./L) and no other information was reported. Therefore, due to the non-definitive nature of the reported toxicity value, the study was not considered acceptable for quantitative use within the context of this risk assessment and a fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate an Atlantic silverside (the most acutely sensitive estuarine/marine fish) chronic toxicity value. The estimated chronic NOAEC value for the Atlantic silverside was calculated as follows:

$$\frac{\text{Acute fathead}}{\text{Chronic fathead}} = \frac{\text{Acute silverside}}{\text{Chronic silverside}}$$

Where, the acute fathead value is based on the geometric mean (4.602 µg a.i./L) of the three acute LC_{50} values available for fathead minnows exposed to permethrin, the chronic fathead minnow NOAEC is 0.30 µg a.i./L as described above, and the acute Atlantic silverside LC_{50} is 2.2 µg a.i./L as described previously.

Therefore,

$$\frac{4.602\ \mu g\ a.i./L}{0.30\ \mu g\ a.i./L} = \frac{2.2\ \mu g\ a.i./L}{X}$$

And,

Estimated Atlantic silverside NOAEC = (0.30 x 2.2) / 4.602 = 0.1434 µg a.i./L

This estimated NOAEC of 0.1434 µg a.i./L for Atlantic silversides will be used to quantitatively estimate chronic risk to estuarine/marine fish.

4.1.3.3 Estuarine/Marine Fish: Sub-lethal Effects and Additional Open Literature Data

No additional acceptable studies from the open literature were identified for estuarine/marine fish that: established more sensitive acute or chronic endpoints than existing data; filled critical data gaps; presented a toxicity profile for under-represented taxa (*e.g.*, toxicity data for amphibians); or provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk.

4.1.4 Toxicity to Estuarine/Marine Invertebrates

A summary of acute and chronic estuarine/marine invertebrate data, including data published in the open literature, is provided below in **Sections 4.1.4.1** through **4.1.4.3**.

4.1.4.1 Estuarine/Marine Invertebrates: Acute Exposure (Mortality) Studies

The acute toxicity studies available to the Agency demonstrate that permethrin can be classified as moderately toxic to very highly toxic to estuarine/marine invertebrates, with EC_{50} values ranging from 0.018 to 6500 µg a.i./L. It should be noted that permethrin generally appears to be less toxic to bivalves (Eastern and Pacific oysters; *Crassostrea virginica* and *Crassostrea gigas*) than other estuarine/marine invertebrates; EC_{50} values ranged from >407 to 6500 µg a.i./L and 0.018 to 7.6 µg a.i./L for bivalves and the rest of the estuarine/marine invertebrates, respectively. The studies also demonstrate that both the technical grade active ingredient and formulated permethrin can be classified as moderately toxic to very highly toxic, with EC_{50} values ranging from 0.018 to >1050 µg a.i./L and 0.51 to 6500 µg a.i./L, respectively. The most sensitive acute EC_{50} value of 0.018 µg a.i./L (MRID 40228401) for stone crabs (*Menippe mercenaria*) will be used to quantitatively estimate acute risk to estuarine/marine invertebrates.

4.1.4.2 Estuarine/Marine Invertebrates: Chronic Exposure (Growth/Reproduction) Studies

There is only one chronic exposure study with permethrin (95% a.i.) involving estuarine/marine invertebrates (MRID 41315701) available to the Agency. This life-cycle study with mysids (*Americamysis bahia*) reports NOAEC and LOAEC values of 0.011 and 0.024 µg a.i./L, respectively, based on a 20% increase in mortality at the LOAEC relative to the control. While no adverse effects on growth were noted based on adult body weight (length measurements were not taken), the effects of chronic exposure to permethrin on reproduction of mysids could not be evaluated in this study due to significant study limitations (*i.e.*, poor reproductive performance of controls). Therefore, the utility of this study for risk assessment purposes is severely limited. Subsequently, the previously described fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a stone crab (*Menippe mercenaria*) chronic toxicity value because the chronic toxicity data available for mysids are less sensitive than the most sensitive acute toxicity value (based on the only chronic study available for estuarine/marine invertebrates the LOAEC = 0.024 µg a.i./L; the acute EC_{50} for stone crabs was reported to be 0.018 µg a.i./L) and because the chronic study was not performed using the most acutely sensitive estuarine/marine invertebrate. The estimated chronic NOAEC value for stone crabs (*Menippe mercenaria*) was calculated in the same manner as for freshwater fish, but the acute toxicity value for stone crabs was used instead of the acute bluegill LC_{50}.

$$\frac{\text{Acute fathead}}{\text{Chronic fathead}} = \frac{\text{Acute stone crab}}{\text{Chronic stone crab}}$$

Where, the acute fathead value is based on the geometric mean (4.602 µg a.i./L) of the three acute LC_{50} values available for fathead minnows exposed to permethrin, the chronic fathead minnow NOAEC is 0.30 µg a.i./L as described above, and the acute stone crab EC_{50} is 0.018 µg a.i./L as described previously.

Therefore,

$$\frac{4.602\ \mu g\ a.i./L}{0.30\ \mu g\ a.i./L} = \frac{0.018\ \mu g\ a.i./L}{X}$$

And,

Estimated stone crab NOAEC = (0.30 x 0.018) / 4.602 = 0.0012 µg a.i./L

This estimated NOAEC of 0.0012 µg a.i./L for stone crabs will be used to quantitatively estimate chronic risk to estuarine/marine invertebrates.

4.1.4.3 Estuarine/Marine Invertebrates: Sub-lethal Effects and Additional Open Literature Data

No additional acceptable studies from the open literature were identified for estuarine/marine invertebrates that: established more sensitive acute or chronic endpoints than existing data; filled critical data gaps; presented a toxicity profile for under-represented taxa (*e.g.*, toxicity data for amphibians); or provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk.

4.1.5 Toxicity to Aquatic-phase Amphibians

A number of studies involving amphibian toxicity testing and permethrin were identified in the open literature and are summarized below. None of these studies provide reliable estimates of toxicity that may be used quantitatively in this risk assessment; however they do provide some information regarding the hazard of permethrin to amphibians.
For a comprehensive consideration of all potential effects data and additional information for amphibians please refer to the detailed spreadsheet of the available ECOTOX open literature data that can be found in **APPENDIX H**.

Dwyer et al 2005 (ECOTOX Ref. # 81380) compared boreal toad (*Bufo boreas boreas)* larvae sensitivity to the sensitivity of fish for permethrin. However, significant limitations of these data severely hinder their utility for quantitative risk assessment purposes. For instance, toxicity estimates for the boreal toad are based on static nominal concentrations and there is considerable variability in the measured concentrations taken only from the stock solutions relative to the nominal, the concentration of the co-solvent (acetone) in the study is not stated, wild-caught frogs with an unknown exposure history were used, the developmental stage of the test larvae was not stated and it is unknown whether the stage is matched across treatments, and test animal weight was expressed as the average of 20 animals. Particularly, reliance on the nominal concentrations is problematic and toxicity estimates are unacceptably uncertain due to permethrin's low solubility (5.5 µg a.i./L), high k_{oc}, and propensity to sorb. However, in spite of these limitations the study may be useful for qualitative purposes to demonstrate that boreal toad larvae were less sensitive than the tested fish species to permethrin (96-hr LC_{50}>10 µg a.i./L).

Jolly et al 1978 (ECOTOX Ref. # 5181) evaluated the acute toxicity of permethrin on crayfish (*Procambarus clarkii*), channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), mosquito fish (*Gambusia affinis*), and bullfrogs (*Rana catesbeiana*). While the study may be useful for qualitative risk assessment purposes, serious design issues and uncertainties make it unacceptable for quantitative use. In particular, wild-caught frogs with an unknown exposure history were used, the actual formulation tested is not stated and its potential inert ingredients are unknown, it is unknown whether the estimated toxicity endpoints are corrected for percent active ingredient, it is unclear whether the toxicity endpoints are based on measured exposure concentrations, and larvae 6 - 8 mm in length were use. Because larvae of 6-8 mm in length were used, and bullfrog larvae reported in open literature are 10 mm in length, it suggests that the animals are close to being newly hatched and it is possible that they still have their yolk sac. Subsequently, this may have affected the extent to which they uptake chemicals in the water, and toxicity could be significantly underestimated. In addition, potentially relying on nominal concentrations is problematic due to permethrin's low solubility (5.5 µg a.i./L), high k_{oc}, and propensity to sorb. Therefore, toxicity estimates are unacceptably uncertain. However, the study does provide information on the relative toxicity of the permethrin formulated product to bullfrogs under these test conditions; compared to newly hatched crayfish (96 hr LC_{50} = 0.39 µg/L), bullfrog larvae are 18,000X less sensitive (96-hr LC_{50}=7033 µg /L).

Thurston et al 1985 (ECOTOX Ref. #12004) evaluated the relative acute toxicity of permethrin to a variety of freshwater animals, including Bullfrog tadpoles (*Rana catesbiana*), under standardized test conditions for the purposes of determining the extent to which a single species might be used as a surrogate for others. A number of study limitations include: the amount of solvent (dimethylformamide) used was not reported and it is not clear whether a solvent control was evaluated; although concentrations were measured, recovery of the chemical was not reported; the number of tadpoles tested per treatment was not reported; the loading rate was not reported; and tadpoles had a considerable range in sizes (2 - 5 g), their developmental stages as tadpoles likely varied considerably, and it is unknown whether the stages were matched across treatments. These deviations and the lack of description of some significant details on design, hinder the use of this study for quantitative risk assessment purposes. However, the study does provide information on the relative toxicity of the permethrin to bullfrogs under these test conditions. The bullfrog was less sensitive to permethrin relative to most other species tested; the 96-hr LC_{50} values for bullfrog larvae, goldfish (*Carassius auratus*), waterfleas (D*aphnia magna*), rainbow trout (*Oncorhynchus mykiss*), and bluegill sunfish (*Lepomis macrochirus*) were 115 µg a.i./L (95% CI: 53.8 - 245 µg a.i./L), >228 µg a.i./L , <1.4 µg a.i./L, 5 µg a.i./L, and 5 µg a.i./L, respectively.

Johansson et al 2006 (ECOTOX Ref. #88266) investigated the effects of acute exposure to permethrin on survival and development of the tadpoles of the common frog, *Rana temporaria*, and assessed the influence of chronic exposure. In the 3-day acute study, tadpoles at a Gosner stage 25 were exposed to permethrin concentrations of 2, 8, and 32 µg a.i./L under presumably static conditions; concentrations were selected based on a previously reported LC_{50} of 2.5 µg a.i./L. In the chronic study, tadpoles were exposed to 0, 0.1, and 1 µg a.i./L permethrin from 6-hrs post fertilization until metamorphosis under static renewal conditions (every 72 hours). Response variables included growth (body length, tail length, wet weight), survival, age at metamorphosis and growth rate (body weight at metamorphosis divided by the number of days required to complete metamorphosis).

In the acute study, permethrin showed no effect of concentration on growth measurements ($p>0.09$). There was a weak but significant effect of permethrin concentration on survival ($p=0.0026$), and it appeared that survival was reduced by roughly 20% at the highest test concentration (32 µg a.i./L). In the chronic study, permethrin had a significant effect on size at metamorphosis (body weight $p=0.017$; tail length $p=0.0068$; wet weight $p=0.0018$) and the metamorphs gradually increased in size with increasing pesticide concentration. No effect of permethrin on either survival or age at metamorphosis was observed; however, weight showed a distinct and sharp increase across increasing concentrations of permethrin. Control animals were roughly 0.85 g, while animals in the 0.1 and 1 µg a.i./L treatments were 0.9 and roughly 1.1 g, respectively.

The limitations of this study that hinder its utility for risk assessment purposes include: a very high loading rate of tadpoles (exceeded the recommended rate of 1 tadpole/L) for the acute study and for the early part of the chronic study; test organisms were fed during the acute study and it may have reduced the amount of permethrin in solution and confidence in exposure estimates; and wild-caught frogs with an unknown exposure history were used. At most, this study does offer that survival may be adversely affected following a 3-day acute exposure period, while growth may be positively correlated with increasing permethrin concentrations following chronic exposure from 6-day post-fertilization through metamorphosis.

The objective of Berril et al (ECOTOX Ref. # 2850) was to evaluate the effects of exposure of tadpoles and embryos of five amphibian species to permethrin to determine behavioral effects. Species tested included the leopard frog (*Rana pipiens*), green frog (*R. clamitans*), wood frog (*R. sylvatica*), American toad (*Bufo americanus*), and the spotted salamander (*Ambystoma maculatum*). However, wild-caught frogs with an unknown exposure history were used, the purity of permethrin was not reported, all exposure concentrations were reported as nominal, no concentrations were measured, loading rates were very high, test conditions were very poorly described, river water was used as dilution water and the exposure to other chemicals is unknown, and it is not clear whether eggs were dejellied in order to conduct the exposure studies of embryos and if so, what the procedure was to accomplish this task. Particularly, reliance on the nominal concentrations is problematic and toxicity estimates are unacceptably uncertain due to permethrin's low solubility (5.5 µg a.i./L), high k_{oc}, and propensity to sorb. The only notable results of the study are that permethrin exposure under the conditions tested had transient effects on growth and may have decreased survival at 50 and 100 µg a.i./L. Subsequently, due to an extreme number of uncertainties and significant study limitations, it is not possible to put any observed effects into context for this risk assessment and they will not be discussed further.

The objective of Yasmeen and Nayccmunnisa 1992 (ECOTOX Ref. # 100130) was to look at acetylcholine esterase, choline acetylase, and calmodulin in the brains of *Rana cyanphlictis*. However, wild-caught frogs with an unknown exposure history were used, only a single nominal concentration of 0.25 mg /L was tested and it was unclear whether the concentrations were corrected for percent active ingredient of the tested formulation 25% a.i.), inert ingredients in the formulation were unknown, loading rates, measured concentrations, and water quality were not discussed, it was not clear whether there was any true replication of test groups, the methods of quantification of enzyme activity had a low sensitivity (polyacrylamide gel electrophoresis was used along with gel densitometry), enzyme activity was not normalized to protein content, and methods of measuring protein content were not reported. Subsequently, due to significant study limitations, it is not possible to put any observed effects into context for this risk assessment and they will not be discussed further.

While Fort et al 1999 (ECOTOX Ref. # 89641) exposed embryos of *Xenopus laevis* to pond water and sediment contaminated with multiple chemicals including permethrin, the contribution of the various chemical to the observed toxicity is uncertain. Therefore, the utility of this study comes from the portion in which physicochemical characterization of the causes of abnormal frog embryo–larval and limb development was performed using the frog embryo teratogenesis assay—*Xenopus* (FETAX). In this portion of the study, specific compounds, including permethrin, were subsequently identified within the complex mixture fractions from the pond and sediment and tested by dilution in a control solution and native reference water using both the 4- and 30-d treatment protocols. The 4-day assays suggest that permethrin could be a teratogen and cause potential adverse effects on gut and neural development (EC_{50}=59.4 µg a.i./L; minimum concentration to inhibit growth at p<0.05 was 50 µg a.i./L; LC_{50}=693 µg a.i./L) in blastula-stage embryos. The extended portion of the study observed no effects of permethrin on limb development. However, in addition to inadequate characterization of exposure of test subjects (*e.g.*,no information on test concentrations), the results of the study are problematic due to relatively high loading rates and the use of static renewal. Since larvae do not develop at the same rate, the presumption is that some larvae were exposed for longer periods of time than others. The study was conducted under static renewal with 48 hour water changes, potentially resulting in poor water quality given the loading rate of 10 larvae/L (the recommended loading is 1 per Liter). Therefore, the utility of this study for quantitative risk assessment purposes is severely limited.

4.1.6 Toxicity to Aquatic Plants

Laboratory studies were used to determine whether permethrin may cause direct effects to aquatic plants. A summary of the laboratory data for aquatic plants, including data published in the open literature, is provided in **Section 4.1.6.1**.

4.1.6.1 Toxicity to Aquatic Plants

For the purposes of this assessment, vascular and non-vascular aquatic plant acute EC_{50} values, rather than NOAEC values, are to be used to assess the potential for effects to the aquatic-phase CRLF, CCR, SFGS, and SMHM via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community), because there are no obligate relationships between the assessed species and any aquatic plant species. Only one study examining the toxicity of permethrin to non-vascular aquatic plants was initially available to the Agency (MRID 40228401). This study involving technical permethrin (93% a.i.) and the marine diatom (*Skeletonema costatum*) reports an EC_{50} value of 92 µg a.i./L However, no NOAEL, raw data, or additional information were reported.

Only two other studies establishing EC_{50} values for non-vascular plants were identified in the open literature. The first (Stratton *et al.*, 1980; ECOTOX Ref # 4684) laboratory toxicity assay was conducted to determine the effects of permethrin on the growth (yield and rate), $^{14}CO_2$ uptake, and acetylene reduction of the blue-green alga, *Anabaena inequalis*. The study determined the EC_{50} of permethrin towards growth yield, growth rate, photosynthesis (uptake of $^{14}CO_2$ and $NaH^{14}CO_3$), and acetylene reduction to be 1.6, 5.0, >100 and >100 mg a.i./L, respectively. However, no NOAEL or raw data were reported.

The second open literature study (Walsh and Alexander, 1980; ECOTOX Ref # 5297) was conducted to evaluate methodologies of marine algal bioassays and to determine the effects of permethrin on the marine alga, *Skeletonema costatum*. EC_{50} values and their 95% confidence intervals were calculated on a Digital Equipment Corporation PDP11/45 computer by moving average method. The 96-hour static toxicity test yielded growth EC_{50} values of 68 and 72 µg a.i./L, based on cell counts and absorbance, respectively. However, no NOAEL or raw data were reported.

No acceptable data from registrant-submitted studies or the open literature on the toxicity of permethrin to aquatic vascular plants were available to the Agency for this assessment. Therefore, the most sensitive EC_{50} value of 68 µg a.i./L µg a.i./L (Walsh and Alexander, 1980; ECOTOX Ref # 5297) for the marine alga, *Skeletonema costatum*, will be used to quantitatively estimate risk to aquatic plants resulting from exposure to permethrin.

4.1.7 Freshwater Field/Mesocosm Studies

One registrant-submitted study field study with aquatic organisms was available for permethrin (MRID 00042134). In the study, researchers monitored a 5-acre pound for unspecified amount of time prior to spraying a 5-acre cotton field adjacent to it with two formulations of permethrin (Pounce and Ambush; % a.i. not reported). The two formulations were alternately applied at a single rate of 0.2 lb a.i./acre on 5 rows of cotton each time by ground spray equipment, every five days, for seventeen total applications. Fish, crayfish, mussels, zooplankton and macroinvertebrate populations were monitored bimonthly for five months following the application period. Samples of fish, crayfish, mussels, water, and sediment from the pond and soil from the cotton field were collected for residue analysis. Although no treatment-related effects were noted in fish, crayfish, mussel, or zooplankton populations, aquatic insect populations decreased by 79% following a significant rainfall after permethrin applications (unclear, but around the 9th or 10th application). Water sampled from the pond after the drop in macro-invertebrate abundance contained 0.05 - 0.11 µg a.i./L permethrin. The populations of insects did not increase until a month a half after the decline and almost a month after the final application. Tissue analyses showed 0.06 mg a.i./kg-bw permethrin in crayfish samples, 0.03 mg a.i./kg-bw in mussel, and no detectable levels in fish samples.

Any definitive conclusions are difficult to draw from this study due to poor experimental design, a lack of control pond data, the fact that the water level in the pond was maintained by pumped well water, and the inability to perform any statistical analyses. However, the results of this experiment do suggest the potential for toxic effects to aquatic invertebrates as a result of permethrin use at a rate similar to those allowed under current labels. The occurrence of macro-invertebrate population decline after a heavy rainfall following treatment, suggests the potential for off-site transport of permethrin to aquatic systems via erosion/runoff at concentrations that could be harmful to aquatic organisms. The potential effects may include food chain interruption and removal of biomass. The potential for of-site transport is also supported by the fact that permethrin soil concentrations near the pond were higher than those further away from the pond. Under aerial application conditions and higher ratios of treated land surface to water surface, the potential for increased levels of contamination and intensified toxic effects would be expected to be even higher.

4.2 Toxicity of Permethrin to Terrestrial Organisms

Table 4.3 summarizes the most sensitive terrestrial toxicity endpoints, based on an evaluation of both the submitted studies and the open literature. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment is presented below.

Table 4.3. Terrestrial toxicity profile for permethrin.					
Assessment Endpoint	**Purity (% a.i.)**	**Surrogate Species**	**Toxicity Value Used for Quantitative Risk Estimates (µg a.i./L)**	**Effects**	**Comments (Reference/Acceptability)**
Birds, Terrestrial-phase Amphibians, and Reptiles [a]					
Survival	95.7	Northern bobwhite quail *(Colinus virginianus)*	LC_{50} > 10,000 mg/kg-diet	No treatment -related mortality	MRID 00072845/Acceptable
Survival	Technical; Purity not reported	Mallard duck *(Anas platyrhynchos)*	LD_{50} > 9,869 mg/kg-bw	No treatment-related mortality	MRID 00042142/Acceptable
Reproduction and Growth	95.2	Mallard duck *(Anas platyrhynchos)*	NOAEC = 125 mg/kg-diet LOAEC = 500 mg/kg-diet	Overall decrease in egg production (↓13.2%) at 500 mg/kg-diet; not statistically significant but correlated with an apparent increase in the number of hens with a regressing ovary.	MRID 42322902/ Acceptable
Mammals					
Survival	94	Rat (*Rattus norvegicus*)	LD_{50} = 152 mg/kg-bw [b]	Mortality	Cantalamessa 1993 (ECOTOX Ref. # 74863)
Reproduction and Growth	94	Mouse (*Mus musculus*)	NOAEL= 2.77 mg/kg-bw/day (~55.44 mg/kg-diet) [c] LOAEL = 5.59 mg/kg-bw/day (~111.8 mg/kg-diet) [c]	Decreased maternal body weight gain during gestation (↓57% from controls) and lactation (↓187% from controls), increased # of dead pups (↑64% from controls), decreased # of live pups (↓10% from controls), and decreased body weight gain of pups (↓52% from controls) at 9.8 mg/kg-bw/day	Farag *et al.* 2006 (ECOTOX Ref. # 100119)
Terrestrial Invertebrates					
Survival	93.1	Honey bee (*Apis mellifera*)	48-hour LD_{50} = 0.024 µg a.i./bee	Mortality	MRID 42674501/Acceptable
Terrestrial Plants					
Survival and Growth	No acceptable data identified				

[a] Birds are used as a surrogate for terrestrial-phase amphibians and reptiles because no acceptable data for quantitative use currently exist for permethrin toxicity to these taxonomic groups.
[b] This LD_{50} is based on the 24-hour LD_{50} value of 340.5 mg/kg-bw reported in the study for 8-day old rats but was scaled to be representative of the assumed typical test organism, a 350g laboratory rat, for use in T-REX. Please refer to the discussion in the "Toxicity to Mammals" section of the "Effects Assessment" (**Section 4**) for additional details.
[c] The NOAEL and LOAEL values are based on the values of 4.9 and 9.8 mg/kg-bw, respectively, reported in the study for mice but were scaled to be representative of the assumed typical test organism, a 350g laboratory rat, for use in T-REX. Please refer to the discussion in the "Toxicity to Mammals" section of the "Effects Assessment" (**Section 4**) for additional details.

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

Table 4.4. Categories of acute toxicity for avian and mammalian studies.		
Toxicity Category	**Oral LD_{50}**	**Dietary LC_{50}**
Very highly toxic	< 10 mg/kg	< 50 ppm

Table 4.4. Categories of acute toxicity for avian and mammalian studies.		
Toxicity Category	**Oral LD_{50}**	**Dietary LC_{50}**
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

4.2.1 Toxicity to Birds

As specified in the Overview Document, the Agency uses birds as a surrogate for reptiles and terrestrial-phase amphibians when toxicity data for each specific taxon are not available (U.S. EPA, 2004). A summary of acute and chronic bird data, including data published in the open literature, is provided below in **Sections 4.2.1.1** through **4.2.1.3**. No acceptable data for reptiles or terrestrial-phase amphibians have been submitted to the Agency or were identified in the open literature using the ECOTOX database.

4.2.1.1 Birds: Acute Exposure (Mortality) Studies

The results of the sub-acute dietary toxicity studies (MRID 00112939, 41888403, 41888402, 00072845, 00042123, and 00043733, and ACC.# 227722) available for permethrin indicate that it can be classified as practically non-toxic to avian species on an acute dietary basis with LC_{50} values for mallard ducks (*Anas platyrhynchos*), Northern bobwhite quail (*Colinus virginianus*), Japanese quail (*Coturnix japonica*), and ring-necked pheasants (*Phasianus colchicus*) ranging from >5,200 to >23,000 mg a.i./kg-diet. Based on all of the sub-acute dietary toxicity studies, bobwhite quail were the species tested at the lowest concentrations; therefore, for the purposes of this assessment they were considered the “most sensitive species tested” with LC_{50} values ranging from >5,200 to >10,000 mg a.i./kg-diet. While the LC_{50} value of >10,000 mg a.i./kg-diet for bobwhite quail was considered the most sensitive sub-acute dietary toxicity endpoint for all tested avian species, it should be noted that no treatment-related mortality was observed.

The results of the acute oral toxicity studies (MRID 00112938, 41888401, 00042142, 00042121, 00042120, 00042144) available for permethrin indicate that it can be classified as practically non-toxic to avian species on an acute oral basis with LD_{50} values for mallard ducks (*Anas platyrhynchos*), Japanese quail (*Coturnix coturnix*), starlings (*Sturnus vulgaris*), and ring-necked pheasants (*Phasianus colchicus*) ranging from >2,000 to >42,706 mg a.i./kg-body weight. Based on all of the acute oral toxicity studies, mallard ducks were the species tested at the lowest concentrations; therefore, for the purposes of this assessment they were considered the “most sensitive species tested” with LD_{50} values ranging from >2000 to >10,327 (for females; >9,869 mg a.i./kg-body weight for males) mg a.i./kg-diet. While the LD_{50} value of >9,869 mg a.i./kg-body weight for mallard duck males was considered the most sensitive acute oral toxicity endpoint for all tested avian species, it should be noted that no treatment-related mortality was observed.

4.2.1.2 Birds: Chronic Exposure (Growth, Reproduction) Studies

Four avian reproduction studies with mallard ducks (*Anas platyrhynchos*) and Northern bobwhite quail (*Colinus virginianus*) have been submitted to the Agency for permethrin (MRID 00110670, 00110671, 42322901, and 42322902). In three of the four studies (MRID 00110670, 00110671, 42322901), there were no observed adverse effects on any of the endpoints including food consumption, number of eggs laid, eggs cracked, egg shell thickness, viable embryos, live three-week embryos, normal hatchlings, 14-day-old survivors and offspring body weight. While the one study with bobwhite quail (MRID 42322901) established a NOAEC at the highest tested concentration of 500 mg a.i./kg-diet (LOAEC>500 mg a.i./kg-diet), the other two studies that evaluated effects on bobwhite quail (MRID 00110671) and mallards (MRID 00110670) only tested up to 25 mg a.i./kg-diet (NOAEC=25 mg a.i./kg-diet, LOAEC>500 mg a.i./kg-diet).

In the fourth avian reproduction study with permethrin and mallard ducks (MRID 42322901), there was a decrease in food consumption and an overall decrease in egg production (↓13.2%) at 500 mg a.i./kg-diet; although these effects were not statistically significant, they were associated with an apparent increase in the number of hens with a regressed ovary (8 hens in the 500 mg a.i./kg-diet treatment group compared to 2 in control). Although the effects were not statistically significant, given the magnitude of effects, the associated increase in occurrences of regressed ovaries, and the acknowledgment by the study authors that the effects may be treatment-related, the NOAEC and LOAEC for this study have been set at 125 and 500 mg a.i./kg-diet, respectively. The results of this study indicate that permethrin may have adverse effects on avian reproduction at higher levels of exposure, and the most sensitive NOAEC of 125 mg a.i./kg-diet will be used to quantitatively estimate risks to birds (and thus, terrestrial-phase amphibians and reptiles) resulting from chronic exposure to permethrin.

4.2.1.3 Birds: Open Literature Studies

No additional acceptable studies from the open literature were identified for birds (or terrestrial-phase amphibians or reptiles) that: established more sensitive acute or chronic endpoints than existing data; filled critical data gaps; presented a toxicity profile for under-represented taxa (*e.g.*, toxicity data for amphibians or reptiles); or provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk.

4.2.2 Toxicity to Mammals

Typically, mammalian toxicity data from the Agency's Health Effects Division (HED) 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 to wild mammal species have been submitted by the registrants for permethrin. However, additional laboratory data were available from the open literature, as well as from HED, and have been considered as surrogate data for mammalian wildlife for the purposes of this risk assessment. A summary of acute and chronic laboratory mammalian data, including data submitted by registrants as well as published in the open literature, is provided below in **Sections 4.2.2.1** through **4.2.2.4**.

4.2.2.1 Mammals: Registrant Submitted Acute Exposure (Mortality) Studies

There is one registrant submitted acceptable rat acute oral toxicity study discussed in the HED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin (Dated April 4th 2006; DP Barcode D324993). The reported laboratory rat LD_{50} value for the technical active ingredient of permethrin for females was 2280 mg a.i./kg-bw (3580 mg a.i./kg-bw for males)(MRID 242899); no other information was discussed. In addition to the data used and reported by HED, an LD_{50} value of 8900 mg a.i./kg-bw for acute oral toxicity of the technical active ingredient of permethrin to laboratory rats was reported in the EFED chapter of the RED for permethrin (Dated April 5th 2006; DP Barcode D326784); no additional information could be found in the chapter or in the EFED files (No MRID; Document Reference No. 279-GNRU, 1978). Based on these reported laboratory rat LD_{50} values, permethrin is practically non-toxic to small mammals on an acute oral basis.

Following the completion of the EFED and HED chapters written for the RED in 2006, additional acceptable acute oral toxicity data with the technical active ingredient of permethrin (92% a.i.) have been submitted to the Agency (MRID 44707301). The reported laboratory LD_{50} value for the technical active ingredient of permethrin for female Sprague-Dawley rats (6-8 weeks old) in this study was 570 mg a.i./kg-bw (703 mg a.i./kg-bw for males; 614 mg a.i./kg-bw combined)**.** Based on this reported laboratory rat LD_{50} value, permethrin is classified as slightly toxic to small mammals on an acute oral basis.

4.2.2.2 Mammals: Open Literature Acute Exposure (Mortality) Studies

In addition to the registrant data, more sensitive acceptable acute toxicity data considered for quantitative risk estimation purposes for mammals were identified in the open literature. *Cantalamessa* (1993; ECOTOX Ref # 74863) reported 24-hour LD_{50} values of 340.5 (95% CL = 308.8-375.6), 399.0 (95% CL = 346.1-460.0), 471.0 (95% CL = 384.5-577.0), and 1500.0 (95% CL = 938.0-2345.3) mg/kg-bw for 8-day old, 16-day old, 21-day old, and adult Wistar rats. LD_{50} values and associated confidence intervals were determined by using ten animals per dose level, with individuals in four or more dose levels being exposed to permethrin (25:75, cis:trans, 94% purity) dissolved in corn oil via gavage. At least two separate experiments were used to evaluate pyrethroid lethality, and the reported LD_{50} values represent the average of the two separate experiments. Based on the range of reported laboratory rat LD_{50} values from this study, permethrin can be classified as moderately toxic to slightly toxic to small mammals on an acute oral basis.

In electing to use this study for quantitative risk estimation purposes, it is acknowledged that the toxicity endpoint and the associated approximated risk estimates for free-feeding wild mammals based on 8-day old neonatal rats exposed via gavage may represent a conservative scenario. However, it is also noted that some small mammals, some members of the Muridae Family for example, are weaned within the first week following birth (Whitaker and Hamilton, 1998). In addition, one of the listed species considered in this assessment is the Salt marsh harvest mouse, a member of the closely related Cricetidae family, and relatively little is known about the weaning habits of this species. Therefore, in order to be as protective of the assessed species as is reasonable, the Agency has opted to maintain a conservative approach by estimating risk based on the 24-hour LD_{50} value reported in this study for 8-day old rats. However, direct use of this endpoint in T-REX would be inappropriate because T-REX assumes a set bodyweight of 350g for the tested species, assuming they are the young adult rats (6-8 weeks old) that are tested in acute oral toxicity studies that are typically submitted to the Agency. Use of endpoints from other organisms that differ markedly in weight would result in inaccuracies in extrapolating test endpoints to modeled animals. Therefore, prior to input into T-REX, the 24-hour LD_{50} value of 340.5 mg/kg-bw reported in this study for 8-day old rats was scaled to be representative of the assumed typical test organism, a 350g laboratory rat, by using the following equation as mentioned in the T-REX user's manual:

$$Adj.\,NOAEL\ or\ LD_{50} = NOAEL\ or\ LD_{50}\left(\frac{TW}{AW}\right)^{(0.25)}$$

where:

Adj. LD_{50} = adjusted LD_{50} (mg/kg-bw) for acute mammalian toxicity
LD_{50} = value reported from *Cantalamessa* (1993; ECOTOX Ref # 74863); 340.5 mg/kg-bw
TW = body weight of tested animal (8 day old rat); not reported, assumed approximately 14g based on average body weights of 7-day and 9-day old Wistar rats reported by *Pullen* (1976)
AW = body weight of assessed animal; in this case is equal to 350g, the TREX assumed body weight for adult rats

Therefore, the adjusted LD_{50} equals 340.5 * (14/350)^ $^{(0.25)}$, or 152.28 mg/kg-bw. This adjusted 24-hour LD_{50} value of 152.28 mg/kg-bw is the acute toxicity value that was directly used in T-REX for quantitative risk estimation purposes and determining the potential for direct effects to the Salt marsh harvest mouse (*Reithrodontomys raviventris*), as well indirect effects to those listed species that rely on mammals during at least some portion of their life-cycle (*i.e.*, CRLF, salt marsh harvest mouse, San Francisco garter snake, and California clapper rail).

4.2.2.3 Mammals: Registrant Submitted Chronic/Reproduction Exposure (Growth, Reproduction) Studies

In the HED chapter of the RED for permethrin (Dated April 4th 2006; DP Barcode D324993) one registrant-submitted acceptable/guideline three generation reproduction study (MRID 92142092, 120271, 92142037) with rats was discussed. In this study, permethrin (purity, 94.0-98.8%) was administered to groups of 12 male and 24 female Wistar rats in the diet at concentrations of 0, 500, 1000, or 2500 ppm (0, 25, 50, and 125 mg/kg/day, respectively, using a standard conversion factor of 0.05). The LOAEL for systemic toxicity is 2500 ppm (125 mg/kg/day) based on tremors observed in the F0 females, and the F1 and F2 males and females. The systemic toxicity NOAEL is 1000 ppm (50 mg/kg/day). The reproductive toxicity NOAEL is ≥2500 ppm (125 mg/kg/day) and the reproductive toxicity LOAEL is not identified. The NOAEL for offspring growth and development is ≥2500 ppm (125 mg/kg/day) and the offspring LOAEL is not identified. However, one of the major deficiencies noted for this study was a lack of homogeneity and stability of the compound in the test diets, suggesting that the estimated exposure levels may be unreliable.

In addition to the three generation reproduction study, the other studies that were discussed in the HED RED chapter that demonstrated adverse effects on growth or reproduction of mammals at more sensitive quantifiable levels was an acceptable/guideline prenatal developmental study with rats (MRID 40943603) and an acceptable/guideline chronic oral toxicity study with dogs (MRID 00129600). In the developmental study, 24 presumed pregnant Wistar rats per group were administered 0 (corn oil carrier), 15, 50, or 150 mg/kg/day of permethrin (93.9% a.i.; 38 cis:62 trans isomers) by gavage on gestation days (GD) 7-16, inclusive. The maternal toxicity NOAEL and LOAEL were 50 mg/kg/day and 150 mg/kg/day, respectively, based on clinical signs of toxicity and decreased body weight gain (↓18-88% from controls; $p \leq 0.05$) and food consumption. The developmental toxicity NOAEL and LOAEL were 50 mg/kg/day and 150 mg/kg/day, respectively, based on decreased fetal body weight (↓3.2% from controls; $p \leq 0.05$). However, mean litter weight of the 150 mg/kg/day group was 3% (n.s.) greater than that of the controls. Therefore, the reduced fetal body weights were considered a questionable toxic response.

In the chronic oral toxicity study, permethrin (92.5% a.i., cis/trans 32.3/60.2) was administered to beagle dogs (6/sex/group) in corn oil by gelatin capsule at dose levels of 0, 5, 100, or 1000 mg/kg/day for one year. There were no mortalities but neurological clinical signs (tremors, uncoordinated gait, nervousness and convulsions, also excessive salivation and vomiting) were observed in the high-dose group. At the high-dose, decreased body weight gain (37% and 33% less than control for males and females, respectively) and decreased food consumption (increased food left uneaten) were reported. Therefore, the systemic toxicity NOAEL and LOAEL for this study are 100 and 1000 mg/kg/day, respectively, based on clinical neurotoxic signs and decreased body weight gain and food consumption.

No other relevant studies of sufficient detail or with more sensitive endpoints were found in the EFED files. Only one additional study of limited utility for the purposes of this risk assessment was found in the EFED files. This laboratory study conducted with white mice (*Mus musculus*), evaluated the effects of cotton treated with the formulation

Damminix (7.4% a.i.; to be used as small rodent nesting material in woodlots to control disease-transmitting) used as nest material on the survivability of neonates born in the nests, and the ability of those exposed mice to reproduce successfully when they became adults. Pregnant mice formed nests of the treated cotton, and their offspring lived in these nests for 21 days, until they were weaned, were separated into groups, and mated. No significant effects were noted on any parameter, suggesting that neonatal mice are not affected by Damminix-treated nesting material, and can reproduce successful when they reach adulthood.

4.2.2.4 Mammals: Open Literature Chronic Exposure (Growth, Reproduction) Studies

In addition to the registrant data, more sensitive acceptable reproduction toxicity data considered for quantitative risk estimation purposes for mammals were identified in the open literature. *Farag et al.* (2006; ECOTOX Ref # 100119) reported a NOAEL of 4.9 mg/kg-bw/day in mice based on increased number of dead pups, decreased number of live pups, decreased body weight and body weight gain in pups, and decreased maternal body weights. While no significant effects were noted in the lowest test group of 4.9 mg/kg-bw/day as compared to the control, significant adverse effects were noted in both the 9.8 mg/kg-bw/day and 19.6 mg/kg-bw/day treatment groups. At the LOAEL of 9.8 mg/kg-bw/day, maternal body weight gain decreased during gestation (↓57% from controls) and lactation (↓187% from controls), the number of dead pups increased (↑64% from controls), the number of live pups decreased (↓10% from controls), and body weight gain of pups was decreased (↓52% from controls).

The study design should be carefully considered when interpreting the results and conservative nature of the experiment. In particular, it should be noted that sixty 10-week old mice (30 males and 30 females) at each treatment level were given permethrin (40:60, cis:trans, 94% purity) by gavage at dose levels of 0 (corn oil), 4.9, 9.8, and 19.6 mg/kg-bw/day before mating for 5 days a week for 4 weeks. Typically, the 2-generation reproduction studies with rats that are submitted to the Agency expose rats via treated feed; the dosing regime in this study with mice represents one that is intensified as compared to what the Agency normally receives. The gavage route of administration potentially influences the metabolism and toxicity of a test compound, and may increase or decrease its toxicity compared to dietary administration. It generally is predicted to increase the toxicity of a compound compared to dietary administration because of the bolus dose and rapid absorption of the compound from the small intestine. In addition, although similar to the other acute and chronic studies (other than the three-generation rat study) discussed for permethrin, corn oil was used as a carrier, and may enhance the bioavailability of permethrin. While the results of this study are likely reflective of a conservative exposure scenario, the degree to which they are representative of actual high-end exposure scenarios encountered in the wild is uncertain. Therefore, in order to be as protective of the assessed species as is reasonable, the Agency has opted to maintain a conservative approach by estimating risk based on the most sensitive NOAEL value reported in this study with laboratory mice.

However, as explained previously for the acute mammalian toxicity endpoint found in the open literature, direct use of this endpoint in T-REX would be inappropriate because T-REX assumes a set bodyweight of 350g for the tested species. Therefore, prior to input into T-REX, the NOAEL value of 4.9 mg/kg-bw reported in this study for mice was scaled to be representative of the assumed typical test organism, a 350g laboratory rat, by using the following equation as mentioned in the T-REX users' manual:

$$Adj.\,NOAEL\ or\ LD_{50} = NOAEL\ or\ LD_{50}\left(\frac{TW}{AW}\right)^{(0.25)}$$

where:

Adj. NOAEL= adjusted NOAEL (mg/kg-bw) for adverse effects to mammalian reproduction
NOAEL = value reported from *Farag et al.* (2006; ECOTOX Ref # 100119); 4.9 mg/kg-bw
TW = body weight of tested animal; average weight of male and female mice for the 4.9 mg/kg-bw treatment group in the study was approximately 36g throughout the treatment period
AW = body weight of assessed animal; in this case is equal to 350g, the TREX assumed body weight for adult rats

Therefore, the adjusted NOAEL equals 4.9 * (36/350) ^ $^{(0.25)}$, or 2.77 mg/kg-bw. This adjusted NOAEL value of 2.77 mg/kg-bw is the chronic toxicity value that was directly used in T-REX for quantitative risk estimation purposes and determining the potential for direct effects to the Salt marsh harvest mouse (*Reithrodontomys raviventris*), as well indirect effects to those listed species that rely on mammals during at least some portion of their life-cycle (*i.e*., CRLF, salt marsh harvest mouse, San Francisco garter snake, and California clapper rail).

4.2.3 Toxicity to Terrestrial Invertebrates

A summary of terrestrial invertebrate data, including data published in the open literature, is provided below in **Sections 4.2.3.1** through **4.2.3.2**.

4.2.3.1 Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

The only Agency guideline terrestrial invertebrate tests are for honey bees (*Apis mellifera*). A total of six studies include acute contact, acute oral, and acute contact with treated foliage LD_{50} values for permethrin technical grade active ingredient (TGAI) and formulated permethrin and honey bees (MRID 00045044, 00045046, 42674501, 42009301). The acute contact LD_{50} values range from 0.024 (with TGAI) to 0.16 μg a.i./bee (with formulation), the acute oral LD_{50} ranges from 0.13 to 0.19 μg a.i./bee (both with TGAI), and the single treated foliage study (treated with formulation Ambush 25W) reports an LD_{50} value of < 0.2 lb a.i./A. Based on these results, permethrin is classified as 'highly toxic' to honey bees on an acute exposure basis. Potential risks to terrestrial invertebrates resulting from exposure to permethrin will be based on the most sensitive

LD_{50} of 0.024 µg a.i./bee for honey bees. The acute contact LD_{50} of 0.024 µg a.i./bee will be multiplied by 1 bee/0.128g, which is based on the weight of an adult honey bee, in order to estimate the toxicity in terms of ppm (µg a.i./g of bee). The resulting estimated value of 0.1875 µg a.i./g of bee will be the value used for quantitative risk estimation purposes.

In addition to the guideline studies with honey bees, a number of other older studies with terrestrial invertebrates and formulated permethrin are available to the Agency; however, many of the studies have little information reported and the results presented below are presented as they are in the studies. One acute contact 5-day study with various species of parastitic wasps (MRID 05009995) demonstrates a range in sensitivity of the five tested species ((*Apanteles sp.*, *Opius bruneipus*, *Telenomus remus*, *Copidosoma truncatellum*, and *Diglyphus intermedius*), with mortality ranging from 0% to 85% at 0.1 lb a.i./A, and 40% to 100% at 0.2 lb a.i./A. A study with alkali bees (*Nomia melanderi*) exposed to foliage treated with formulated permethrin reported mortality ranging from 25% to 78% at rates ranging from 0.5 oz. a.i./A to 2 o.z. a.i./A, respectively (NR 1975). Another study with alfalfa leafcutter bees (*Megachile rotundata pacifica*), exposed to foliage treated with formulated permethrin reported mortality ranging from 24% to 88% at rates ranging from 0.5 oz. a.i./A to 2 o.z. a.i./A, respectively (ICI US 1975). In other studies with mites (*Amblyseium fallacis*), convergent ladybeetles (*Hippodamia convergens*), and predatory mites (*Metaseiulus occidentalis*) acutely exposed to formulated permethrin, LD_{50} values ranging from <0.5 to 15.5 ppm a.i. were reported (MRID 00045048, 05009995, 00045048, ICI US 1975, ICI US 1976, ICI US NR). These laboratory studies indicate that permethrin is highly toxic to terrestrial invertebrates at rates equal to or below the maximum allowed on current labels, or concentrations well below what can be expected to be found in the environment following use of permethrin according to current labels.

In addition to the above laboratory studies, a number of field studies examining the toxicity of permethrin to ladybird beetles (*C. undecimpunctata* and *Coccinella septempunctata*) (ICI US NR), hover flies (Syrphidae) (ICI US NR), six-spotted thrips (*Scolothrips sexmaculatus*) (ICI US 1976), hemipteran predators (*Geocoris pallens*, *Orius tristicolor*,and *Nabis americoferris*) (NR 1976), and earthworms (*Lumbricus and Allolobophora spp*.) and unnamed spiders, mites and collembola were available to the Agency. Again, however, the utility of these studies for risk assessment purposes is limited because very little information was reported in the available files. Spray application of permethrin to oil rape seed resulted in significant reductions in ladybird beetles were observed at rates as low as 15 ppm. Spray application of permethrin at rates as low as 31.2 ppm caused a reduction in the numbers of hover fly larvae, and at 125 ppm no larvae survived. A field 8-spray program on a 10 day interval with an 25% EC of permethrin applied to cotton caused a significant reduction in the numbers at all rates tested (0.8, 1.6 and 3.2 oz) in all hemipteran predators, with populations temporarily eliminated. Lastly, earthworm populations were slightly reduced (non-statistically significant) when exposed to permethrin at levels of 11 lb a.i./A, but not at 1.1 lb a.i./A. Overall, these studies show that applications of formulated permethrin are likely to reduce the numbers and possibly eliminate populations of invertebrates.

4.2.3.2 Terrestrial Invertebrates: Open Literature Studies

Data on the toxicity of permethrin to terrestrial invertebrates from the ECOTOX open literature database were not extracted and reviewed in time for this assessment due to the extensive body of open literature and the limited amount of time for review. However, because permethrin is an efficacious broad spectrum insecticide, it has already been established in existing toxicity studies available to the Agency that permethrin is very highly toxic to terrestrial invertebrates, and LOC exceedances based on existing data are already expected to occur for terrestrial invertebrates on all land cover types throughout the state of California as a result of this federal action, it is expected that further review of the open literature is not likely to result in radical alterations of this risk assessment's conclusions. Therefore, for the purposes of risk estimation for terrestrial invertebrates, the Agency is relying on the registrant-submitted guideline studies as previously discussed. To the extent to which toxcitity data from the open literature are not considered in this assessment for terrestrial invertebrates, the potential direct and indirect effects of permethrin on listed species may be underestimated. For a comprehensive consideration of all potential effects data for terrestrial invertebrates please refer to the detailed spreadsheet of the available ECOTOX open literature data that can be found in **APPENDIX H**.

4.2.4 Toxicity to Terrestrial Plants

No data have been submitted to the Agency to evaluate the effects of permethrin on terrestrial plants because historically, terrestrial plant toxicity studies and associated risk analysis of plants were not required for registration of a pesticide unless it met specific use and pesticide classification criteria which would trigger potential concerns. In addition to the lack of registrant-submitted data, no studies demonstrating significant adverse effects of permethrin to any terrestrial plant have been identified in the open literature. Although a number of studies involving terrestrial plants and permethrin were identified in the open literature, none of these studies provide reliable estimates of toxicity that may be used in this risk assessment. Reasons that these studies were deemed unacceptable for use include, but are not limited to, the following reasons: there were no observed effects at any test level but did not test up to the maximum allowable rate, there were no controls, they were efficacy studies in which observed effects were confounded by the presence of an insect pest complex, there were severe methodology limitations inhibiting the achievement of definitive conclusions. For a comprehensive consideration of all potential effects data and additional information for terrestrial plants please refer to the detailed spreadsheet of the available ECOTOX open literature data that can be found in **APPENDIX H**.

4.3 Use of Probit Slope Response Relationship to Provide Information on the Listed 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 (U.S. EPA, 2004).

As part of the risk characterization, an interpretation of acute RQs 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 permethrin on par with the acute toxicity endpoint selected for RQ calculation. To accomplish this interpretation, the Agency uses the slope of the dose response relationship available from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group that is relevant to this assessment. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available.

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

4.4 Incident Database Review

EPA maintains an incident database system (Ecological Incident Information System or EIIS) to track and evaluate accidental kills associated with pesticide use. The likelihood that a particular pesticide caused the incident is classified as “highly probable”, “probable”, “possible”, or “unlikely”, based on the information contained in the incident report. A review of the EIIS database for ecological incidents involving permethrin was completed on August 19, 2008. This database consists of exposure incident reports submitted to the EPA from 1994 to present. The results of this review for terrestrial, plant, and aquatic incidents are discussed below in S**ections 4.4.1** through **4.4.3**, respectively. In addition, summarizes of the ecological incidents involving terrestrial animals, terrestrial plants, and aquatic organisms can be found in **Tables 4.5**, **4.6**, and **4.7**, respectively. A complete list of the incidents involving permethrin including associated uncertainties is included in **APPENDIX K**.

4.4.1 Terrestrial Animal Incidents

Six permethrin incidents involving terrestrial animals exist in the EIIS database. Two incidents were listed as highly probable, and four as possible. One of the highly probable incidents resulted from registered use. A municipality was sprayed with permethrin, and hundreds to thousands of dead butterflies were found by residents of the area shortly after application. Species listed in these reports included bee, monarch butterfly, other unknown butterflies, parakeet, dog, unknown birds, unknown trees and ornamental plants. A full list of all incidents involving permethrin is shown in **Table 4.5**.

Table 4.5. Permethrin incident reports involving terrestrial animal species.

Incident #	Organism(s) Affected	Certainty [a]	Legality of Use	Description

Table 4.5. Permethrin incident reports involving terrestrial animal species.				
Incident #	**Organism(s) Affected**	**Certainty [a]**	**Legality of Use**	**Description**
I003826-028	Bee (Apidae)	Highly probable	Accidental misuse	Bee keepers report bee kills in hives and attribute the damage to aerial application of pesticide to a nearby soybean field. A certified aerial applicator treated 400 acres of soybean fields. Permethrin was found in nearby vegetation samples in concentrations ranging from 0.32 – 4.1 ppb. The applicator paid an $1800 fine to the North Carolina Department of Agriculture for misuse. North Carolina, 8/30/1994.
I011527-001	Monarch butterfly (*Danaus plexippus*) and unknown butterfly (Lepidoptera)	Highly probable	Registered use	A municipality was sprayed with permethrin and piperonyl butoxide. Several hours after application, residents began noticing hundreds to thousands of dead butterflies (mostly monarch). Analysis showed 20 – 37 ppm permethrin in butterfly samples. Minnesota, 8/23/2000.
I004852-015	Parakeet (Psittacidae)	Possible	Unknown	A residence was treated with permethrin and four days later, four parakeets died. No analytical evidence was reported. Oklahoma, 10/29/1996.
I000340-006	Dog (*Canis Familiaris*)	Possible	Unknown	A dog was treated with permethrin and cypermethrin. The dog then became ill and incapacitated. Both pyrethroids are known toxicants to animals. New York, 12/3/1992.
I012515-004	Bee (Apidae)	Possible	Unknown	Apiary damage possibly caused by permethrin and piperonyl butoxide. No information available on method of application or suspected misuse. Mississippi, 5/9/2001.
I015105-005	Unknown nursery trees, ornamentals and birds	Possible	Unknown	Drift from permethrin, atrazine, glyphosate and S-metolachlor caused the deaths of three birds and damage to trees and ornamentals in a nursery. The report did not specify which active ingredient may have caused the damage. Tennessee, 4/27/2004.
[a] Certainty index rating describing likelihood that permethrin was the actual cause of incident.				

4.4.2 Terrestrial Plant Incidents

Seven permethrin incident reports were recorded for terrestrial plant species. All incidents were only listed as possible or unlikely. Two reports involved registered use. The first registered-use incident involved both permethrin and piperonyl butoxide, and the plant damage could not be solely attributed to either chemical. In the second registered-use incident, many pesticides were involved and imazethapyr was suspected to be the cause of any plant injuries, not permethrin. All permethrin-related plant incidents in the EIIS database are listed in **Table 4.6**.

Table 4.6. Permethrin incident reports involving terrestrial plant species.				
Incident #	**Organism(s) Affected**	**Certainty [a]**	**Legality of Use**	**Description**
I007340-620	Unknown edible crop	Possible	Unknown	Damage occurred to an edible crop as a result of permethrin use. Florida, 4/22/1998.
I010927-003	Alfalfa (*Medicago sativa)*	Possible	Registered use	An alfalfa field had been previously treated with permethrin and chlorpyrifos, and damaged occurred due to carryover. Both pesticides are believed to have contributed to the damage. Wisconsin, 4/15/1999.
I012515-002	Unknown	Possible	Unknown	Tropical plants were treated with permethrin and piperonyl

Table 4.6. Permethrin incident reports involving terrestrial plant species.				
Incident #	**Organism(s) Affected**	**Certainty [a]**	**Legality of Use**	**Description**
	tropical plants			butoxide. Plants exhibited burn spots, yellowing leaves and defoliation. Plants may have been suffering from nutrient deficiency, which may have compromised the waxy cuticle and made the plants more vulnerable to exposure. Unknown location, 8/13/2001.
I019442-001	Clover (Trifolium sp.), timothy-grass (*Phleum pretense*) and unknown grasses and legumes	Possible	Intentional misuse	Pesticide application to a right-of-way possibly caused chlorosis as far as 200 feet away in an adjacent hay and pasture field. Pesticides involved include permethrin, 2,4-D, acetochlor, atrazine, glyphosate, metribuzin and clomazone. Plant tissue samples from the right-of-way contained 9.85 ppm of Pendimethalin. None of the aforementioned chemicals were detected in samples from the hay and pasture field. The observed whitening of the vegetation is symptomatic of clomazone damage, but other herbicides present may have contributed. Ohio, 7/19/2007.
I009544-001	Soybean (*Glycine max*)	Possible	Unknown	A farmer attributes the reduced productivity of 142 acres of soybeans to permethrin and carboxin application. The pesticides are believed to have killed the *Rhizobium* bacteria in the soil inoculate added at the time of planting. The soybeans showed stunted growth and a light yellow color indicative of nitrogen deficiency. Wisconsin, 7/10/1999.
I016138-001	Cauliflower (*Brassica oleracea*)	Unlikely	Registered use	Aerial spraying of pesticides damages 70 acres of cauliflower, to the extent that the crop is claimed to be unfit for human consumption. Owner of field claims that the mixture of insecticides used was "contaminated and adulterated with herbicides". Pesticides involved include permethrin, indoxacarb and imazethapyr. Imazethapyr is toxic to cauliflower and not registered for use on this crop, but no evidence was presented to show that the herbicide was actually sprayed in this instance. California, 10/11/2004.
I000340-007	Unknown lawn plants	Unlikely	Unknown	Permethrin was applied near a residence, and browning of lawn plants was reported. However, permethrin is not known to cause plant damage, and it is unlikely to be the cause of the observed browning. Florida, 10/7/1992.

[a] Certainty index rating describing likelihood that permethrin was the actual cause of incident.

4.4.3 Aquatic Incidents

The majority of ecological incidents involving permethrin occurred in aquatic environments. Twenty-six aquatic incidents caused by permethrin have been reported to the EPA since 1994. Of these incidents, nine are listed as highly probable, ten as probable, and seven under possible. Twenty-four incidents affected fish species, and the other two reports involved crayfish. Approximately half (thirteen) of the incidents resulted from registered use of permethrin. Many of these incidents originate with permethrin application to residences or other buildings, followed by permethrin runoff into nearby water bodies. One case listed as a possible permethrin-related event involved frogs. A mosquito control employee of the Maryland Department of Agriculture sprayed permethrin within 100 feet of a pond, and one day later many frogs, fish and crayfish were found dead. Although the applicator's certificate was suspended, permethrin is implicated as only a possible cause because no tissues or water samples were analyzed. A complete list of permethrin-related aquatic incidents is included in **Table 4.7**.

Table 4.7. Permethrin incident reports involving aquatic organisms.

Incident #	Organism(s) Affected	Certainty [a]	Legality of Use	Description
I001849-002	Unknown fish	Highly probable	Registered use	A commercial pesticide applicator treated a building with permethrin. The next night, a heavy rain caused runoff of permethrin to a nearby private pond, killing approximately 300 fish. Louisiana, 4/6/1994.
I016338-006	Bullhead (*Ameiurus* sp.), fathead minnow (*Pimephales promelas*), and rainbow trout (*Onchorhynchus mykiss*)	Highly probable	Registered use	Multiple buildings were sprayed with permethrin and bifenthrin, with around 100 gallons of pesticides used combined. After application, a storm carried the pesticides to a nearby holding pond and killed hundreds of bullheads, flathead minnows, and rainbow trout. The pond water contained 0.098 - 3.40 ppb bifenthrin and 99.8 ppb permethrin. Trout fillets contained 34.4 ppb bifenthrin and 406 ppb permethrin. New York, 5/2/2005.
I005761-001	Unknown fish	Highly probable	Unknown	A rancher sprayed 120 cattle with permethrin and removed the livestock from the vicinity of the nearby pond for several hours. After the cattle returned to the pond, an undetermined number of fish died. Iowa, 8/5/1997.
I001849-003	Unknown fish	Highly probable	Registered use	Permethrin and terbufos were applied to approximately 3,769 acres of corn fields, prior to planting. Heavy storms during the next month created heavy runoff and subsequent death of an estimated 1386 fish. The LSU School of Veterinary Medicine attributed the fishkill to both permethrin and terbufos (no data shown). Louisiana, 4/12/1994.
I004374-003	Catfish (Ictaluridae) and sunfish (Centrarchidae)	Highly probable	Accidental misuse	A fishkill occurred after a home was treated with permethrin. The pesticide equipment was rinsed in a manner that resulted in runoff to a nearby pond. Rain occurring after the treatment also contributed to runoff. Thousands of catfish and sunfish were killed. Missouri, 6/10/1995.
I003402-005	Crayfish (Decapoda)	Highly probable	Registered use	Permethrin was applied to a residence for termite control. A heavy rain washed the pesticide into a stream, and thousands of dead crayfish were found 1-1.5 miles downstream. Soil samples taken underneath the house contained 46.0 ppm permethrin and soil near the drainpipe contained 0.554 ppm permethrin. Permethrin was not detected in water samples, but sampling did not occur until two days after the incident. Virginia, 11/14/1995.
I003653-001	Bass (Centrarchidae spp.), carp (*Cyprinus carpio*) and catfish (Ictaluridae spp.)	Highly probable	Registered use	The basement floor and walls of a home were treated with permethrin to control for termites. A snowstorm occurred after the treatment, and the following snowmelt washed the pesticide into a nearby lake. Tissue samples for bass, carp and catfish contained 3.27, 3.7 and 3.7 ppm permethrin, respectively. Pennsylvania, 3/3/1996.

Table 4.7. Permethrin incident reports involving aquatic organisms.				
Incident #	**Organism(s) Affected**	**Certainty [a]**	**Legality of Use**	**Description**
I004439-038	Unknown fish	Highly probable	Accidental misuse	A fishkill of unknown magnitude occurred in a backyard pond, after the lawn was treated with permethrin. Massachusetts, 6/20/1996.
I009136-001	Crayfish (Decapoda)	Highly probable	Registered use	Heavy rains carried permethrin from a residence to a nearby stream. Dead crayfish were found one-third of a mile away from the home. Soil samples contained 10.0 ppb permethrin, while water samples had no detectable levels of the pesticide. Virginia, 4/13/1998.
I006022-001	Rockfish (*Sebastes* sp.)	Probable	Accidental misuse	A state mosquito control truck sprayed permethrin within 10 feet of a commercial fish pond, killing 3000 rockfish. Maryland, 6/16/1997.
I000598-022	Black bullhead catfish (*Ictalurus melas*) and bluegill (*Lepomis macrochirus*)	Probable	Accidental misuse	After aerial spraying of permethrin in a nearby cornfield, an estimated 500 fish were killed in a nearby pond. Ten days after the accident occurred, samples were taken from the water, soil and sediment of the pond. Residues were below detection levels. Nebraska, 7/5/1992.
I000124-014	Bluegill (*Lepomis macrochirus*)	Probable	Accidental misuse	Treatment of home with permethrin entered house sump pump and emptied into fish pond, killing an unknown number of bluegill. Illinois, 3/31/1992.
I001028-010	Unknown fish	Probable	Registered use	During a light rain, a home and outside deck were treated with permethrin. The runoff drained into a nearby canal, where dead fish were later discovered. The species and number of fish killed were not reported. Florida, 8/1/1993.
I006261-001	Crayfish (Decapoda) and rainbow trout (*Onchorhynchus mykiss*)	Probable	Accidental misuse	After permethrin termiticide application to a home, around 230 dead crayfish and 50 dead rainbow trout were reported in a creek 160 feet away from the residence. Soil samples indicated permethrin levels between 17.0 – 53.0 ppb. Virginia, 4/16/1997.
I007226-001	Bass (Centrarchidae sp.) and bream	Probable	Registered use	Permethrin was applied within the city limits of Greenville, Mississippi for vector control. Three days after the application, fifteen bass and two bream were found dead in a lake. Mississippi, 9/2/1998.
I003582-010	Unknown fish	Probable	Unknown	An unknown number of fish were killed as a result of permethrin contamination in a stream. Pennsylvania, 3/5/1996.
I003582-042	Unknown fish	Probable	Unknown	Runoff from permethrin treatment spray killed fish in a downhill pond. Indiana, 5/6/1996.
I004439-039	Unknown fish	Probable	Registered use	A home was treated for termites with permethrin, and a fishkill of unknown magnitude occurred in a pond 20 feet away. Tennessee, 6/21/1996.
I014689-015	Bluegill (*Lepomis macrochirus*) and catfish (Ictaluridae)	Probable	Misuse	Permethrin was applied 400 feet away from a pond. Eight bluegill and seventy-two catfish were found dead. No further information on treatment site or method of application. Indiana, 5/7/2003.
I003826-030	Unknown fish	Possible	Registered use	A fish kill occurred in a commercial fish pond. The owner attributed the problem to pesticide drift from nearby corn and soybean fields. After conducting tests for a range of pesticides, the NC Department of

Table 4.7. Permethrin incident reports involving aquatic organisms.				
Incident #	Organism(s) Affected	Certainty [a]	Legality of Use	Description
				Agriculture stated that pesticides could not be determined as the cause of the fish kill. However, permethrin was found in the soil (0.41 ppm) and vegetation (1.4 ppm) of the area. Total magnitude of the fish kill was not reported. North Carolina, 6/14/1994.
B000175-001	Unknown fish	Possible	Registered use	Three pesticides (paraquat, permethrin and bicep) and fertilizer were applied to a corn field. A fishkill in a nearby pond occurred after a heavy storm. The incident was attributed to the fertilizer and low dissolved oxygen, but permethrin may be another contributing factor due to its high toxicity to fish. Kentucky, 1992.
I004439-121	Unknown fish	Possible	Unknown	A lawn was treated with permethrin. After an unspecified time, an unknown number of fish located in a nearby pond died. New Jersey, 9/9/1996.
I004439-119	Unknown fish	Possible	Unknown	A home exterior, 210 feet from a pond, was treated with permethrin. Four days later, a fish kill was observed. Virginia, 9/21/1996.
I007984-003	Striped bass (*Morone saxatilis)*, crayfish (Decapoda) and unknown frogs	Possible	Accidental misuse	An employee of the Mosquito Control section of the Maryland Department of Agriculture applied permethrin to a residential property. One day later, 600 fish, crayfish and frogs were found dead. The spraying was 74 feet away from the pond, while regulations require 100 feet. Pond water sampled a few days after the incident showed low dissolved oxygen. Maryland, 6/16/1997.
I014312-001	Goldfish (*Carassius auratus*)	Possible	Registered use	Permethrin was applied to a lawn, and runoff caused by rains resulted in an estimated 40 – 60 goldfish deaths in a proximate pond. Kansas, 4/1/2003.
I008293-001	Velvet swords (*Xiphophorus helleri*), oscars (*Astronotus ocellatus)* and discus (Symphysodon sp.)	Possible	Registered use	Drift from four pesticides (including permethrin) applied to tomato fields may have caused a fishkill in ponds 100 yards away. The species include several ornamental fish, including velvet swords, oscars, and discus. The applicator was observed lifting booms at row ends without ceasing spray flow. Oily residue was found at pond edges, and the ponds contained low dissolved oxygen. Dying fish exhibited tremors symptomatic of pyrethroid or organophosphate exposure. Florida, 12/1/1998.
[a] Certainty index rating describing likelihood that permethrin was the actual cause of incident.				

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 California red-legged frog *(Rana aurora draytonii*) (CRLF), California clapper rail (*Rallus longirostris obsoletus*), Salt marsh harvest mouse (*Reithrodontomys raviventris*), San Francisco garter snake (*Thamnophis sirtalis tetrataenia*), and Bay checkerspot butterfly (*Euphydryas editha bayensis*) or for modification to their designated critical habitat from the use of permethrin 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 assessed species or their 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 D**). For acute exposures to the aquatic animals, as well as terrestrial invertebrates, the LOC is 0.05. For acute exposures to the birds (and, thus, reptiles and terrestrial-phase amphibians) and mammals, the LOC is 0.1. The LOC for chronic exposures to animals, as well as acute exposures to plants is 1.0.

Acute and chronic risks to aquatic organisms are estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended permethrin usage scenarios summarized in **Table 3.1** and the appropriate aquatic toxicity endpoint from **Table 4.1**. Acute and chronic risks to terrestrial animals are estimated based on exposures resulting from applications of permethrin (**Tables 3.8** through **3.11**) and the appropriate toxicity endpoint from **Table 4.3**. Exposures were not derived for terrestrial plants, as discussed in **Section 3.4**.

5.1.1 Exposures in the Aquatic Habitat

5.1.1.1 Freshwater Fish and Aquatic-phase Amphibians

Acute risk to freshwater fish and aquatic-phase amphibians, and the potential for direct effects to CRLF specifically, is based on peak EECs in the standard PRZM/EXAMS pond and the lowest acute toxicity value for freshwater fish. Currently registered agricultural and non-agricultural uses of permethrin within California include: alfalfa, nut trees, avocados, cole crops, corn, forestry, fruit trees, garlic, leafy vegetables, cucurbit vegetables, nursery uses, onions, potato and turnip, row crops, tomatoes, turf, ant mound treatments (residential, agricultural, turf, recreational areas), mosquito control, barrier treatment (fence rows, hedge rows, range land, urban and rural structures), residential turf and ornamentals, outdoor perimeter treatments, termite treatment, residential garden uses, and down-the-drain applications (*e.g.*, pet shampoos)(Please refer to the "Use Characterization" section of the document for additional details, **Section 2.4.4**). Based on surrogate freshwater fish toxicity data (LC_{50} value of 0.79 µg a.i./L for bluegill sunfish) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for freshwater fish range from 0.06 (Soil Barrier Treatment on Fencerows and Hedgerows) to 6.96 (Nursery Uses and Residential Turf and Ornamentals); therefore, the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's acute listed species LOC (RQ≥0.05)(**Table 5.1**).

Chronic risk to freshwater fish and aquatic-phase amphibians, and the potential for direct effects to CRLF specifically, is based on 60-day EECs and the lowest chronic toxicity value for freshwater fish. However, in the case of permethrin, the fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a bluegill sunfish chronic toxicity NOAEC value of 0.0515 µg a.i./L because it is the most acutely sensitive freshwater fish species and no chronic toxicity data are available for it. Based on 60-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.0515 µg a.i./L, all chronic RQs for freshwater fish range from 0.14 (Soil Barrier Treatment on Fencerows and Hedgerows) to 61.17 (Nursery Uses based on the current maximum label rate for pine seed orchards). While 40 of the 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for freshwater fish, 8 of the 48 modeled scenarios did not (**Table 5.1**).

Based on exceedances of the Agency's acute listed species LOC (RQ≥0.05) for the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and exceedances of the Agency's chronic risk LOC (RQ≥1) for 40 of the 48 modeled scenarios, permethrin does have the potential to directly affect the CRLF. Additionally, since the acute and chronic RQs are exceeded, there is a potential for indirect effects to those listed species that rely on freshwater fish (and/or aquatic-phase amphibians) during at least some portion of their life-cycle (*i.e.*, CRLF, SFGS, and CCR).

Table 5.1. Acute and chronic RQs for freshwater fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]

USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	60-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Agricultural Use Patterns									
Alfalfa	**Alfalfa hay and seed crops**	**CA alfalfa**	**0.20**	**5**	**30**	0.437	0.0853	**0.55**	**1.66**
Nut Trees	**Pistachio**	**CA almond**	**0.3**	**3**	**10**	0.629	0.114	**0.80**	**2.21**
Avocado	**Avocado**	**CA avocado**	**0.20**	**4**	**7**	0.660	0.112	**0.84**	**2.17**
Cole crop	**Broccoli**	**CA cole crop**	**0.20**	**4**	**5**	0.908	0.235	**1.15**	**4.56**
Corn	**Corn (pop)**	**CA corn**	**0.2**	**3**	**5**	0.465	0.106	**0.59**	**2.06**
Corn	**Corn (sweet)**	**CA corn**	**0.2**	**4**	**3**	0.582	0.142	**0.74**	**2.76**

Table 5.1. Acute and chronic RQs for freshwater fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (μg/L)	60-day EEC (μg/L)	Acute RQ [3]	Chronic RQ [4]
Forestry	Softwood (conifer), hybrid cottonwood/ poplar	CA Forestry	0.20	N/S, Assumed to be 10	N/S, Assumed to be 5	4.74	0.910	**6.00**	**17.67**
Fruit tree	Pear	CA fruit tree	1@0.4 and 1@0.25	2	10	0.504	0.0776	**0.64**	**1.51**
Fruit tree	Peach	CA fruit tree	0.25	3	10	0.759	0.0693	**0.96**	**1.35**
Garlic	Garlic	CA garlic	0.20	4	10	0.479	0.116	**0.61**	**2.25**
Leafy vegetables	Major leafy vegetables[5]	CA lettuce	0.2	4	7	1.56	0.319	**1.97**	**6.19**
Leafy vegetables	Minor leafy vegetables[6]	CA lettuce	0.2	10	3	3.54	0.772	**4.48**	**14.99**
Cucurbit vegetables	Major cucurbit vegetables[7]	CA melons	0.2	6	7	0.441	0.115	**0.56**	**2.23**
Cucurbit vegetables	Minor cucurbit vegetables[8]	CA melons	0.24	8	N/S, assumed to be 7	0.557	0.179	**0.71**	**3.48**
Nursery	X-mass trees, Nursery stock and Pine seed orchard[9]	CA nursery	0.4	6	28	5.50[10]	0.849	**6.96**	**16.49**
Nursery	Pine seed orchard (current label low rate) [9]	CA nursery	0.75	6	28	5.50[10]	1.59	**6.96**	**30.87**
Nursery	Pine seed orchard (current label high rate) [9]	CA nursery	1.6	6	28	5.50[10]	3.15	**6.96**	**61.17**
Onion	Onion	CA onion	1@0.1 and 3@0.3	4	7	0.162	0.0294	**0.21**	0.57
Onion	Fennel	CA onion	0.2	10	3	0.527	0.193	**0.67**	**3.75**
Potato	Potato	CA potato	0.2	4	10	0.414	0.0765	**0.52**	**1.49**
Row Crops	Celery, artichoke, asparagus, pepper	CA row crop	0.2	5	7	0.648	0.173	**0.82**	**3.36**

Table 5.1. Acute and chronic RQs for freshwater fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	60-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Row Crops	Rhubarb, field grown roses	CA row crop	0.2	10	5	1.09	0.331	**1.38**	**6.43**
Tomato	Tomato	CA tomato	0.2	3	7	0.414	0.0634	**0.52**	**1.23**
Tomato	Tomatillo	CA tomato	0.2	6	N/S, assumed to be 7	0.447	0.120	**0.57**	**2.33**
Turf	Golf course, recreational areas	CA turf	0.87	6	N/S, Assumed 7	0.571	0.175	**0.72**	**3.40**
Ant mound treatment	Agricultural fruit trees	CA fruit	0.84	N/S, Assumed 4	N/S, Assumed 7	0.539	0.126	**0.68**	**2.45**
Non-Agricultural Use Patterns									
Mosquito control – Pre-CFR 2005-1	Northern Recreational areas	CA turf	0.007	26 [11]	1	0.496	0.268	**0.63**	**5.20**
Mosquito control – Post-CFR 2005-1 [12]	Northern Recreational areas	CA turf	0.007	26[11]	1	0.221	0.119	**0.28**	**2.31**
Mosquito control – Pre-CFR 2005-1	Northern Agricultural Areas (metfile W93193.dvf)	CA alfalfa	0.007	26[11]	1	0.452	0.223	**0.57**	**4.33**
Mosquito control – Post-CFR 2005-1[12]	Northern Agricultural Areas (metfile W93193.dvf)	CA alfalfa	0.007	26[11]	1	0.200	0.0982	**0.25**	**1.91**
Mosquito control – Pre-CFR 2005-1	Central Agricultural Areas (metfile W23232.dvf)	CA alfalfa	0.007	26[11]	1	0.472	0.242	**0.60**	**4.70**
Mosquito control – Post-CFR 2005-1[12]	Central Agricultural Areas (metfile W23232.dvf)	CA alfalfa	0.007	26[11]	1	0.208	0.106	**0.26**	**2.06**
Ant mound Treatment	Non-agricultural areas, turf, recreational areas	CA turf	0.84	N/S, Assumed 4	N/S, Assumed 7	0.598	0.146	**0.76**	**2.83**
Soil Barrier Treatment	Fencerows and Hedgerows	CA range-land-hay	0.01	N/S, assumed to be 10	N/S, assumed to be 7	0.0447	0.00714	**0.06**	0.14

Table 5.1. Acute and chronic RQs for freshwater fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]

USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	60-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Soil Barrier Treatment	**Range Land**	**CA range-land-hay**	**0.1**	**N/S, assumed to be 10**	**N/S, assumed to be 7**	0.448	0.0715	**0.57**	**1.39**
Residential Turf and Ornamentals	**Home & Garden**	**CA residential**	**4.23**	**N/S, assumed to be 3**	**5**	5.50[10]	0.616	**6.96**	**11.96**
Perimeter Treatment	**Urban & Rural Structures**	**CA residential**	**1.43**	**N/S, assumed to be 4**	**N/S, assumed to be 90**	1.814	0.206	**2.30**	**4.00**
Termite Treatment	**Urban & Rural Structures**	**CA residential**	**0.77**	**1**	**None**	0.454	0.042	**0.57**	0.82
Garden Vegetables	**Home & Garden**	**CA residential**	**0.25**	**6**	**3**	0.329	0.046	**0.42**	0.89
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**N/S, assumed to be 10**	0.506	0.063	**0.64**	**1.22**
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**10**	0.506	0.063	**0.64**	**1.22**
Barrier Treatment	**Urban & Rural Structures**	**CA residential**	**1@0.08 and 3@0.10**	**2**	**N/S, assumed to be 7**	0.195	0.016	**0.25**	0.31
Home Garden Fire Ant Treatment	**Home & Garden**	**CA residential**	**1.00**	**N/S, assumed to be 4**	**N/S, assumed to be 7**	1.534	0.130	**1.94**	**2.52**
Turf (Granular formulation)	**Home & Garden**	**CA residential**	**0.33**	**N/S, assumed to be 3**	**N/S, assumed to be 7**	0.505	0.038	**0.64**	0.74
Garden Vegetables(Granular formulation)	**Home & Garden**	**CA residential**	**0.27**	**6**	**3**	0.413	0.029	**0.52**	0.56
Down-the Drain[13]	**Household “down-the-drain” applications[13]**	**52% removal[14]**	**N/A**	**N/A**	**N/A**	0.71[15]	0.39[16]	**0.90**	**7.57**
Down-the Drain[13]	**Household “down-the-drain” applications[13]**	**75% removal[14]**	**N/A**	**N/A**	**N/A**	0.37[15]	0.21[16]	**0.47**	**4.08**

Table 5.1. Acute and chronic RQs for freshwater fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**60-day EEC (µg/L)**	**Acute RQ [3]**	**Chronic RQ [4]**
Down-the Drain[13]	**Household "down-the-drain" applications[13]**	**94% removal[14]**	**N/A**	**N/A**	**N/A**	0.09[15]	0.05[16]	**0.11**	0.97

[1] Acute RQs for freshwater fish are calculated as follows: use-specific peak EEC / 0.79 µg a.i./L. Chronic RQs for freshwater fish are calculated as follows: use-specific 60-day EEC / 0.0515 µg a.i./L . The acute LC_{50} of 0.79 µg a.i./L used to derive acute RQs for freshwater fish is based on a study with bluegill sunfish (*Lepomis macrochirus*), while the chronic NOAEC of 0.0515 µg a.i./L used to derive chronic RQs is an estimated toxicity value. The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate a bluegill sunfish (*Lepomis macrochirus*) chronic toxicity value because it is the most acutely sensitive freshwater fish species and no chronic toxicity data are available for it.
[2] Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.
[3] All bolded and shaded acute RQs exceed the Agency's acute risk LOC for listed species (0.05).
[4] All bolded and shaded chronic RQs exceed the Agency's chronic risk LOC (1).
[5] Lettuce, Brussel sprouts, orach, spinach, New Zealand spinach.
[6] Chinese amaranth, cardoon, celetuce, Swiss chard, chervil chicory, leafy chrysanthemum, corn salad, garden and upland cress, dandelion, dock (scorrel), parsley, purslane (winter and garden), roquette (arugula).
[7] Cucumber, cantaloupe, eggplant, pumpkin, squash, watermelon.
[8] Melons, melons (bitter, balsam pear), citron melon, melons (honeydew, mango, musk and winter "Casaba/ Crenshaw/ Honeydew/ Persian").
[9] The first run is a reduced exposure scenario which represents what one registrant has claimed to be the maximum intended use scenario for the application of permethrin to pine seed orchards. However, the label could be interpreted to allow for the modeled maximum exposure scenario for pine seed orchards (4 applications of a maximum single application rate of 1.6 lb a.i./A with a 28-day interval). At this time, this run covers Christmas trees and nursery stock (0.2 lb a.i/A rate) and the registrant-suggested rate for pine seed orchards. The second run covers the current label low rate (0.75 lbs a.i. /A) while the third run covers the highest rate in the current label (1.6 lb a.i. /A).
[10] Limited by the solubility of permethrin in water.
[11] The modeled scenario was run based on the most conservative assumptions regarding use parameters (i.e., rate, interval, and # of applications) as is possible under both the newly revised labels (based on mitigation) and the labels prior to mitigation. On some newly revised labels, a one-day interval is allowed and represents the most conservative assumption possible. The maximum number of applications (26) represents the maximum number of applications currently allowed by the PRZM/EXAMS model, and the maximum allowed under most newly revised labels. Previously, mosquito adulticide labels did not have restrictions on the number of applications and some labels have not yet been revised based on mitigation measures at the time this assessment was written.
[12] It should be noted that not all labels for mosquito control uses have been revised based on the suggested mitigation measures at the time this assessment was written. Therefore, caution should be used when basing risk conclusions for mosquito control uses on these use scenarios because it may underestimate exposure to aquatic organisms if not all labels are eventually revised based on mitigation measures.
[13] In order to address the issue of permethrin release to domestic wastewater, the Agency relied on the Office of Pollution Prevention and Toxics (OPPT) consumer exposure model, E-FAST (v. 2.0; USEPA, 2007) which is specifically designed to address all sources of permethrin that could potentially be disposed to domestic wastewater from a "down-the-drain" application. This model provides screening-level estimate of chemical residues in surface water that may result from household uses and the disposal of these consumer products into wastewater. Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.
[14] The E-FAST model was used, so the PRZM scenario is not applicable. The first, second, and third Down-the-drain scenarios assume 52%, 75%, and 94% removal of permethrin from wastewater, respectively.
[15] In this case, the acute EEC is not the peak EEC from PRZM/EXAMS; rather it is the SF_{1Q10} (Dilution Factor=1.00) from the E-FAST model which represents the EEC for the single day of lowest flow over a 10-year period (appropriate for acute surface water concentrations to compare with concentrations of concern for aquatic life).
[16] In this case, the chronic EEC is not the 60-day EEC from PRZM/EXAMS; rather it is thSF_{30Q5} (Dilution Factor=1.80) from the E-FAST model which represents the EEC for the thirty consecutive days of lowest flow over a 5-year period (appropriate for chronic surface water concentrations to compare with the concentrations of concern for aquatic life).

5.1.1.2 Freshwater Invertebrates

Acute risk to freshwater invertebrates is based on peak EECs in the standard PRZM/EXAMS pond and the lowest acute toxicity value for freshwater invertebrates. Based on surrogate freshwater invertebrate toxicity data (EC_{50} value of 0.0212 µg a.i./L for scuds) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for freshwater invertebrates range from 2.11 (Soil Barrier Treatment on Fencerows and Hedgerows) to 259.43 (Nursery Uses and Residential Turf and Ornamentals); therefore, the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's acute listed species LOC (RQ≥0.05) for freshwater invertebrates (**Table 5.2**).

Chronic risk is based on 21-day EECs and the lowest chronic toxicity value for freshwater invertebrates. However, in the case of permethrin, the fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a scud chronic toxicity NOAEC value of 0.0014 µg a.i./L because the chronic toxicity data available for freshwater invertebrates are less sensitive than the most sensitive acute toxicity value (the most sensitive LOAEC from all of the available chronic studies with freshwater invertebrates equals 0.084 µg a.i./L). Based on 21-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.0014 µg a.i./L, all chronic RQs for freshwater invertebrates range from 6.66 (Soil Barrier Treatment on Fencerows and Hedgerows) to 3271.43 (Nursery Uses based on the current maximum label rate for pine seed orchards); therefore, the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for freshwater invertebrates (**Table 5.2**).

Based on exceedances of the Agency's acute listed species LOC (RQ≥0.05) and chronic risk LOC (RQ≥1) for the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, there is a potential for indirect effects to those listed species that rely on freshwater invertebrates during at least some portion of their life-cycle (*i.e.*, CRLF, SFGS, and CCR).

Table 5.2. Acute and chronic RQs for freshwater invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]

USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	21-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Agricultural Use Patterns									
Alfalfa	**Alfalfa hay and seed crops**	**CA alfalfa**	**0.20**	**5**	**30**	0.437	0.0967	**20.61**	**69.07**
Nut Trees	**Pistachio**	**CA almond**	**0.3**	**3**	**10**	0.629	0.159	**29.67**	**113.57**
Avocado	**Avocado**	**CA avocado**	**0.20**	**4**	**7**	0.66	0.149	**31.13**	**106.43**
Cole crop	**Broccoli**	**CA cole crop**	**0.20**	**4**	**5**	0.908	0.287	**42.83**	**205.00**
Corn	**Corn (pop)**	**CA corn**	**0.2**	**3**	**5**	0.465	0.152	**21.93**	**108.57**
Corn	**Corn (sweet)**	**CA corn**	**0.2**	**4**	**3**	0.582	0.203	**27.45**	**145.00**

Table 5.2. Acute and chronic RQs for freshwater invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	21-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Forestry	Softwood (conifer), hybrid cottonwood/ poplar	CA Forestry	0.20	N/S, Assumed to be 10	N/S, Assumed to be 5	4.74	1.17	223.58	835.71
Fruit tree	Pear	CA fruit tree	1@0.4 and 1@0.25	2	10	0.504	0.113	23.77	80.71
Fruit tree	Peach	CA fruit tree	0.25	3	10	0.759	0.119	35.80	85.00
Garlic	Garlic	CA garlic	0.20	4	10	0.479	0.145	22.59	103.57
Leafy vegetables	Major leafy vegetables[5]	CA lettuce	0.2	4	7	1.56	0.402	73.58	287.14
Leafy vegetables	Minor leafy vegetables[6]	CA lettuce	0.2	10	3	3.54	0.98	166.98	700.00
Cucurbit vegetables	Major cucurbit vegetables[7]	CA melons	0.2	6	7	0.441	0.141	20.80	100.71
Cucurbit vegetables	Minor cucurbit vegetables[8]	CA melons	0.24	8	N/S, assumed to be 7	0.557	0.198	26.27	141.43
Nursery	X-mass trees, Nursery stock and Pine seed orchard[9]	CA nursery	0.4	6	28	5.50[10]	1.18	259.43	842.86
Nursery	Pine seed orchard (current label low rate) [9]	CA nursery	0.75	6	28	5.50[10]	2.22	259.43	1585.71
Nursery	Pine seed orchard (current label high rate) [9]	CA nursery	1.6	6	28	5.50[10]	4.58	259.43	3271.43
Onion	Onion	CA onion	1@0.1 and 3@0.3	4	7	0.162	0.0447	7.64	31.93
Onion	Fennel	CA onion	0.2	10	3	0.527	0.271	24.86	193.57
Potato	Potato	CA potato	0.2	4	10	0.414	0.101	19.53	72.14
Row Crops	Celery, artichoke, asparagus, pepper	CA row crop	0.2	5	7	0.648	0.216	30.57	154.29

Table 5.2. Acute and chronic RQs for freshwater invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Acute RQ** [3]	**Chronic RQ** [4]
Row Crops	**Rhubarb, field grown roses**	**CA row crop**	**0.2**	**10**	**5**	1.09	0.389	**51.42**	**277.86**
Tomato	**Tomato**	**CA tomato**	**0.2**	**3**	**7**	0.414	0.105	**19.53**	**75.00**
Tomato	**Tomatillo**	**CA tomato**	**0.2**	**6**	**N/S, assumed to be 7**	0.447	0.145	**21.08**	**103.57**
Turf	**Golf course, recreational areas**	**CA turf**	**0.87**	**6**	**N/S, Assumed 7**	0.571	0.204	**26.93**	**145.71**
Ant mound treatment	**Agricultural fruit trees**	**CA fruit**	**0.84**	**N/S, Assumed 4**	**N/S, Assumed 7**	0.539	0.179	**25.42**	**127.86**
Non-Agricultural Use Patterns									
Mosquito control – Pre-CFR 2005-1	**Northern Recreational areas**	**CA turf**	**0.007**	**26** [11]	**1**	0.496	0.385	**23.40**	**275.00**
Mosquito control – Post-CFR 2005-1 [12]	**Northern Recreational areas**	**CA turf**	**0.007**	**26** [11]	**1**	0.221	0.171	**10.42**	**122.14**
Mosquito control – Pre-CFR 2005-1	**Northern Agricultural Areas (metfile W93193.dvf)**	**CA alfalfa**	**0.007**	**26** [11]	**1**	0.452	0.342	**21.32**	**244.29**
Mosquito control – Post-CFR 2005-1 [12]	**Northern Agricultural Areas (metfile W93193.dvf)**	**CA alfalfa**	**0.007**	**26** [11]	**1**	0.2	0.151	**9.43**	**107.86**
Mosquito control – Pre-CFR 2005-1	**Central Agricultural Areas (metfile W23232.dvf)**	**CA alfalfa**	**0.007**	**26** [11]	**1**	0.472	0.361	**22.26**	**257.86**
Mosquito control – Post-CFR 2005-1 [12]	**Central Agricultural Areas (metfile W23232.dvf)**	**CA alfalfa**	**0.007**	**26** [11]	**1**	0.208	0.159	**9.81**	**113.57**
Ant mound Treatment	**Non-agricultural areas, turf, recreational areas**	**CA turf**	**0.84**	**N/S, Assumed 4**	**N/S, Assumed 7**	0.598	0.191	**28.21**	**136.43**
Soil Barrier Treatment	**Fencerows and Hedgerows**	**CA range-land-hay**	**0.01**	**N/S, Assumed 10**	**N/S, assumed to be 7**	0.0447	0.00932	**2.11**	**6.66**

Table 5.2. Acute and chronic RQs for freshwater invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Acute RQ** [3]	**Chronic RQ** [4]
Soil Barrier Treatment	**Range Land**	**CA range-land-hay**	**0.1**	**N/S, Assumed 10**	**N/S, assumed to be 7**	0.448	0.0932	**21.13**	**66.57**
Residential Turf and Ornamentals	**Home & Garden**	**CA residential**	**4.23**	**N/S, assumed to be 3**	**5**	5.50[10]	1.166	**259.43**	**832.86**
Perimeter Treatment	**Urban & Rural Structures**	**CA residential**	**1.43**	**N/S, assumed to be 4**	**N/S, assumed to be 90**	1.814	0.325	**85.57**	**232.14**
Termite Treatment	**Urban & Rural Structures**	**CA residential**	**0.77**	**1**	**None**	0.454	0.077	**21.42**	**55.00**
Garden Vegetables	**Home & Garden**	**CA residential**	**0.25**	**6**	**3**	0.329	0.089	**15.52**	**63.57**
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**N/S, assumed to be 10**	0.506	0.095	**23.87**	**67.86**
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**10**	0.506	0.095	**23.87**	**67.86**
Barrier Treatment	**Urban & Rural Structures**	**CA residential**	**1@0.08 and 3@0.10**	**2**	**N/S, assumed to be 7**	0.195	0.03	**9.20**	**21.43**
Home and Garden Fire Ant Treatment	**Home & Garden**	**CA residential**	**1.00**	**N/S, assumed to be 4**	**N/S, assumed to be 7**	1.534	0.253	**72.36**	**180.71**
Turf (Granular formulation)	**Home & Garden**	**CA residential**	**0.33**	**N/S, assumed to be 3**	**N/S, assumed to be 7**	0.505	0.076	**23.82**	**54.29**
Garden Vegetables(Granular formulation)	**Home & Garden**	**CA residential**	**0.27**	**6**	**3**	0.413	0.053	**19.48**	**37.86**
Down-the Drain[13]	**Household "down-the-drain" applications**[13]	**52% removal**[14]	**N/A**	**N/A**	**N/A**	0.71[15]	0.39[16]	**33.49**	**278.57**
Down-the Drain[13]	**Household "down-the-drain" applications**[13]	**75% removal**[14]	**N/A**	**N/A**	**N/A**	0.37[15]	0.21[16]	**17.45**	**150.00**

Table 5.2. Acute and chronic RQs for freshwater invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Acute RQ [3]**	**Chronic RQ [4]**
Down-the Drain[13]	**Household "down-the-drain" applications[13]**	**94% removal[14]**	**N/A**	**N/A**	**N/A**	0.09[15]	0.05[16]	**4.25**	**35.71**

[1] Acute RQs for freshwater invertebrates are calculated as follows: use-specific peak EEC / 0.0212 µg a.i./L. Chronic RQs for freshwater invertebrates are calculated as follows: use-specific 21-day EEC / 0.0014 µg a.i./L . The acute EC_{50} of 0.0212 µg a.i./L used to derive acute RQs for freshwater invertebrates is based on a study with scuds (*Hyalella azteca*), while the chronic NOAEC of 0.0014 µg a.i./L used to derive chronic RQs is an estimated toxicity value. The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate a scud (*Hyalella azteca*) chronic toxicity value because the most sensitive chronic toxicity data available for freshwater invertebrates are less sensitive than the most sensitive acute toxicity value (the most sensitive LOAEC from all of the available chronic studies with freshwater invertebrates equals 0.084 µg a.i./L).

[2] Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.

[3] All bolded and shaded acute RQs exceed the Agency's acute risk LOC for listed species (0.05).

[4] All bolded and shaded chronic RQs exceed the Agency's chronic risk LOC (1).

[5] Lettuce, Brussel sprouts, orach, spinach, New Zealand spinach.

[6] Chinese amaranth, cardoon, celetuce, Swiss chard, chervil chicory, leafy chrysanthemum, corn salad, garden and upland cress, dandelion, dock (scorrel), parsley, purslane (winter and garden), roquette (arugula).

[7] Cucumber, cantaloupe, eggplant, pumpkin, squash, watermelon.

[8] Melons, melons (bitter, balsam pear), citron melon, melons (honeydew, mango, musk and winter "Casaba/ Crenshaw/ Honeydew/ Persian").

[9] The first run is a reduced exposure scenario which represents what one registrant has claimed to be the maximum intended use scenario for the application of permethrin to pine seed orchards. However, the label could be interpreted to allow for the modeled maximum exposure scenario for pine seed orchards (4 applications of a maximum single application rate of 1.6 lb a.i./A with a 28-day interval). At this time, this run covers Christmas trees and nursery stock (0.2 lb a.i/A rate) and the registrant-suggested rate for pine seed orchards. The second run covers the current label low rate (0.75 lbs a.i. /A) while the third run covers the highest rate in the current label (1.6 lb a.i. /A).

[10] Limited by the solubility of permethrin in water.

[11] The modeled scenario was run based on the most conservative assumptions regarding use parameters (i.e., rate, interval, and # of applications) as is possible under both the newly revised labels (based on mitigation) and the labels prior to mitigation. On some newly revised labels, a one-day interval is allowed and represents the most conservative assumption possible. The maximum number of applications (26) represents the maximum number of applications currently allowed by the PRZM/EXAMS model, and the maximum allowed under most newly revised labels. Previously, mosquito adulticide labels did not have restrictions on the number of applications and some labels have not yet been revised based on mitigation measures at the time this assessment was written.

[12] It should be noted that not all labels for mosquito control uses have been revised based on the suggested mitigation measures at the time this assessment was written. Therefore, caution should be used when basing risk conclusions for mosquito control uses on these use scenarios because it may underestimate exposure to aquatic organisms if not all labels are eventually revised based on mitigation measures.

[13] In order to address the issue of permethrin release to domestic wastewater, the Agency relied on the Office of Pollution Prevention and Toxics (OPPT) consumer exposure model, E-FAST (v. 2.0; USEPA, 2007) which is specifically designed to address all sources of permethrin that could potentially be disposed to domestic wastewater from a "down-the-drain" application. This model provides screening-level estimate of chemical residues in surface water that may result from household uses and the disposal of these consumer products into wastewater. Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.

[14] The E-FAST model was used, so the PRZM scenario is not applicable. The first, second, and third Down-the-drain scenarios assume 52%, 75%, and 94% removal of permethrin from wastewater, respectively.

[15] In this case, the acute EEC is not the peak EEC from PRZM/EXAMS; rather it is the SF_{1Q10} (Dilution Factor=1.00) from the E-FAST model which represents the EEC for the single day of lowest flow over a 10-year period (appropriate for acute surface water concentrations to compare with concentrations of concern for aquatic life).

[16] In this case, the chronic EEC is not the 21-day EEC from PRZM/EXAMS; rather it is thSF_{30Q5} ((Dilution Factor=1.80) from the E-FAST model which represents the EEC for the thirty consecutive days of lowest flow over a 5-year period (appropriate for chronic surface water concentrations to compare with the concentrations of concern for aquatic life).

5.1.1.3 Estuarine/Marine Fish

Acute risk to estuarine/marine fish is based on peak EECs in the standard PRZM/EXAMS pond and the lowest acute toxicity value for estuarine/marine fish. Based on surrogate estuarine/marine fish toxicity data (LC_{50} value of 2.2 µg a.i./L for Atlantic silverside) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for estuarine/marine fish range from 0.02 (Soil Barrier Treatment on Fencerows and Hedgerows) to 2.50 (Nursery Uses and Residential Turf and Ornamentals). 44 of the 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's acute listed species LOC (RQ$\geq$0.05) for estuarine/marine fish; therefore, only 1 of the 45 modeled scenarios (Soil Barrier Treatment on Fencerows and Hedgerows) did not (**Table 5.3**).

Chronic risk to estuarine/marine fish is typically based on 60-day EECs and the lowest chronic toxicity value for estuarine/marine fish. However, in the case of permethrin, the fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate an Atlantic silverside chronic toxicity NOAEC value of 0.1434 µg a.i./L because there currently are no definitive chronic endpoints determined for the estuarine/marine fish taxonomic group (effects were seen at the lowest concentration tested in the only chronic study available; NOAEC < 10 µg a.i./L). Based on 60-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.1434 µg a.i./L, all chronic RQs for estuarine/marine fish range from 0.05 (Soil Barrier Treatment on Fencerows and Hedgerows) to 21.97 (Nursery Uses based on the current maximum label rate for pine seed orchards). While 18 of the 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for estuarine/marine fish, 27 of the 45 modeled scenarios did not (**Table 5.3**).

Based on exceedances of the Agency's acute listed species LOC (RQ$\geq$0.05) for 44 of the 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and exceedances of the Agency's chronic risk LOC (RQ≥1) for 18 of the 45 modeled scenarios, there is a potential for indirect effects to those listed species that rely on estuarine marine fish during at least some portion of their life-cycle (*i.e.*, CCR).

Table 5.3. Acute and chronic RQs for estuarine/marine fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]

USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	60-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Agricultural Use Patterns									
Alfalfa	**Alfalfa hay and seed crops**	**CA alfalfa**	**0.20**	**5**	**30**	0.437	0.0853	**0.20**	0.59
Nut Trees	**Pistachio**	**CA almond**	**0.3**	**3**	**10**	0.629	0.114	**0.29**	0.79
Avocado	**Avocado**	**CA avocado**	**0.20**	**4**	**7**	0.660	0.112	**0.30**	0.78
Cole crop	**Broccoli**	**CA cole crop**	**0.20**	**4**	**5**	0.908	0.235	**0.41**	**1.64**
Corn	**Corn (pop)**	**CA corn**	**0.2**	**3**	**5**	0.465	0.106	**0.21**	0.74

Table 5.3. Acute and chronic RQs for estuarine/marine fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**60-day EEC (µg/L)**	**Acute RQ [3]**	**Chronic RQ [4]**
Corn	**Corn (sweet)**	**CA corn**	**0.2**	**4**	**3**	0.582	0.142	**0.26**	0.99
Forestry	**Softwood (conifer), hybrid cottonwood/ poplar**	**CA Forestry**	**0.20**	**N/S, Assumed to be 10**	**N/S, Assumed to be 5**	4.74	0.910	**2.15**	**6.35**
Fruit tree	**Pear**	**CA fruit tree**	**1@0.4 and 1@0.25**	**2**	**10**	0.504	0.0776	**0.23**	0.54
Fruit tree	**Peach**	**CA fruit tree**	**0.25**	**3**	**10**	0.759	0.0693	**0.35**	0.48
Garlic	**Garlic**	**CA garlic**	**0.20**	**4**	**10**	0.479	0.116	**0.22**	0.81
Leafy vegetables	**Major leafy vegetables[5]**	**CA lettuce**	**0.2**	**4**	**7**	1.56	0.319	**0.71**	**2.22**
Leafy vegetables	**Minor leafy vegetables[6]**	**CA lettuce**	**0.2**	**10**	**3**	3.54	0.772	**1.61**	**5.38**
Cucurbit vegetables	**Major cucurbit vegetables[7]**	**CA melons**	**0.2**	**6**	**7**	0.441	0.115	**0.20**	0.80
Cucurbit vegetables	**Minor cucurbit vegetables[8]**	**CA melons**	**0.24**	**8**	**N/S, assumed to be 7**	0.557	0.179	**0.25**	**1.25**
Nursery	**X-mass trees, Nursery stock and Pine seed orchard[9]**	**CA nursery**	**0.4**	**6**	**28**	5.50[10]	0.849	**2.50**	**5.92**
Nursery	**Pine seed orchard (current label low rate) [9]**	**CA nursery**	**0.75**	**6**	**28**	5.50[10]	1.59	**2.50**	**11.09**
Nursery	**Pine seed orchard (current label high rate) [9]**	**CA nursery**	**1.6**	**6**	**28**	5.50[10]	3.15	**2.50**	**21.97**
Onion	**Onion**	**CA onion**	**1@0.1 and 3@0.3**	**4**	**7**	0.162	0.0294	**0.07**	0.21
Onion	**Fennel**	**CA onion**	**0.2**	**10**	**3**	0.527	0.193	**0.24**	**1.35**
Potato	**Potato**	**CA potato**	**0.2**	**4**	**10**	0.414	0.0765	**0.19**	0.53

Table 5.3. Acute and chronic RQs for estuarine/marine fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**60-day EEC (µg/L)**	**Acute RQ** [3]	**Chronic RQ** [4]
Row Crops	**Celery, artichoke, asparagus, pepper**	**CA row crop**	**0.2**	**5**	**7**	0.648	0.173	**0.29**	**1.21**
Row Crops	**Rhubarb, field grown roses**	**CA row crop**	**0.2**	**10**	**5**	1.09	0.331	**0.50**	**2.31**
Tomato	**Tomato**	**CA tomato**	**0.2**	**3**	**7**	0.414	0.0634	**0.19**	0.44
Tomato	**Tomatillo**	**CA tomato**	**0.2**	**6**	**N/S, assumed to be 7**	0.447	0.120	**0.20**	0.84
Turf	**Golf course, recreational areas**	**CA turf**	**0.87**	**6**	**N/S, Assumed 7**	0.571	0.175	**0.26**	**1.22**
Ant mound treatment	**Agricultural fruit trees**	**CA fruit**	**0.84**	**N/S, Assumed 4**	**N/S, Assumed 7**	0.539	0.126	**0.25**	0.88
Non-Agricultural Use Patterns									
Mosquito control – Pre-CFR 2005-1	**Northern Recreational areas**	**CA turf**	**0.007**	**26** [11]	**1**	0.496	0.268	**0.23**	**1.87**
Mosquito control – Post-CFR 2005-1 [12]	**Northern Recreational areas**	**CA turf**	**0.007**	**26**[11]	**1**	0.221	0.119	**0.10**	0.83
Mosquito control – Pre-CFR 2005-1	**Northern Agricultural Areas (metfile W93193.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.452	0.223	**0.21**	**1.56**
Mosquito control – Post-CFR 2005-1[12]	**Northern Agricultural Areas (metfile W93193.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.200	0.0982	**0.09**	0.68
Mosquito control – Pre-CFR 2005-1	**Central Agricultural Areas (metfile W23232.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.472	0.242	**0.21**	**1.69**
Mosquito control – Post-CFR 2005-1[12]	**Central Agricultural Areas (metfile W23232.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.208	0.106	**0.09**	0.74

Table 5.3. Acute and chronic RQs for estuarine/marine fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**60-day EEC (µg/L)**	**Acute RQ** [3]	**Chronic RQ** [4]
Ant mound Treatment	**Non-agricultural areas, turf, recreational areas**	**CA turf**	**0.84**	**N/S, Assumed 4**	**N/S, Assumed 7**	0.598	0.146	**0.27**	**1.02**
Soil Barrier Treatment	**Fencerows and Hedgerows**	**CA range-land-hay**	**0.01**	**N/S, Assumed 10**	**N/S, assumed to be 7**	0.0447	0.00714	0.02	0.05
Soil Barrier Treatment	**Range Land**	**CA range-land-hay**	**0.1**	**N/S, Assumed 10**	**N/S, assumed to be 7**	0.448	0.0715	**0.20**	0.50
Residential Turf and Ornamentals	**Home & Garden**	**CA residential**	**4.23**	**N/S, assumed to be 3**	**5**	5.50[10]	0.616	**2.50**	**4.30**
Perimeter Treatment	**Urban & Rural Structures**	**CA residential**	**1.43**	**N/S, assumed to be 4**	**N/S, assumed to be 90**	1.814	0.206	**0.82**	**1.44**
Termite Treatment	**Urban & Rural Structures**	**CA residential**	**0.77**	**1**	**None**	0.454	0.042	**0.21**	0.29
Garden Vegetables	**Home & Garden**	**CA residential**	**0.25**	**6**	**3**	0.329	0.046	**0.15**	0.32
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**N/S, assumed to be 10**	0.506	0.063	**0.23**	0.44
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**10**	0.506	0.063	**0.23**	0.44
Barrier Treatment	**Urban & Rural Structures**	**CA residential**	**1@0.08 and 3@0.10**	**2**	**N/S, assumed to be 7**	0.195	0.016	**0.09**	0.11
Home and Garden Fire Ant Treatment	**Home & Garden**	**CA residential**	**1.00**	**N/S, assumed to be 4**	**N/S, assumed to be 7**	1.534	0.130	**0.70**	0.91
Turf (Granular formulation)	**Home & Garden**	**CA residential**	**0.33**	**N/S, assumed to be 3**	**N/S, assumed to be 7**	0.505	0.038	**0.23**	0.26
Garden Vegetables(Granular formulation)	**Home & Garden**	**CA residential**	**0.27**	**6**	**3**	0.413	0.029	**0.19**	0.20

Table 5.3. Acute and chronic RQs for estuarine/marine fish based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**60-day EEC (µg/L)**	**Acute RQ [3]**	**Chronic RQ [4]**

[1] Acute RQs for estuarine/marine fish are calculated as follows: use-specific peak EEC / 2.2 µg a.i./L. Chronic RQs for estuarine/marine fish are calculated as follows: use-specific 60-day EEC / 0.1434 µg a.i./L . The acute LC_{50} of 2.2 µg a.i./L used to derive acute RQs for estuarine/marine fish is based on a study with Atlantic silverside (*Menidia menidia*), while the chronic NOAEC of 0.1434 µg a.i./L used to derive chronic RQs is an estimated toxicity value. The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate an Atlantic Silverside (*Menidia menidia*) chronic toxicity value because there currently are no definitive chronic endpoints determined for the estuarine/marine fish taxonomic group (effects were seen at the lowest concentration tested in the only chronic study available; NOAEC < 10 µg a.i./L).

[2] Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.

[3] All bolded and shaded acute RQs exceed the Agency's acute risk LOC for listed species (0.05).

[4] All bolded and shaded chronic RQs exceed the Agency's chronic risk LOC (1).

[5] Lettuce, Brussel sprouts, orach, spinach, New Zealand spinach.

[6] Chinese amaranth, cardoon, celetuce, Swiss chard, chervil chicory, leafy chrysanthemum, corn salad, garden and upland cress, dandelion, dock (scorrel), parsley, purslane (winter and garden), roquette (arugula).

[7] Cucumber, cantaloupe, eggplant, pumpkin, squash, watermelon.

[8] Melons, melons (bitter, balsam pear), citron melon, melons (honeydew, mango, musk and winter "Casaba/ Crenshaw/ Honeydew/ Persian").

[9] The first run is a reduced exposure scenario which represents what one registrant has claimed to be the maximum intended use scenario for the application of permethrin to pine seed orchards. However, the label could be interpreted to allow for the modeled maximum exposure scenario for pine seed orchards (4 applications of a maximum single application rate of 1.6 lb a.i./A with a 28-day interval). At this time, this run covers Christmas trees and nursery stock (0.2 lb a.i/A rate) and the registrant-suggested rate for pine seed orchards. The second run covers the current label low rate (0.75 lbs a.i./A) while the third run covers the highest rate in the current label (1.6 lb a.i. /A).

[10] Limited by the solubility of permethrin in water.

[11] The modeled scenario was run based on the most conservative assumptions regarding use parameters (i.e., rate, interval, and # of applications) as is possible under both the newly revised labels (based on mitigation) and the labels prior to mitigation. On some newly revised labels, a one-day interval is allowed and represents the most conservative assumption possible. The maximum number of applications (26) represents the maximum number of applications currently allowed by the PRZM/EXAMS model, and the maximum allowed under most newly revised labels. Previously, mosquito adulticide labels did not have restrictions on the number of applications and some labels have not yet been revised based on mitigation measures at the time this assessment was written.

[12] It should be noted that not all labels for mosquito control uses have been revised based on the suggested mitigation measures at the time this assessment was written. Therefore, caution should be used when basing risk conclusions for mosquito control uses on these use scenarios because it may underestimate exposure to aquatic organisms if not all labels are eventually revised based on mitigation measures.

5.1.1.4 Estuarine/Marine Invertebrates

Acute risk to estuarine/marine invertebrates is based on peak EECs in the standard PRZM/EXAMS pond and the lowest acute toxicity value for estuarine/marine invertebrates. Based on surrogate estuarine/marine invertebrate toxicity data (EC_{50} value of 0.018 µg a.i./L for stone crabs) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for estuarine/marine invertebrates range from 2.48 (Soil Barrier Treatment on Fencerows and Hedgerows) to 305.56 (Nursery Uses and Residential Turf and Ornamentals); therefore, the entire set of 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's acute listed species LOC (RQ$\geq$0.05) for estuarine/marine invertebrates (**Table 5.4**).

Chronic risk is based on 21-day EECs and the lowest chronic toxicity value for estuarine/marine invertebrates. However, in the case of permethrin, the fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a stone crab chronic toxicity value because the chronic toxicity data available for mysids are less sensitive than the most sensitive acute toxicity value (based on the only chronic study available for estuarine/marine invertebrates the LOAEC = 0.024 µg a.i./L; the acute EC_{50} for stone crabs was reported to be 0.018 µg a.i./L) and because the chronic study was not performed using the most acutely sensitive estuarine/marine invertebrate. Based on 21-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.0012 µg a.i./L, all chronic RQs for estuarine/marine invertebrates range from 7.77 (Soil Barrier Treatment on Fencerows and Hedgerows) to 3816.67 (Nursery Uses based on the current maximum label rate for pine seed orchards); therefore, the entire set of 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for estuarine/marine invertebrates (**Table 5.4**).

Based on exceedances of the Agency's acute listed species LOC (RQ≥0.05) and chronic risk LOC (RQ≥1) for the entire set of 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, there is a potential for indirect effects to those listed species that rely on estuarine/marine invertebrates during at least some portion of their life-cycle (*i.e.*, CCR).

Table 5.4. Acute and chronic RQs for estuarine/marine invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]

USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	21-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]
Agricultural Use Patterns									
Alfalfa	**Alfalfa hay and seed crops**	**CA alfalfa**	**0.20**	**5**	**30**	0.437	0.0967	**24.28**	**80.58**
Nut Trees	**Pistachio**	**CA almond**	**0.3**	**3**	**10**	0.629	0.159	**34.94**	**132.50**
Avocado	**Avocado**	**CA avocado**	**0.20**	**4**	**7**	0.66	0.149	**36.67**	**124.17**
Cole crop	**Broccoli**	**CA cole crop**	**0.20**	**4**	**5**	0.908	0.287	**50.44**	**239.17**
Corn	**Corn (pop)**	**CA corn**	**0.2**	**3**	**5**	0.465	0.152	**25.83**	**126.67**
Corn	**Corn (sweet)**	**CA corn**	**0.2**	**4**	**3**	0.582	0.203	**32.33**	**169.17**
Forestry	**Softwood (conifer), hybrid cottonwood/ poplar**	**CA Forestry**	**0.20**	**N/S, Assumed to be 10**	**N/S, Assumed to be 5**	4.74	1.17	**263.33**	**975.00**
Fruit tree	**Pear**	**CA fruit tree**	**1@0.4 and 1@0.25**	**2**	**10**	0.504	0.113	**28.00**	**94.17**
Fruit tree	**Peach**	**CA fruit tree**	**0.25**	**3**	**10**	0.759	0.119	**42.17**	**99.17**

Table 5.4. Acute and chronic RQs for estuarine/marine invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Acute RQ [3]**	**Chronic RQ [4]**
Garlic	**Garlic**	**CA garlic**	**0.20**	**4**	**10**	0.479	0.145	**26.61**	**120.83**
Leafy vegetables	**Major leafy vegetables[5]**	**CA lettuce**	**0.2**	**4**	**7**	1.56	0.402	**86.67**	**335.00**
Leafy vegetables	**Minor leafy vegetables[6]**	**CA lettuce**	**0.2**	**10**	**3**	3.54	0.98	**196.67**	**816.67**
Cucurbit vegetables	**Major cucurbit vegetables[7]**	**CA melons**	**0.2**	**6**	**7**	0.441	0.141	**24.50**	**117.50**
Cucurbit vegetables	**Minor cucurbit vegetables[8]**	**CA melons**	**0.24**	**8**	**N/S, assumed to be 7**	0.557	0.198	**30.94**	**165.00**
Nursery	**X-mass trees, Nursery stock and Pine seed orchard[9]**	**CA nursery**	**0.4**	**6**	**28**	5.50[10]	1.18	**305.56**	**983.33**
Nursery	**Pine seed orchard (current label low rate) [9]**	**CA nursery**	**0.75**	**6**	**28**	5.50[10]	2.22	**305.56**	**1850.00**
Nursery	**Pine seed orchard (current label high rate) [9]**	**CA nursery**	**1.6**	**6**	**28**	5.50[10]	4.58	**305.56**	**3816.67**
Onion	**Onion**	**CA onion**	**1@0.1 and 3@0.3**	**4**	**7**	0.162	0.0447	**9.00**	**37.25**
Onion	**Fennel**	**CA onion**	**0.2**	**10**	**3**	0.527	0.271	**29.28**	**225.83**
Potato	**Potato**	**CA potato**	**0.2**	**4**	**10**	0.414	0.101	**23.00**	**84.17**
Row Crops	**Celery, artichoke, asparagus, pepper**	**CA row crop**	**0.2**	**5**	**7**	0.648	0.216	**36.00**	**180.00**
Row Crops	**Rhubarb, field grown roses**	**CA row crop**	**0.2**	**10**	**5**	1.09	0.389	**60.56**	**324.17**
Tomato	**Tomato**	**CA tomato**	**0.2**	**3**	**7**	0.414	0.105	**23.00**	**87.50**
Tomato	**Tomatillo**	**CA tomato**	**0.2**	**6**	**N/S, assumed to be 7**	0.447	0.145	**24.83**	**120.83**
Turf	**Golf course, recreational areas**	**CA turf**	**0.87**	**6**	**N/S, Assumed 7**	0.571	0.204	**31.72**	**170.00**

Table 5.4. Acute and chronic RQs for estuarine/marine invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Acute RQ** [3]	**Chronic RQ** [4]
Ant mound treatment	**Agricultural fruit trees**	**CA fruit**	**0.84**	**N/S, Assumed 4**	**N/S, Assumed 7**	0.539	0.179	**29.94**	**149.17**
Non-Agricultural Use Patterns									
Mosquito control – Pre-CFR 2005-1	**Northern Recreational areas**	**CA turf**	**0.007**	**26** [11]	**1**	0.496	0.385	**27.56**	**320.83**
Mosquito control – Post-CFR 2005-1 [12]	**Northern Recreational areas**	**CA turf**	**0.007**	**26**[11]	**1**	0.221	0.171	**12.28**	**142.50**
Mosquito control – Pre-CFR 2005-1	**Northern Agricultural Areas (metfile W93193.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.452	0.342	**25.11**	**285.00**
Mosquito control – Post-CFR 2005-1[12]	**Northern Agricultural Areas (metfile W93193.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.2	0.151	**11.11**	**125.83**
Mosquito control – Pre-CFR 2005-1	**Central Agricultural Areas (metfile W23232.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.472	0.361	**26.22**	**300.83**
Mosquito control – Post-CFR 2005-1[12]	**Central Agricultural Areas (metfile W23232.dvf)**	**CA alfalfa**	**0.007**	**26**[11]	**1**	0.208	0.159	**11.56**	**132.50**
Ant mound Treatment	**Non-agricultural areas, turf, recreational areas**	**CA turf**	**0.84**	**N/S, Assumed 4**	**N/S, Assumed 7**	0.598	0.191	**33.22**	**159.17**
Soil Barrier Treatment	**Fencerows and Hedgerows**	**CA range-land-hay**	**0.01**	**N/S, Assumed 10**	**N/S, assumed to be 7**	0.0447	0.00932	**2.48**	**7.77**
Soil Barrier Treatment	**Range Land**	**CA range-land-hay**	**0.1**	**N/S, Assumed 10**	**N/S, assumed to be 7**	0.448	0.0932	**24.89**	**77.67**
Residential Turf and Ornamentals	**Home & Garden**	**CA residential**	**4.23**	**N/S, assumed to be 3**	**5**	5.50[10]	1.166	**305.56**	**971.67**
Perimeter Treatment	**Urban & Rural Structures**	**CA residential**	**1.43**	**N/S, assumed to be 4**	**N/S, assumed to be 90**	1.814	0.325	**100.78**	**270.83**

Table 5.4. Acute and chronic RQs for estuarine/marine invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	**USES**	**PRZM SCENARIO**	**MAX APP RATE (lbs ai/A)**	**# APPS/ CROP**	**MIN INTER-VAL**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**Acute RQ [3]**	**Chronic RQ [4]**
Termite Treatment	**Urban & Rural Structures**	**CA residential**	**0.77**	**1**	**None**	0.454	0.077	**25.22**	**64.17**
Garden Vegetables	**Home & Garden**	**CA residential**	**0.25**	**6**	**3**	0.329	0.089	**18.28**	**74.17**
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**N/S, assumed to be 10**	0.506	0.095	**28.11**	**79.17**
Garden Nuts and Fruits	**Home & Garden**	**CA residential**	**0.4**	**5**	**10**	0.506	0.095	**28.11**	**79.17**
Barrier Treatment	**Urban & Rural Structures**	**CA residential**	**1@0.08 and 3@0.10**	**2**	**N/S, assumed to be 7**	0.195	0.03	**10.83**	**25.00**
Home and Garden Fire Ant Treatment	**Home & Garden**	**CA residential**	**1.00**	**N/S, assumed to be 4**	**N/S, assumed to be 7**	1.534	0.253	**85.22**	**210.83**
Turf (Granular formulation)	**Home & Garden**	**CA residential**	**0.33**	**N/S, assumed to be 3**	**N/S, assumed to be 7**	0.505	0.076	**28.06**	**63.33**
Garden Vegetables(Granular formulation)	**Home & Garden**	**CA residential**	**0.27**	**6**	**3**	0.413	0.053	**22.94**	**44.17**

Table 5.4. Acute and chronic RQs for estuarine/marine invertebrates based on EECs for use categories used to represent all permethrin uses in CA. [1, 2]									
USE CATEGORY	USES	PRZM SCENARIO	MAX APP RATE (lbs ai/A)	# APPS/ CROP	MIN INTER-VAL	Peak EEC (µg/L)	21-day EEC (µg/L)	Acute RQ [3]	Chronic RQ [4]

[1] Acute RQs for estuarine/marine invertebrates are calculated as follows: use-specific peak EEC / 0.018 µg a.i./L. Chronic RQs for estuarine/marine invertebrates are calculated as follows: use-specific 21-day EEC / 0.0012 µg a.i./L . The acute EC_{50} of 0.018 µg a.i./L used to derive acute RQs for estuarine/marine invertebrates is based on a study with stone crabs (*Menippe mercenaria*), while the chronic NOAEC of 0.0012 µg a.i./L used to derive chronic RQs is an estimated toxicity value. The fathead minnow (*Pimephales promelas*) acute to chronic ratio (ACR=15.34) was used to estimate a stone crab (*Menippe mercenaria*) chronic toxicity value because the chronic toxicity data available for mysids are less sensitive than the most sensitive acute toxicity value (based on the only chronic study available for estuarine/marine invertebrates the LOAEC = 0.024 µg a.i./L; the acute EC_{50} for stone crabs was reported to be 0.018 µg a.i./L) and because the chronic study was not performed using the most acutely sensitive estuarine/marine invertebrate.

[2] Please refer to the “Aquatic Exposure Assessment” section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.

[3] All bolded and shaded acute RQs exceed the Agency’s acute risk LOC for listed species (0.05).

[4] All bolded and shaded chronic RQs exceed the Agency’s chronic risk LOC (1).

[5] Lettuce, Brussel sprouts, orach, spinach, New Zealand spinach.

[6] Chinese amaranth, cardoon, celetuce, Swiss chard, chervil chicory, leafy chrysanthemum, corn salad, garden and upland cress, dandelion, dock (scorrel), parsley, purslane (winter and garden), roquette (arugula).

[7] Cucumber, cantaloupe, eggplant, pumpkin, squash, watermelon.

[8] Melons, melons (bitter, balsam pear), citron melon, melons (honeydew, mango, musk and winter “Casaba/ Crenshaw/ Honeydew/ Persian”).

[9] The first run is a reduced exposure scenario which represents what one registrant has claimed to be the maximum intended use scenario for the application of permethrin to pine seed orchards. However, the label could be interpreted to allow for the modeled maximum exposure scenario for pine seed orchards (4 applications of a maximum single application rate of 1.6 lb a.i./A with a 28-day interval). At this time, this run covers Christmas trees and nursery stock (0.2 lb a.i/A rate) and the registrant-suggested rate for pine seed orchards. The second run covers the current label low rate (0.75 lbs a.i. /A) while the third run covers the highest rate in the current label (1.6 lb a.i. /A).

[10] Limited by the solubility of permethrin in water.

[11] The modeled scenario was run based on the most conservative assumptions regarding use parameters (i.e., rate, interval, and # of applications) as is possible under both the newly revised labels (based on mitigation) and the labels prior to mitigation. On some newly revised labels, a one-day interval is allowed and represents the most conservative assumption possible. The maximum number of applications (26) represents the maximum number of applications currently allowed by the PRZM/EXAMS model, and the maximum allowed under most newly revised labels. Previously, mosquito adulticide labels did not have restrictions on the number of applications and some labels have not yet been revised based on mitigation measures at the time this assessment was written.

[12] It should be noted that not all labels for mosquito control uses have been revised based on the suggested mitigation measures at the time this assessment was written. Therefore, caution should be used when basing risk conclusions for mosquito control uses on these use scenarios because it may underestimate exposure to aquatic organisms if not all labels are eventually revised based on mitigation measures.

5.1.1.5 Non-vascular Aquatic Plants

Acute risk to aquatic non-vascular plants is based on peak EECs in the standard pond and the lowest acute toxicity value. Because all EC_{50} values available for aquatic non-vascular plants are an order of magnitude or greater than the limit of solubility of permethrin, risk to this taxonomic group was expected to be low. In fact, based on the most sensitive surrogate aquatic non-vascular plant toxicity data (EC_{50} value of 68 µg a.i./L for the marine alga, *Skeletonema costatum*) and the maximum aquatic peak EEC of all use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all RQs for aquatic non-vascular plants are ≤0.08 (**Table 5.5**). Since the RQs do not exceed the Agency’s LOC (1) for aquatic non-vascular plants, permethrin appears not likely to indirectly affect those listed species that rely on non-vascular aquatic plants during at least some portion of their life-cycle (*i.e.*, aquatic-phase CRLF, CCR, SFGS, and SMHM).

Table 5.5. RQs for aquatic non-vascular aquatic plants based on the peak EECs for the use categories that resulted in the maximum peak EEC of all modeled scenarios.[1]		
Use Category	**Peak EEC (µg/L)**	**RQ[2]**
Nursery and Residential Turf and Ornamentals	5.50[3]	0.08[4]

[1] The EECs from the scenarios that resulted in the maximum peak EEC of all modeled scenarios were the only ones presented here because even they do not result in an exceedances of the Agency's LOC for plants; therefore, non-vascular plant RQs for all other scenarios are expected to be below the Agency's LOC.
[2] RQ = maximum peak EEC for all modeled scenarios / *Skeletonema costatum* EC_{50}=68 µga.i./L
[3] Limited by the solubility of permethrin in water.
[4] RQ is below the Agency's LOC for plants (1).

5.1.1.6 Vascular Aquatic Plants

Toxicity data have not been identified for quantitatively estimating risk to non-vascular aquatic plants, and therefore, RQs cannot be calculated at this time for this taxonomic group. Discussion regarding lines of evidence for the potential for indirect effects to those listed species that rely on vascular aquatic plants during at least some portion of their life-cycle (*i.e.*, aquatic-phase CRLF, CCR, SFGS, and SMHM) can be found in the "Risk Description" portion of the chapter (**Section 5.2**).

5.1.2 Exposures in the Terrestrial Habitat

5.1.2.1 Birds (surrogate for Reptiles and Terrestrial-phase amphibians)

As previously discussed in **Section 3.3**, potential direct and indirect effects to terrestrial species are based on agricultural and non-agricultural foliar spray and granular applications of permethrin, as well as seed treatment uses. Potential risks to birds (and, thus, reptiles and terrestrial-phase amphibians) resulting from foliar spray applications of permethrin were derived using T-REX, chronic toxicity data for the most sensitive bird species for which data are available, and a variety of dietary categories. Although T-REX has the capability to generate dietary estimates of acute exposure and risk, and dose-based estimates of acute exposure and risk for a variety of body-sizes of birds, acute estimates of risk for birds were not generated for foliar spray applications using T-REX because the acute avian effects data show no treatment-related mortality to bobwhite quail at the highest tested level of permethrin in the sub-acute avian dietary studies (LC_{50} >10,000 mg/kg-diet). In addition, no treatment-related mortality was observed in the acute oral toxicity study establishing the most sensitive acute LD_{50} value for birds (mallard duck LD_{50}> 9,869 mg/kg-bw) (**Table 4.3**). Therefore, for foliar spray applications of permethrin, only dietary-based chronic RQs for birds (and, thus, reptiles and terrestrial-phase amphibians) were derived based for a variety of dietary categories.

Again, potential acute risks to birds (and, thus, reptiles and terrestrial-phase amphibians) could not be estimated for granular uses or seed treatment uses of permethrin using the T-REX $LD_{50}ft^{-2}$ analysis or the T-REX seed treatment analysis approach, respectively. However, dietary-based estimates of chronic risk to insectivorous birds and birds that consume seeds were estimated using a fugacity-based (equilibrium partitioning) approach and the T-REX seed treatment analysis approach, respectively.

Based on surrogate avian toxicity data (NOAEC = 125 mg/kg-diet for mallards), the maximum allowable application rate (3 applications, 4.23 lbs a.i./acre/application, 5-day application interval), the foliar dissipation half-life of 15.4 days for permethrin from Willis and McDowell (1987), and upper bound Kenaga values from T-REX, there is a potential for direct adverse effects on CCR, SFGS, and terrestrial-phase CRLF individuals from foliar spray applications of permethrin in CA (**Table 5.6**). The dietary-based chronic RQs range from <0.01 to 19.78, from <0.01 to 9.07, from <0.01 to 11.13, and from <0.01 to 1.24, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively, with the highest RQs being for birds that feed on short grass under the Residential Turf and Ornamentals exposure scenario and the lowest RQs being for birds that feed on fruits/pods/seeds/large insects under the Mosquito Adulticide exposure scenario based on labels according to mitigation measures. While 24 of the 34 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on short grass, 9 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on broadleaf plants/small insects, 7 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on tall grass, 1 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on fruits/pods/seeds/large insects, and 10 of the 34 modeled scenarios resulted in no exceedances of the Agency's chronic risk LOC (RQ≥1). Therefore, RQs for birds feeding on all various forage categories exceed the Agency's chronic risk LOC (RQ≥1) (**Table 5.6**).

Based on RQs for permethrin seed treatments (chronic RQs= 2.50) exceeding the Agency's chronic risk LOC (RQ≥1), there is a potential for direct adverse effects on CCR individuals that feed on seeds as result of permethrin seed treatments in CA (**Table 5.9**). RQs for granular applications of permethrin do not exceed the Agency's chronic risk LOC of 1 (RQs ≤ 0.43) (**Table 5.8**).

In addition to the potential for direct effects to CCR, SFGS, and terrestrial-phase CRLF individuals, based on exceedances of the Agency's chronic risk LOC (RQ≥1) for 24 of the 34 modeled foliar spray application scenarios and for all seed treatments, there is a potential for indirect effects to those listed species that rely on birds (and, thus, reptiles and/or terrestrial-phase amphibians) during at least some portion of their life-cycle (*i.e.*, CCR, SFGS, CRLF, and SMHM).

5.1.2.2 Mammals

Potential risks to mammals resulting from foliar spray applications of permethrin are derived using T-REX, the most sensitive acute and chronic/reproductive toxicity data for mammals, and a variety of dietary categories. In addition, T-REX has the capability to generate dose-based estimates of exposure and risk for a variety of body-sizes; however, only dose-based estimates of risk for small mammals (15 grams) were generated because that is the only size class of mammals that is relevant for the listed species considered in this assessment. Therefore, for foliar spray applications of permethrin, chronic dietary-based risk estimates, as well as acute and chronic dose-based estimates of risk for small mammals were generated.

For granular applications of permethrin, the T-REX $LD_{50}ft^{-2}$ analysis was used to generate acute estimates of risk for small (15 g) mammals, while the fugacity-based (equilibrium partitioning) approach was used to generate chronic dietary- and dose-based RQs for small mammals that feed on soil-dwelling invertebrates. For permethrin seed treatments, the T-REX seed treatment analysis approach was employed to generate acute dose-based and chronic dietary-based RQs for small (15 g) mammals expected to potentially feed on seeds.

Based on surrogate toxicity data (LD_{50}=152 mg/kg-bw and NOAEL = 2.77 mg/kg-bw/day), the maximum allowable application rate (3 applications, 4.23 lbs a.i./acre/application, 5-day application interval), the foliar dissipation half-life of 15.4 days for permethrin from Willis and McDowell (1987), and upper bound Kenaga values from T-REX, there is a potential for direct adverse effects on SMHM individuals from foliar spray applications of permethrin in CA (**Table 5.6**).

The dose-based acute RQs range from <0.01 to 7.05, from <0.01 to 3.23, from <0.01 to 3.96, and from <0.01 to 0.44, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively, with the highest RQs being for mammals that feed on short grass under the Residential Turf and Ornamentals exposure scenario and the lowest RQs being for mammals that feed on fruits/pods/seeds/large insects under the Mosquito Adulticide exposure scenario based on labels according to mitigation measures. For acute dose-based RQs, 31 of the 34 modeled scenarios used resulted in an exceedance of the Agency’s acute listed species LOC (RQ≥0.1) for mammals that feed on short grass, 30 of the 34 modeled scenarios resulted in an exceedance of the Agency’s acute listed species LOC (RQ≥0.1) for mammals that feed on tall grass or broadleaf plants/small insects, and 4 of the 34 modeled scenarios resulted in an exceedance of the Agency’s acute listed species LOC (RQ≥0.1) for mammals that feed on fruits/pods/seeds/large insects.

The dose-based chronic RQs range from 0.08 to 387.30, from 0.04 to 177.51, from 0.05 to 217.86, and from 0.01 to 24.21, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively, with the highest RQs being for mammals that feed on short grass under the Residential Turf and Ornamentals exposure scenario and the lowest RQs being for mammals that feed on fruits/pods/seeds/large insects under the Mosquito Adulticide exposure scenario based on labels according to mitigation measures. For chronic dose-based RQs, 33 of the 34 modeled scenarios resulted in an exceedance of the Agency’s chronic risk LOC (RQ≥1) for mammals that feed on short grass, 32 of the 34 modeled scenarios resulted in an exceedance of the Agency’s chronic risk LOC (RQ≥1) for mammals that feed on tall grass or broadleaf plants/small insects, and 28 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on fruits/pods/seeds/large insects.

The dietary-based chronic RQs range from 0.01 to 44.64, from <0.01 to 20.46, from 0.01 to 25.11, and from <0.01 to 2.79, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively, with the highest RQs being for mammals that feed on short grass under the Residential Turf and Ornamentals exposure scenario and the lowest RQs being for mammals that feed on fruits/pods/seeds/large insects under the Mosquito Adulticide exposure scenario based on labels according to mitigation measures. For chronic dietary-based RQs, 30 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on short grass, 25 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on tall grass, 28 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on broadleaf plants/small insects, and 1 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on fruits/pods/seeds/large insects. Therefore, RQs for mammals exceed the Agency's acute listed species LOC (RQ≥0.1) and chronic risk LOC (RQ≥1) for mammals (**Table 5.6**) for foliar spray applications of permethrin.

Based on RQs for permethrin granular applications, the $LD_{50}ft^{-2}$ and fugacity-based approach result in exceedances of the Agency's acute listed species LOC (RQ≥0.1) and chronic risk LOC (RQ≥1) for mammals, respectively (**Tables 5.7** and **5.8**; acute RQs range fro 0.41 to 2.07; chronic dose-based RQs range from 1.74 to 8.38; chronic dietary-based RQs range from 0.20 to 0.97); therefore, there is a potential for direct adverse effects on SMHM individuals from granular applications of permethrin in CA.

Based on the T-REX seed treatment analysis, RQs for permethrin seed treatments exceed the Agency's acute listed species LOC (RQ≥0.1) and chronic risk LOC (RQ≥1) for mammals (**Table 5.9**; acute RQs Based on Available A.I. <0.01; acute RQs Based on Nagy Dose= 0.20; Chronic RQs Based on Maximum Seed Application Rate =5.65); therefore, there is a potential for direct adverse effects on SMHM individuals from seed treatment uses of permethrin in CA.

In addition to the potential for direct effects to SMHM, based on exceedances of the Agency's acute (RQ≥0.1) and chronic risk LOCs (RQ≥1), there is a potential for indirect effects to those listed species that rely on mammals during at least some portion of their life-cycle (*i.e.*, CCR, SFGS, CRLF, and SMHM).

5.1.2.3 Terrestrial Invertebrates

Potential risks to terrestrial invertebrates resulting from foliar spray applications of permethrin are derived using T-REX, and the most sensitive toxicity data available for terrestrial invertebrates. In the case of permethrin, the honey bee was used as a surrogate for evaluating risks of permethrin to terrestrial invertebrates. The toxicity value for terrestrial invertebrates was calculated by multiplying the lowest available acute contact

LD_{50} of 0.024 µg a.i./bee by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs in ppm (µg a.i./g of bee) calculated by T-REX for small and large insects were divided by the calculated toxicity value for terrestrial invertebrates, which is 0.1875 µg a.i./g of bee, to derive RQs. To evaluate the potential for risks to terrestrial soil-dwelling invertebrates resulting from granular applications of permethrin, EECs (mg a.i./kg-bw) in earthworms were estimated using the fugacity-based approach and divided by the calculated toxicity value for terrestrial invertebrates, which is 0.1875 µg a.i./g of bee, or 0.1875 mg a.i./kg of bee.

Based on exceedances of the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05), permethrin use in CA does have the potential to directly adversely affect the BCB (**Table 5.6**). RQs for terrestrial invertebrates exceed the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05) based on EECs for both small and large insects for all permethrin spray application scenarios considered in this assessment (**Table 5.6**; RQs based on EECs for small insects and large insects range from 1.60 to 7418.67 and 0.16 to 826.67, respectively).

For all granular applications of permethrin, RQs for soil-dwelling terrestrial invertebrates exceed the Agency's interim LOC (RQ≥0.05) for listed terrestrial invertebrates based on EECs estimated using the fugacity-based approach (**Table 5.8**; RQs range from 59.41 to 286.35). Therefore, since RQs exceed the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05) for both spray and granular applications of permethrin, there is a potential for indirect effects to those listed species that rely on terrestrial invertebrates during at least some portion of their life-cycle (*i.e.*, CCR, SFGS, CRLF, and SMHM).

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Mammals			Birds	Terrestrial Invertebrates	
			Acute[3] Dose-Based	Chronic[4] Dose-Based	Chronic[4] Dietary-Based	Chronic[4] Dietary-Based	Small Insects[5]	Large Insects[5]
Alfalfa (Alfalfa)	0.2, 30, 5	Short Grass	**0.18**	**10.14**	**1.17**	0.52		
		Tall Grass	0.08	**4.65**	0.54	0.24		
		Broadleaf plants, Small Insects	**0.10**	**5.70**	0.66	0.29	**194.13**	
		Fruits, Pods, Seeds, Lg Insects	0.01	0.63	0.07	0.03		**21.33**
Nut Trees (Pistachio)	0.3, 10, 3	Short Grass	**0.42**	**23.05**	**2.66**	**1.18**		
		Tall Grass	**0.19**	**10.56**	**1.22**	0.54		
		Broadleaf plants, Small Insects	**0.24**	**12.96**	**1.49**	0.66	**441.60**	

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Mammals			Birds	Terrestrial Invertebrates	
			Acute[3] Dose-Based	Chronic[4] Dose-Based	Chronic[4] Dietary-Based	Chronic[4] Dietary-Based	Small Insects[5]	Large Insects[5]
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.44**	0.17	0.07		**49.07**
Avocado (Avocado)	0.2, 7, 4	Short Grass	**0.36**	**19.93**	**2.30**	**1.02**		
		Tall Grass	**0.17**	**9.13**	**1.05**	0.47		
		Broadleaf plants, Small Insects	**0.20**	**11.21**	**1.29**	0.57	**381.87**	
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.25**	0.14	0.06		**42.67**
Cole Crops (Broccoli)	0.2, 5, 4	Short Grass	**0.40**	**22.14**	**2.55**	**1.13**		
		Tall Grass	**0.18**	**10.15**	**1.17**	0.52		
		Broadleaf plants, Small Insects	**0.23**	**12.45**	**1.44**	0.64	**424.00**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.38**	0.16	0.07		**46.93**
Corn (Pop corn)	0.2, 5, 3 [13]	Short Grass	**0.33**	**18.31**	**2.11**	0.94		
		Tall Grass	**0.15**	**8.39**	0.97	0.43		
		Broadleaf plants, Small Insects	**0.19**	**10.30**	**1.19**	0.53	**350.93**	
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.14**	0.13	0.06		**38.93**
Corn (Sweet corn)	0.2, 3, 4	Short Grass	**0.45**	**24.84**	**2.86**	**1.27**		
		Tall Grass	**0.21**	**11.38**	**1.31**	0.58		
		Broadleaf plants, Small Insects	**0.25**	**13.97**	**1.61**	0.71	**475.73**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.55**	0.18	0.08		**52.80**
Forestry (Cottonwood)	0.2, 5 [6], 10 [6]	Short Grass	**0.61**	**33.37**	**3.85**	**1.7**		
		Tall Grass	**0.28**	**15.30**	**1.76**	0.78		
		Broadleaf plants, Small Insects	**0.34**	**18.77**	**2.16**	0.96	**639.47**	
		Fruits, Pods, Seeds, Lg Insects	0.04	**2.09**	0.24	0.11		**70.93**
Fruit Trees (Pear) [7]	0.4, 10, 2	Short Grass	**0.45**	**24.62**	**2.84**	**1.26**		
		Tall Grass	**0.21**	**11.28**	**1.30**	0.58		
		Broadleaf plants, Small Insects	**0.25**	**13.85**	**1.60**	0.71	**471.47**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.54**	0.18	0.08		**52.27**

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Mammals			Birds	Terrestrial Invertebrates	
			Acute[3] Dose-Based	Chronic[4] Dose-Based	Chronic[4] Dietary-Based	Chronic[4] Dietary-Based	Small Insects[5]	Large Insects[5]
Fruit Trees (Peach)	**0.25, 10, 3**	**Short Grass**	**0.35**	**19.21**	**2.21**	0.98		
		Tall Grass	**0.16**	**8.80**	**1.01**	0.45		
		Broadleaf plants, Small Insects	**0.20**	**10.80**	**1.25**	0.55	**368.00**	
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.20**	0.14	0.06		**41.07**
Garlic & Potatoes (Garlic & Potatoes)	**0.2, 10, 4**	**Short Grass**	**0.31**	**17.31**	**2.00**	0.88		
		Tall Grass	**0.14**	**7.94**	0.91	0.41		
		Broadleaf plants, Small Insects	**0.18**	**9.74**	**1.12**	0.5	**331.73**	
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.08**	0.12	0.06		**36.80**
Major Leafy Vegetables (Lettuce)	**0.2, 7, 4**	**Short Grass**	**0.36**	**19.93**	**2.30**	**1.02**		
		Tall Grass	**0.17**	**9.13**	**1.05**	0.47		
		Broadleaf plants, Small Insects	**0.20**	**11.21**	**1.29**	0.57	**381.87**	
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.25**	0.14	0.06		**42.67**
Minor Leafy Vegetables [8]	**0.2, 3, 10**	**Short Grass**	**0.80**	**44.09**	**5.08**	**2.25**		
		Tall Grass	**0.37**	**20.21**	**2.33**	**1.03**		
		Broadleaf plants, Small Insects	**0.45**	**24.80**	**2.86**	**1.27**	**844.80**	
		Fruits, Pods, Seeds, Lg Insects	0.05	**2.76**	0.32	0.14		**93.87**
Major Cucurbits (Cucumber)	**0.2, 7, 6**	**Short Grass**	**0.43**	**23.61**	**2.72**	**1.21**		
		Tall Grass	**0.20**	**10.82**	**1.25**	0.55		
		Broadleaf plants, Small Insects	**0.24**	**13.28**	**1.53**	0.68	**452.27**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.48**	0.17	0.08		**50.13**
Minor Cucurbits (Melons)	**0.24, 7 [6], 8**	**Short Grass**	**0.56**	**30.69**	**3.54**	**1.57**		
		Tall Grass	**0.26**	**14.07**	**1.62**	0.72		
		Broadleaf plants, Small Insects	**0.31**	**17.26**	**1.99**	0.88	**587.73**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.92**	0.22	0.1		**65.60**
Nursery (Pine Seed	**0.4, 28, 6**	**Short Grass**	**0.38**	**20.97**	**2.42**	**1.07**		
		Tall Grass	**0.17**	**9.61**	**1.11**	0.49		

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.								
Use Category[1]	**App Rate (lbs a.i./A), Interval (Days), # of Apps[2]**	**Dietary Category**	**Mammals**			**Birds**	**Terrestrial Invertebrates**	
			Acute[3] Dose-Based	**Chronic[4] Dose-Based**	**Chronic[4] Dietary-Based**	**Chronic[4] Dietary-Based**	**Small Insects[5]**	**Large Insects[5]**
Orchard-Reduced) [9]		**Broadleaf plants, Small Insects**	**0.21**	**11.80**	**1.36**	0.6	**401.60**	
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.31**	0.15	0.07		**44.80**
Nursery (Pine Seed Orchard-Maximum)	**1.6, 28, 6**	**Short Grass**	**1.53**	**83.90**	**9.67**	**4.29**		
		Tall Grass	**0.70**	**38.45**	**4.43**	**1.96**		
		Broadleaf plants, Small Insects	**0.86**	**47.19**	**5.44**	**2.41**	**1606.93**	
		Fruits, Pods, Seeds, Lg Insects	**0.10**	**5.24**	0.60	0.27		**178.67**
Onions (Onion) [7]	**0.3, 7, 4**	**Short Grass**	**0.54**	**29.89**	**3.45**	**1.53**		
		Tall Grass	**0.25**	**13.70**	**1.58**	0.7		
		Broadleaf plants, Small Insects	**0.31**	**16.81**	**1.94**	0.86	**572.80**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.87**	0.22	0.1		**63.47**
Onions (Fennel)	**0.2, 3, 10**	**Short Grass**	**0.80**	**44.09**	**5.08**	**2.25**		
		Tall Grass	**0.37**	**20.21**	**2.33**	**1.03**		
		Broadleaf plants, Small Insects	**0.45**	**24.80**	**2.86**	**1.27**	**844.80**	
		Fruits, Pods, Seeds, Lg Insects	0.05	**2.76**	0.32	0.14		**93.87**
Row Crops (Celery)	**0.2, 7, 5**	**Short Grass**	**0.40**	**22.06**	**2.54**	**1.13**		
		Tall Grass	**0.18**	**10.11**	**1.17**	0.52		
		Broadleaf plants, Small Insects	**0.23**	**12.41**	**1.43**	0.63	**422.40**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.38**	0.16	0.07		**46.93**
Row Crops (Rhubarb)	**0.2, 5, 10**	**Short Grass**	**0.61**	**33.37**	**3.85**	**1.7**		
		Tall Grass	**0.28**	**15.30**	**1.76**	0.78		
		Broadleaf plants, Small Insects	**0.34**	**18.77**	**2.16**	0.96	**639.47**	
		Fruits, Pods, Seeds, Lg Insects	0.04	**2.09**	0.24	0.11		**70.93**
Tomato (Tomato)	**0.2, 7, 3**	**Short Grass**	**0.31**	**17.01**	**1.96**	0.87		
		Tall Grass	**0.14**	**7.79**	0.90	0.4		
		Broadleaf plants, Small Insects	**0.17**	**9.57**	**1.10**	0.49	**325.87**	

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.								
Use Category[1]	**App Rate (lbs a.i./A), Interval (Days), # of Apps[2]**	**Dietary Category**	**Mammals**			**Birds**	**Terrestrial Invertebrates**	
			Acute[3] Dose-Based	**Chronic[4] Dose-Based**	**Chronic[4] Dietary-Based**	**Chronic[4] Dietary-Based**	**Small Insects[5]**	**Large Insects[5]**
		Fruits, Pods, Seeds, Lg Insects	0.02	**1.06**	0.12	0.05		**36.27**
Tomato (Tomatillos)	**0.2, 7 [6], 6**	**Short Grass**	**0.43**	**23.61**	**2.72**	**1.21**		
		Tall Grass	**0.20**	**10.82**	**1.25**	0.55		
		Broadleaf plants, Small Insects	**0.24**	**13.28**	**1.53**	0.68	**452.27**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.48**	0.17	0.08		**50.13**
Turf (Golf course and Recreational Areas)	**0.87, 7 [6], 6 [6]**	**Short Grass**	**1.87**	**102.72**	**11.84**	**5.25**		
		Tall Grass	**0.86**	**47.08**	**5.43**	**2.41**		
		Broadleaf plants, Small Insects	**1.05**	**57.78**	**6.66**	**2.95**	**1968.00**	
		Fruits, Pods, Seeds, Lg Insects	**0.12**	**6.42**	0.74	0.33		**218.67**
Ant Mound Treatments (Non-ag, Turf, Recreational, &Ag. Fruit Trees)	**0.84, 7 [6], 4 [6]**	**Short Grass**	**1.52**	**83.69**	**9.65**	**4.28**		
		Tall Grass	**0.70**	**38.36**	**4.42**	**1.96**		
		Broadleaf plants, Small Insects	**0.86**	**47.08**	**5.43**	**2.4**	**1603.20**	
		Fruits, Pods, Seeds, Lg Insects	**0.10**	**5.23**	0.60	0.27		**178.13**
Adulticide (Mosquito Control Pre-CFR 2005-1)	**0.003 [10], 1[11], 52 [11]**	**Short Grass**	0.04	**2.32**	0.27	0.12		
		Tall Grass	0.02	**1.06**	0.12	0.05		
		Broadleaf plants, Small Insects	0.02	**1.30**	0.15	0.07	**44.27**	
		Fruits, Pods, Seeds, Lg Insects	<0.01	0.14	0.02	0.01		**4.80**
Adulticide (Mosquito Control Post-CFR 2005-1) [12]	**0.00014 [10], 1, 26**	**Short Grass**	<0.01	0.08	0.01	<0.01		
		Tall Grass	<0.01	0.04	<0.01	<0.01		
		Broadleaf plants, Small Insects	<0.01	0.05	0.01	<0.01	**1.60**	
		Fruits, Pods, Seeds, Lg Insects	<0.01	0.01	<0.01	<0.01		**0.16**
Soil Barrier Treatment (Fencerows & Hedgerows)	**0.01, 7 [6], 10**	**Short Grass**	0.02	**1.33**	0.15	0.07		
		Tall Grass	0.01	0.61	0.07	0.03		
		Broadleaf plants, Small Insects	0.01	0.75	0.09	0.04	**25.60**	
		Fruits, Pods, Seeds,	<0.01	0.08	0.01	<0.01		**2.67**

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Dietary Category	Mammals			Birds	Terrestrial Invertebrates	
			Acute[3] Dose-Based	Chronic[4] Dose-Based	Chronic[4] Dietary-Based	Chronic[4] Dietary-Based	Small Insects[5]	Large Insects[5]
		Lg Insects						
Soil Barrier Treatment (Range Land)	0.1, 7 [6], 10	Short Grass	**0.24**	**13.31**	**1.53**	0.68		
		Tall Grass	**0.11**	**6.10**	0.70	0.31		
		Broadleaf plants, Small Insects	**0.14**	**7.49**	0.86	0.38	**254.93**	
		Fruits, Pods, Seeds, Lg Insects	0.02	0.83	0.10	0.04		**28.27**
Residential Turf and Ornamentals (Home and Garden)	4.23, 5, 3 [6]	Short Grass	**7.05**	**387.30**	**44.64**	**19.78**		
		Tall Grass	**3.23**	**177.51**	**20.46**	**9.07**		
		Broadleaf plants, Small Insects	**3.96**	**217.86**	**25.11**	**11.13**	**7418.67**	
		Fruits, Pods, Seeds, Lg Insects	**0.44**	**24.21**	**2.79**	**1.24**		**826.67**
Perimeter Treatment (Urban and Rural Structures)	1.43, 90 [6], 4 [6]	Short Grass	**0.99**	**54.70**	**6.30**	**2.79**		
		Tall Grass	**0.46**	**25.07**	**2.89**	**1.28**		
		Broadleaf plants, Small Insects	**0.56**	**30.77**	**3.55**	**1.57**	**1048.00**	
		Fruits, Pods, Seeds, Lg Insects	0.06	**3.42**	0.39	0.17		**116.27**
Termite Treatment (Urban and Rural Structures)	0.77, N/A, 1	Short Grass	**0.53**	**28.94**	**3.34**	**1.48**		
		Tall Grass	**0.24**	**13.26**	**1.53**	0.68		
		Broadleaf plants, Small Insects	**0.30**	**16.28**	**1.88**	0.83	**554.67**	
		Fruits, Pods, Seeds, Lg Insects	0.03	**1.81**	0.21	0.09		**61.87**
Garden Vegetables (Home and Garden)	0.25, 3, 6	Short Grass	**0.75**	**41.30**	**4.76**	**2.11**		
		Tall Grass	**0.34**	**18.93**	**2.18**	0.97		
		Broadleaf plants, Small Insects	**0.42**	**23.23**	**2.68**	**1.19**	**791.47**	
		Fruits, Pods, Seeds, Lg Insects	0.05	**2.58**	0.30	0.13		**88.00**
Garden Nuts and Fruits (Home and Garden)	0.4, 10 [6], 5	Short Grass	**0.68**	**37.11**	**4.28**	**1.9**		
		Tall Grass	**0.31**	**17.01**	**1.96**	0.87		
		Broadleaf plants, Small Insects	**0.38**	**20.88**	**2.41**	**1.07**	**710.93**	
		Fruits, Pods, Seeds, Lg Insects	0.04	**2.32**	0.27	0.12		**78.93**
Soil Barrier	0.1, 7 [6], 2	Short Grass	**0.12**	**6.50**	0.75	0.33		

Table 5.6. Summary of the acute and chronic dose- and dietary-based RQs for mammals and birds, and RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v1.3.1.								
Use Category[1]	**App Rate (lbs a.i./A), Interval (Days), # of Apps[2]**	**Dietary Category**	**Mammals**			**Birds**	**Terrestrial Invertebrates**	
			Acute[3] Dose-Based	**Chronic[4] Dose-Based**	**Chronic[4] Dietary-Based**	**Chronic[4] Dietary-Based**	**Small Insects[5]**	**Large Insects[5]**
Treatment (Urban and Rural Structures) [7]		**Tall Grass**	0.05	**2.98**	0.34	0.15		
		Broadleaf plants, Small Insects	0.07	**3.66**	0.42	0.19	**124.80**	
		Fruits, Pods, Seeds, Lg Insects	0.01	0.41	0.05	0.02		**13.87**

[1] Please refer to **Table 3.1** for details regarding which uses are covered under each "Use Category."
[2] The maximum number of applications per year, the minimum application intervals, and the maximum application rates for each use selected as the representative use for a "Use Category" were derived from the product labels and used to model EECs, whereas the foliar half-life of 15.4 days used for modeling was based on data for permethrin in Willis and McDowell (1987). For foliar dissipation, 3 foliar half-life measurements on two crops based on total residues were available. Assuming these values are distributed normally, the value which represents the one tail upper 90% confidence limit of the mean half-lives is 15.4 days.
[3] All bolded and shaded acute RQs exceed the Agency's acute risk LOC for listed species (0.1).
[4] All bolded and shaded chronic RQs exceed the Agency's chronic risk LOC (1).
[5] All bolded and shaded Terrestrial Invertebrate RQs exceed the Agency's interim LOC for listed terrestrial invertebrates (0.05). Small insect RQs for each "Use Category" are calculated as follows: [EEC for Broadleaf Plants, Small Insects]/[(48-hour of LD_{50} = 0.024 µg a.i./honey bee*(1 bee/0.128 g)]**.** Large insect RQs for each "Use Category" are calculated as follows: [EEC for Fruits, Pods, Seeds, Large Insects]/[(48-hour of LD_{50} = 0.024 µg a.i./honey bee*(1 bee/0.128 g)]**.**
[6] Assumed. Please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document for a description of the assumptions regarding input parameters and the reasoning behind them.
[7] The maximum label-recommended seasonal application rates of 0.65 (vs. modeled 0.8), 1.0 (vs. modeled 1.2), and 0.18 (vs. modeled 0.2) lb a.i./A for the use of permethrin on fruit trees (pear), onion (onion), and as a soil barrier treatment (urban and rural structures), respectively, are below the modeled seasonal rates.
[8] For a list of which crops were modeled for this "Crop Category", please refer to the "Aquatic Exposure Assessment" section (**Section 3.2**) of the document.
[9] This reduced exposure scenario represents what one registrant has claimed to be the maximum intended use scenario for the application of permethrin to pine seed orchards. However, the label could be interpreted to allow for the modeled maximum exposure scenario for pine seed orchards (4 applications of a maximum single application rate of 1.6 lb a.i./A with a 28-day interval).
[10] Permethrin as a mosquito adulticide is applied to an air column, not directly to foliage. Therefore, the maximum application rate allowed on the labels (0.007 lb a.i./A) was multiplied by the AGDISP estimated application efficiency (fraction of applied deposited in treated area; 0.449 and 0.020 for Pre- and Post-implementation of RED mitigation measures, respectively) in order to determine the application rate representative of the applied amount to foliage and other various wildlife food items.
[11] The labels pre-implementation of RED mitigation measures had no restrictions on the application interval or number of applications made per year for mosquito adulticide applications. For the sake of being protective, a one day application interval and a maximum of 52 applications were assumed.
[12] Dependence on this scenario for reaching conclusions regarding exposure and risk from mosquito adulticide applications should be done with caution because not all labels have been revised based on mitigation measures. Currently, there are still no specifications on some of the labels for the maximum number of applications or minimum application interval. The revised labels are to have a minimum of a 1-day interval and a maximum of 26 applications.
[13] The label actually allows up to six applications, but the maximum seasonal rate is set at 0.6 lb a.i.A. Therefore, only 3 applications can be made in a season if applying at the maximum single application rate of 0.2 lb a.i./A.

Table 5.7. Summary of the acute RQs (LD_{50} ft^{-2}) for mammals estimated using T-REX v1.3.1 and the LD_{50} ft^{-2} analysis for the maximum granular permethrin application scenarios. [1, 2]				
Use Category [3]	**Modeled Application Rate (lb ai/A)**	**EEC (mg/ft^2)**	**Adjusted LD_{50} Value (mg/kg-bw)[4]**	**RQ (LD_{50} ft^{-2}) [5]**
Nuts	**0.30**	3.12	334.69	**0.62**
Corn and Sod & Golf Turf[6]	**0.2**	2.08		**0.41**
Residential	**1.00**	10.41		**2.07**

[1] The LD_{50} ft^{-2} analysis was only performed for mammals because definitive LD_{50} values were not established for birds.
[2] Only single applications of granules are accounted for using this analysis performed by T-REX.
[3] Please refer to **Table 2.5** for details regarding which uses are covered under each "Use Category."
[4] Adjusted Mammalian $LD_{50} = LD_{50} (TW/AW)^{(0.25)}$
[5] RQ or LD_{50} ft^{-2} = EEC (mg a.i./ft^{-2}) / (Adj LD_{50} * 0.015 body weight (kg) of assessed mammal).
The LD_{50}/ft^2 is compared with the Agency's LOCs in an analogous way in which risk quotients are compared. All bolded and shaded LD_{50}/ft^2 values exceed the Agency's acute risk LOC for listed species (0.1).
[6] The two "Use Categories" for granular uses on "Corn" and on "Sod and Golf Turf" have been considered together for the $LD_{50}ft^{-2}$ analysis since they share the same use parameters (*i.e.*, rate, # of applications, and interval).

Table 5.8. RQs for terrestrial soil invertebrates and insectivorous birds and mammals estimated using a fugacity-based (equilibrium partitioning) approach for the maximum granular permethrin application scenarios. [1]								
Use Category [2]	**App Rate (lbs a.i./A), Interval (Days), # of Apps[3]**	**$C_{soil\ max}$ (mg/kg) [4]**	**$C_{earthworm}$ (mg/kg) [5]**	**Dose-adjusted $C_{earthworm}$ (mg/kg-BW)[6]**	**Dose-Based Chronic RQ for Mammals [7]**	**Dietary-Based Chronic RQ for Mammals[8]**	**Dietary-Based Chronic RQ for Birds[8]**	**RQ for Terrestrial Soil Invertebrates[9]**
Nuts	**0.3, 10, 3**	0.96	12.12	11.51	**1.89**	0.22	0.10	**64.64**
Corn and Sod & Golf Turf	**0.20, 3, 4**	0.88	11.14	10.58	**1.74**	0.20	0.09	**59.41**
Residential	**1.00, 7, 4**	4.25	53.69	51.01	**8.38**	0.97	0.43	**286.35**

[1] All bolded and shaded RQs exceed the Agency's chronic risk LOC (1) for birds and mammals, or the Agency's interim LOC for listed terrestrial invertebrates (0.05).
[2]Please refer to **Table 2.5** for details regarding which uses are covered under each "Use Category."
[3] The maximum number of applications per year, the minimum application intervals, and the maximum application rates for each use selected as the representative use for a "Use Category" were derived from the product labels and used to model EECs.
[4] $C_{soil\ max}$ = the maximum soil concentration (mg/kg) predicted by the model.
[5] $C_{earthworm}$= the earthworm concentration (mg/kg) predicted by the model.
[6] Dose-adjusted $C_{earthworm} = C_{earthworm}$ (ppm) * (%Body weight consumed/100), where % body weight consumed equals 95% for a 15 g mammal.
[7] Dose-based Chronic RQ = Dose-adjusted $C_{earthworm}$ / Adjusted NOAEL, where the Adjusted NOAEL = NOAEL $(TW/AW)^{0.25}$. Equivalent to 6.09 for a 15 g mammal.
[8] Dietary-based Chronic RQ = $C_{earthworm}$ / Avian or Mammalian NOAEC.
[9] RQs for terrestrial invertebrates exposed to granular permethrin are calculated as follows: [$C_{earthworm}$ (mg-kg-bw)]/[(48-hour contact LD_{50} = 0.024 µg a.i./honey bee*(1 bee/0.128 g)].

Table 5.9. Summary of the acute and chronic RQs for birds and mammals estimated using T-REX v1.3.1 and the seed treatment analysis for the maximum permethrin seed treatment scenarios. [1]							
				Mammals			Birds
Use Category	Available A.I. (mg a.i./ft^2)	Nagy Dose for Mammals (mg a.i./kg-bw/day)	Max. Seed App. Rate (mg a.i./kg/seed)	Acute RQ based on Available A.I. (mg a.i./ft^2)[2]	Acute RQ based on Nagy Dose[3]	Chronic RQ based on Max. Seed App. Rate[4]	Chronic RQ based on Max. Seed App. Rate[4]
All Seed Treatments	**0.059[5]**	**66.32**	**313**	<0.01[5]	**0.20[6]**	**5.65[6]**	**2.50[6]**

[1] All bolded and shaded RQs exceed the Agency's chronic risk LOC (1) for birds and mammals, or the Agency's acute risk LOC for listed species (0.1).
[2] Acute RQ based on available a.i. (mg a.i./ft^2) = EEC (mg a.i./ft^{-2}) / (Adj LD_{50} * 0.015 body weight (kg) of assessed mammal).
[3] Acute RQ based on Nagy Dose for 15 g mammal = EEC (mg ai/kg^{-1} day^{-1}) ÷ adjusted LD_{50}, where EEC (mg ai/kg^{-1} day^{-1}) = (daily food intake of a 15 g mammal (g/day) * 0.001 kg/g * maximum seed application rate (mg/kg-seed)) / body weight of animal (0.015 kg), and the Adjusted Mammalian LD_{50} for 15 g mammal= LD_{50} * $(350/15)^{(0.25)}$.
[4] Chronic RQ based on Maximum Seed Application Rate = Maximum Seed Application Rate (mg a.i. kg^{-1} seed) / Avian or mammalian NOAEC (mg/kg-diet).
[5] The reported available a.i. (mg a.i./ft^2) value is the highest value estimated for all seed treatment uses (corn). Therefore, the reported acute RQ based on available a.i. (mg a.i./ft^2) for corn represents the highest for all seed treatment uses and the actual RQ values based on available a.i. (mg a.i./ft^2) for all other seed treatments are less than the reported value.
[6] The reported RQ values represent those for all seed treatment uses. Since the acute RQs based on the Nagy dose and the chronic RQs are all dependent on the maximum seed application rate, which is the same for all seed treatments, RQs are the same for every seed treatment use for permethrin.

5.1.2.4 Terrestrial Plants

Generally, for indirect effects, potential effects on terrestrial vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. However, such toxicity data have not been identified for quantitatively estimating risk to terrestrial plants (as described in **Section 4.2.4**) as a result of permethrin use, and therefore, RQs cannot be calculated at this time for this taxonomic group. Discussion regarding lines of evidence for the potential for indirect effects to those listed species that rely on terrestrial plants during at least some portion of their life-cycle (*i.e.*, terrestrial-phase CRLF, CCR, SFGS, SMHM, and BCB) can be found in the "Risk Description" portion of the chapter (**Section 5.2**).

5.1.3 Primary Constituent Elements of Designated Critical Habitat

For permethrin use, the assessment endpoints for designated critical habitat PCEs involve the same endpoints as those being assessed relative to the potential for direct and indirect effects to the listed species assessed here. Therefore, the effects determinations for direct and indirect effects are used as the basis of the effects determination for potential modification to designated critical habitat.

5.2 Risk Description

The risk description synthesizes overall conclusions 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 assessed species and the potential for modification of their designated critical habitat.

If the RQs presented in the Risk Estimation (**Section 5.1**) show no direct or indirect effects for the assessed species, and no modification to PCEs of the designated critical habitat, a “no effect” determination is made, based on permethrin’s use within the action area. However, if LOCs for direct or indirect effect are exceeded or effects may modify the PCEs of the critical habitat, the Agency concludes a preliminary “may affect” determination for the FIFRA regulatory action regarding permethrin. Based on exceedances of LOCs, a potential to cause adverse effects (*i.e.*, to CRLF, CCR, SFGS, SMHM, and BCB) and habitat modification to designated critical habitat (*i.e.*, for the CRLF and BCB) has been identified and the Agency concludes a preliminary “may affect” determination for the CRLF, CCR, SFGS, SMHM, and BCB for the currently labeled uses of permethrin. A summary of the risk estimation results are provided in **Table 5.10** for direct and indirect effects to the listed species assessed here and in **Table 5.11** for the PCEs of their designated critical habitat.

Table 5.10. Risk estimation summary for permethrin - direct and indirect effects.

Taxa	LOC Exceedance (Y/N)	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Freshwater Fish and Aquatic-phase Amphibians	Non-listed Species (Y)	Acute RQs range from 0.06 to 6.96; exceed the Agency’s acute listed species LOC (0.05) and the Agency’s acute risk LOC (0.5) Chronic RQs range from 0.14 to 61.17; exceed the Agency’s chronic risk LOC (1)	Indirect Effects: Aquatic-phase CRLF, SFGS, and CCR
	Listed Species (Y)		Direct Effects: Aquatic-phase CRLF
Freshwater Invertebrates	Non-listed Species (Y)	Acute RQs range from 2.11 to 259.43; exceed the Agency’s acute risk LOC (0.5) Chronic RQs range from 6.66 to 3271.43; exceed the Agency’s chronic risk LOC (1)	Indirect Effects: Aquatic-phase CRLF, SFGS, and CCR
Estuarine/Marine Fish	Non-listed Species (Y)	Acute RQs range from 0.02 to 2.50; exceed the Agency’s acute risk LOC (0.5) Chronic RQs range from 0.05 to 21.97; exceed the Agency’s chronic risk LOC (1)	Indirect Effects: CCR
Estuarine/Marine Invertebrates	Non-listed Species (Y)	Acute RQs range from 2.48 to 305.56; exceed the Agency’s acute risk LOC (0.5) Chronic RQs range from 7.77 to 3816.67; exceed the Agency’s chronic risk LOC (1)	Indirect Effects: CCR

Table 5.10. Risk estimation summary for permethrin - direct and indirect effects.			
Taxa	**LOC Exceedance (Y/N)**	**Description of Results of Risk Estimation**	**Assessed Species Potentially Affected**
Vascular Aquatic Plants	Non-listed Species (N; however, effects cannot be quantified)	There are no vascular aquatic plant data available.	<u>Indirect Effects</u>: Aquatic-phase CRLF, CCR, SFGS, and SMHM
Non-Vascular Aquatic Plants	Non-listed Species (N)	There are no exceedances of the Agency's LOC for aquatic plants (1); all RQs for aquatic non-vascular plants are ≤0.08.	<u>Indirect Effects</u>: Aquatic-phase CRLF, CCR, SFGS, and SMHM
Birds, Reptiles, and Terrestrial-Phase Amphibians	Non-listed Species (Y)	Spray applications: dietary-based chronic RQs range from <0.01 to 19.78, from <0.01 to 9.07, from <0.01 to 11.13, and from <0.01 to 1.24, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's chronic risk LOC (1) for all dietary categories. Seed treatments: Chronic RQs= 2.50, exceed the Agency's chronic risk LOC (RQ≥1)	<u>Indirect Effects</u>: CCR, SFGS, terrestrial-phase CRLF, and SMHM
	Listed Species (Y)		<u>Direct Effects</u>: CCR, SFGS, and terrestrial-phase CRLF
Mammals	Non-listed Species (Y)	Spray applications: dose-based acute RQs range from <0.01 to 7.05, from <0.01 to 3.23, from <0.01 to 3.96, and from <0.01 to 0.44, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's acute listed species LOC (0.1) and the Agency's acute risk LOC (0.5) for all dietary categories. Dose-based chronic RQs range from 0.08 to 387.30, from 0.04 to 177.51, from 0.05 to 217.86, and from 0.01 to 24.21, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's chronic risk LOC (1) for all dietary categories. Dietary-based chronic RQs range from 0.01 to 44.64, from <0.01 to 20.46, from 0.01 to 25.11, and from <0.01 to 2.79, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's chronic risk LOC (1) for all dietary categories. Seed treatments: RQs for permethrin exceed the Agency's acute listed species LOC (0.1) and chronic risk LOC (1) for mammals; acute RQs Based on Nagy Dose= 0.20; Chronic RQs Based on Maximum Seed Application Rate =5.65. Granular applications: the $LD_{50}ft^{-2}$ and fugacity-based	<u>Indirect Effects</u>: CCR, SFGS, terrestrial-phase CRLF, and SMHM
	Listed Species (Y)		<u>Direct Effects</u>: SMHM

Table 5.10. Risk estimation summary for permethrin - direct and indirect effects.			
Taxa	**LOC Exceedance (Y/N)**	**Description of Results of Risk Estimation**	**Assessed Species Potentially Affected**
		approach result in exceedances of the Agency's acute listed species LOC (0.1), acute risk LOC (0.5) and chronic risk LOC (1); acute RQs range from 0.41 to 2.07; while chronic dose-based RQs range from 1.74 to 8.38.	
Terrestrial Invertebrates	Listed Species (Y)	Spray applications: RQs based on EECs for small insects and large insects range from 1.60 to 7418.67 and 0.16 to 826.67, respectively; exceed the Agency's interim LOC for listed terrestrial invertebrates (0.05). Granular applications: RQs range from 59.41 to 286.35; exceed the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05).	Direct: BCB Indirect Effects: CCR, SFGS, CRLF, and SMHM
Terrestrial Plants – Monocots	Non-listed Species (N; however, effects cannot be quantified)	There are no terrestrial plant data available.	Indirect Effects: CCR, SFGS, CRLF, SMH, and BCB
Terrestrial Plants - Dicots	Non-listed Species (N; however, effects cannot be quantified)	There are no terrestrial plant data available.	Indirect Effects: CCR, SFGS, CRLF, and SMHM
	Listed Species (N; however, effects cannot be quantified)		Indirect Effects: BCB

Table 5.11. Risk estimation summary for permethrin - effects to designated critical habitat. (PCEs).			
Taxa	**LOC Exceedance (Y/N)**	**Description of Results of Risk Estimation**	**Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action**
Freshwater Fish and Aquatic-phase Amphibians	Non-listed Species (Y)	Acute RQs range from 0.06 to 6.96; exceed the Agency's acute listed species LOC (0.05) and the Agency's acute risk LOC (0.5) Chronic RQs range from 0.14 to 61.17; exceed the	CRLF
	Listed Species		

Table 5.11. Risk estimation summary for permethrin - effects to designated critical habitat. (PCEs).			
Taxa	**LOC Exceedance (Y/N)**	**Description of Results of Risk Estimation**	**Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action**
	(Y)	Agency's chronic risk LOC (1)	
Freshwater Invertebrates	Non-listed Species (Y)	Acute RQs range from 2.11 to 259.43; exceed the Agency's acute risk LOC (0.5) Chronic RQs range from 6.66 to 3271.43; exceed the Agency's chronic risk LOC (1)	CRLF
Vascular Aquatic Plants	Non-listed Species (N; however, effects cannot be quantified)	There are no vascular aquatic plant data available.	CRLF
Non-Vascular Aquatic Plants	Non-listed Species (N)	There are no exceedances of the Agency's LOC for aquatic plants (1); all RQs for aquatic non-vascular plants are ≤0.08.	CRLF
Birds, Reptiles, and Terrestrial-Phase Amphibians	Non-listed Species (Y) Listed Species (Y)	Spray applications: dietary-based chronic RQs range from <0.01 to 19.78, from <0.01 to 9.07, from <0.01 to 11.13, and from <0.01 to 1.24, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's chronic risk LOC (1) for all dietary categories. Seed treatments: Chronic RQs= 2.50, exceed the Agency's chronic risk LOC (RQ≥1)	CRLF

Table 5.11. Risk estimation summary for permethrin - effects to designated critical habitat. (PCEs).			
Taxa	**LOC Exceedance (Y/N)**	**Description of Results of Risk Estimation**	**Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action**
Mammals	Non-listed Species (Y)	Spray applications: dose-based acute RQs range from <0.01 to 7.05, from <0.01 to 3.23, from <0.01 to 3.96, and from <0.01 to 0.44, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's acute listed species LOC (0.1) and the Agency's acute risk LOC (0.5) for all dietary categories. Dose-based chronic RQs range from 0.08 to 387.30, from 0.04 to 177.51, from 0.05 to 217.86, and from 0.01 to 24.21, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's chronic risk LOC (1) for all dietary categories. Dietary-based chronic RQs range from 0.01 to 44.64, from <0.01 to 20.46, from 0.01 to 25.11, and from <0.01 to 2.79, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively; exceed the Agency's chronic risk LOC (1) for all dietary categories. Seed treatments: RQs for permethrin exceed the Agency's acute listed species LOC (0.1) and chronic risk LOC (1) for mammals; acute RQs Based on Nagy Dose= 0.20; Chronic RQs Based on Maximum Seed Application Rate =5.65. Granular applications: the $LD_{50}ft^{-2}$ and fugacity-based approach result in exceedances of the Agency's acute listed species LOC (0.1), acute risk LOC (0.5) and chronic risk LOC (1); acute RQs range from 0.41 to 2.07; while chronic dose-based RQs range from 1.74 to 8.38.	CRLF
Terrestrial Invertebrates	Listed Species (Y)	Spray applications: RQs based on EECs for small insects and large insects range from 1.60 to 7418.67 and 0.16 to 826.67, respectively; exceed the Agency's interim LOC for listed terrestrial invertebrates (0.05). Granular applications: RQs range from 59.41 to 286.35; exceed the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05).	CRLF
Terrestrial Plants – Monocots	Non-listed Species (N; however, effects cannot be quantified)	There are no terrestrial plant data available.	Indirect Effects: CRLF and BCB

Table 5.11. Risk estimation summary for permethrin - effects to designated critical habitat. (PCEs).			
Taxa	**LOC Exceedance (Y/N)**	**Description of Results of Risk Estimation**	**Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action**
Terrestrial Plants - Dicots	Non-listed Species (N; however, effects cannot be quantified)	There are no terrestrial plant data available.	Indirect Effects: CRLF
	Listed Species (N; however, effects cannot be quantified)		Indirect Effects: BCB

Following a "may affect" determination, additional information is considered to refine the potential for exposure at the predicted levels based on the life history characteristics (*i.e.*, habitat range, feeding preferences, *etc*.) of the assessed species. 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 assessed species and its designated critical habitat.

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the assessed species or modify 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 effects determination for each of the established assessment endpoints for the assessed species and their designated critical habitat is provided in **Sections 5.2.1** through **5.2.5**. The effects determination section for each listed species assessed will follow a similar pattern. Each will start with a discussion of the potential for direct effects, followed by a discussion of the potential for indirect effects. For those listed species that have designated critical habitat, the section will end with a discussion on the potential for modification to the critical habitat from the use of permethrin.

Table 5.12. Summary of the chance of individual acute effects to aquatic animals based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships. [1,2]

USE CATEGORY	USES	Acute FW Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute FW Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI
N/A	**N/A**	LOC = 0.05	1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})	LOC = 0.05	1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})	LOC = 0.05	1 in 2.94×10^{5} (1 in 44, 1 in 1.86×10^{18})	LOC = 0.05	1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})
Alfalfa	**Alfalfa hay and seed crops**	**0.55**	**1 in 8.24 (1 in 3.31, 1 in 103)**	**0.20**	**1 in 1.21×10^{3} (1 in 12.3, 1 in 6.33×10^{9})**	**20.61**	**1 in 1 (1 in 1, 1 in 1)**	**24.28**	**1 in 1 (1 in 1, 1 in 1)**
Nut Trees	**Pistachio**	**0.80**	**1 in 3.02 (1 in 2.36, 1 in 5.22)**	**0.29**	**1 in 129 (1 in 7.09, 1 in 1.53×10^{6})**	**29.67**	**1 in 1 (1 in 1, 1 in 1)**	**34.94**	**1 in 1 (1 in 1, 1 in 1)**
Avocado	**Avocado**	**0.84**	**1 in 2.73 (1 in 2.27, 1 in 4.04)**	**0.30**	**1 in 107 (1 in 6.76, 1 in 7.91×10^{5})**	**31.13**	**1 in 1 (1 in 1, 1 in 1)**	**36.67**	**1 in 1 (1 in 1, 1 in 1)**
Cole crop	**Broccoli**	**1.15**	**1 in 1.65 (1 in 1.82, 1 in 1.41)**	**0.41**	**1 in 24.6 (1 in 4.56, 1 in 4.06×10^{3})**	**42.83**	**1 in 1 (1 in 1, 1 in 1)**	**50.44**	**1 in 1 (1 in 1, 1 in 1)**
Corn	**Corn (pop)**	**0.59**	**1 in 6.61 (1 in 3.09, 1 in 51.1)**	**0.21**	**1 in 874 (1 in 11.4, 1 in 1.89×10^{9})**	**21.93**	**1 in 1 (1 in 1, 1 in 1)**	**25.83**	**1 in 1 (1 in 1, 1 in 1)**
Corn	**Corn (sweet)**	**0.74**	**1 in 3.60 (1 in 2.52, 1 in 8.36)**	**0.26**	**1 in 236 (1 in 8.27, 1 in 1.43×10^{7})**	**27.45**	**1 in 1 (1 in 1, 1 in 1)**	**32.33**	**1 in 1 (1 in 1, 1 in 1)**
Forestry	**Softwood (conifer), hybrid cottonwood/ poplar**	**6.00**	**1 in 1 (1 in 1.06, 1 in 1)**	**2.15**	**1 in 1.07 (1 in 1.34, 1 in 1)**	**223.58**	**1 in 1 (1 in 1, 1 in 1)**	**263.33**	**1 in 1 (1 in 1, 1 in 1)**
Fruit tree	**Pear**	**0.64**	**1 in 5.22 (1 in 2.86, 1 in 24.7)**	**0.23**	**1 in 491 (1 in 9.91, 1 in 2.17×10^{8})**	**23.77**	**1 in 1 (1 in 1, 1 in 1)**	**28.00**	**1 in 1 (1 in 1, 1 in 1)**
Fruit tree	**Peach**	**0.96**	**1 in 2.14 (1 in 2.06, 1 in 2.29)**	**0.35**	**1 in 49.8 (1 in 5.53, 1 in 4.91×10^{4})**	**35.80**	**1 in 1 (1 in 1, 1 in 1)**	**42.17**	**1 in 1 (1 in 1, 1 in 1)**
Garlic	**Garlic**	**0.61**	**1 in 5.99 (1 in 3.0, 1 in 37.5)**	**0.22**	**1 in 648 (1 in 10.6, 1 in 6.14×10^{8})**	**22.59**	**1 in 1 (1 in 1, 1 in 1)**	**26.61**	**1 in 1 (1 in 1, 1 in 1)**
Leafy vegetables	**Major leafy vegetables**	**1.97**	**1 in 1.10 (1 in 1.38, 1 in 1)**	**0.71**	**1 in 3.97 (1 in 2.61, 1 in 11.1)**	**73.58**	**1 in 1 (1 in 1, 1 in 1)**	**86.67**	**1 in 1 (1 in 1, 1 in 1)**

Table 5.12. Summary of the chance of individual acute effects to aquatic animals based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships. [1,2]

USE CATEGORY	USES	Acute FW Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute FW Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI
Leafy vegetables	Minor leafy vegetables	4.48	1 in 1 (1 in 1.11, 1 in 1)	1.61	1 in 1.21 (1 in 1.51, 1 in 1.03)	166.98	1 in 1 (1 in 1, 1 in 1)	196.67	1 in 1 (1 in 1, 1 in 1)
Cucurbit vegetables	Major cucurbit vegetables	0.56	1 in 7.78 (1 in 3.25, 1 in 85.4)	0.20	1 in 1.21×10^3 (1 in 12.3, 1 in 6.33×10^9)	20.80	1 in 1 (1 in 1, 1 in 1)	24.50	1 in 1 (1 in 1, 1 in 1)
Cucurbit vegetables	Minor cucurbit vegetables[8]	0.71	1 in 3.97 (1 in 2.61, 1 in 11.1)	0.25	1 in 297 (1 in 8.75, 1 in 3.33×10^7)	26.27	1 in 1 (1 in 1, 1 in 1)	30.94	1 in 1 (1 in 1, 1 in 1)
Nursery	X-mass trees, Nursery stock and Pine seed orchard[9]	6.96	1 in 1 (1 in 1.05, 1 in 1)	2.50	1 in 1.04 (1 in 1.27, 1 in 1)	259.43	1 in 1 (1 in 1, 1 in 1)	305.56	1 in 1 (1 in 1, 1 in 1)
Nursery	Pine seed orchard (current label low rate)	6.96	1 in 1 (1 in 1.05, 1 in 1)	2.50	1 in 1.04 (1 in 1.27, 1 in 1)	259.43	1 in 1 (1 in 1, 1 in 1)	305.56	1 in 1 (1 in 1, 1 in 1)
Nursery	Pine seed orchard (current label high rate)	6.96	1 in 1 (1 in 1.05, 1 in 1)	2.50	1 in 1.04 (1 in 1.27, 1 in 1)	259.43	1 in 1 (1 in 1, 1 in 1)	305.56	1 in 1 (1 in 1, 1 in 1)
Onion	Onion	0.21	1 in 874 (1 in 11.4, 1 in 1.89×10^9)	0.07	1 in 9.88×10^6 (1 in 95.7, 1 in 7.58×10^{24})	7.64	1 in 1 (1 in 1.04, 1 in 1)	9.00	1 in 1 (1 in 1.03, 1 in 1)
Onion	Fennel	0.67	1 in 4.61 (1 in 2.75, 1 in 17)	0.24	1 in 378 (1 in 9.3, 1 in 8.22×10^7)	24.86	1 in 1 (1 in 1, 1 in 1)	29.28	1 in 1 (1 in 1, 1 in 1)
Potato	Potato	0.52	1 in 9.94 (1 in 3.51, 1 in 189)	0.19	1 in 1.71×10^3 (1 in 13.4, 1 in 2.35×10^{10})	19.53	1 in 1 (1 in 1, 1 in 1)	23.00	1 in 1 (1 in 1, 1 in 1)

Table 5.12. Summary of the chance of individual acute effects to aquatic animals based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships. [1,2]									
USE CATEGORY	USES	Acute FW Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute FW Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI
Row Crops	Celery, artichoke, asparagus, pepper	0.82	1 in 2.86 (1 in 2.32, 1 in 4.57)	0.29	1 in 129 (1 in 7.09, 1 in 1.53×10^{6})	30.57	1 in 1 (1 in 1, 1 in 1)	36.00	1 in 1 (1 in 1, 1 in 1)
Row Crops	Rhubarb, field grown roses	1.38	1 in 1.36 (1 in 1.64, 1 in 1.12)	0.50	1 in 11.4 (1 in 3.66, 1 in 297)	51.42	1 in 1 (1 in 1, 1 in 1)	60.56	1 in 1 (1 in 1, 1 in 1)
Tomato	Tomato	0.52	1 in 9.94 (1 in 3.51, 1 in 189)	0.19	1 in 1.71×10^{3} (1 in 13.4, 1 in 2.35×10^{10})	19.53	1 in 1 (1 in 1, 1 in 1)	23.00	1 in 1 (1 in 1, 1 in 1)
Tomato	Tomatillo	0.57	1 in 7.35 (1 in 3.20, 1 in 71.4)	0.20	1 in 1.21×10^{3} (1 in 12.3, 1 in 6.33×10^{9})	21.08	1 in 1 (1 in 1, 1 in 1)	24.83	1 in 1 (1 in 1, 1 in 1)
Turf	Golf course, recreational areas	0.72	1 in 3.84 (1 in 2.58, 1 in 10)	0.26	1 in 236 (1 in 8.27, 1 in 1.43×10^{7})	26.93	1 in 1 (1 in 1, 1 in 1)	31.72	1 in 1 (1 in 1, 1 in 1)
Ant mound treatment	Agricultural fruit trees	0.68	1 in 4.43 (1 in 2.71, 1 in 15.2)	0.25	1 in 297 (1 in 8.75, 1 in 3.33×10^{7})	25.42	1 in 1 (1 in 1, 1 in 1)	29.94	1 in 1 (1 in 1, 1 in 1)
Mosquito control – Pre-CFR 2005-1	Northern Recreational areas	0.63	1 in 5.46 (1 in 2.91, 1 in 28.2)	0.23	1 in 491 (1 in 9.91, 1 in 2.17×10^{8})	23.40	1 in 1 (1 in 1, 1 in 1)	27.56	1 in 1 (1 in 1, 1 in 1)
Mosquito control – Post-CFR 2005-1	Northern Recreational areas	0.28	1 in 156 (1 in 7.44, 1 in 3.07×10^{6})	0.10	1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})	10.42	1 in 1 (1 in 1.02, 1 in 1)	12.28	1 in 1 (1 in 1.01, 1 in 1)
Mosquito control – Pre-CFR 2005-1	Northern Agricultural Areas (metfile W93193.dvf)	0.57	1 in 7.35 (1 in 3.20, 1 in 71.4)	0.21	1 in 874 (1 in 11.4, 1 in 1.89×10^{9})	21.32	1 in 1 (1 in 1, 1 in 1)	25.11	1 in 1 (1 in 1, 1 in 1)

Table 5.12. Summary of the chance of individual acute effects to aquatic animals based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships. [1,2]

USE CATEGORY	USES	Acute FW Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute FW Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI
Mosquito control – Post-CFR 2005-1	Northern Agricultural Areas (metfile W93193.dvf)	0.25	1 in 297 (1 in 8.75, 1 in $3.33x10^7$)	0.09	1 in $7.91x10^5$ (1 in 54.8, 1 in $4.1x10^{20}$)	9.43	1 in 1 (1 in 1.03, 1 in 1)	11.11	1 in 1 (1 in 1.02, 1 in 1)
Mosquito control – Pre-CFR 2005-1	Central Agricultural Areas (metfile W23232.dvf)	0.60	1 in 6.29 (1 in 3.04, 1 in 43.6)	0.21	1 in 874 (1 in 11.4, 1 in $1.89x10^9$)	22.26	1 in 1 (1 in 1, 1 in 1)	26.22	1 in 1 (1 in 1, 1 in 1)
Mosquito control – Post-CFR 2005-1	Central Agricultural Areas (metfile W23232.dvf)	0.26	1 in 236 (1 in 8.27, 1 in $1.43x10^7$)	0.09	1 in $7.91x10^5$ (1 in 54.8, 1 in $4.1x10^{20}$)	9.81	1 in 1 (1 in 1.02, 1 in 1)	11.56	1 in 1 (1 in 1.02, 1 in 1)
Ant mound Treatment	Non-agricultural areas, turf, recreational areas	0.76	1 in 3.38 (1 in 2.46, 1 in 7.06)	0.27	1 in 190 (1 in 7.83, 1 in $6.47x10^6$)	28.21	1 in 1 (1 in 1, 1 in 1)	33.22	1 in 1 (1 in 1, 1 in 1)
Soil Barrier Treatment	Fencerows and Hedgerows	0.06	1 in $5.22x10^7$ (1 in 138, 1 in $5.04x10^{27}$)	0.02		2.11	1 in 1.08 (1 in 1.35, 1 in 1)	2.48	1 in 1.05 (1 in 1.27, 1 in 1)
Soil Barrier Treatment	Range Land	0.57	1 in 7.35 (1 in 3.20, 1 in 71.4)	0.20	1 in $1.21x10^3$ (1 in 12.3, 1 in $6.33x10^9$)	21.13	1 in 1 (1 in 1, 1 in 1)	24.89	1 in 1 (1 in 1, 1 in 1)
Residential Turf and Ornamentals	Home & Garden	6.96	1 in 1 (1 in 1.05, 1 in 1)	2.50	1 in 1.04 (1 in 1.27, 1 in 1)	259.43	1 in 1 (1 in 1, 1 in 1)	305.56	1 in 1 (1 in 1, 1 in 1)

Table 5.12. Summary of the chance of individual acute effects to aquatic animals based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships. [1,2]										
USE CATEGORY	USES	Acute FW Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Fish RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute FW Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI	Acute E/M Invert. RQ	Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI
Perimeter Treatment	**Urban & Rural Structures**	**2.30**	**1 in 1.05 (1 in 1.31, 1 in 1)**	**0.82**	**1 in 2.86 (1 in 2.32, 1 in 4.57)**	**85.57**	**1 in 1 (1 in 1, 1 in 1)**	**100.78**	**1 in 1 (1 in 1, 1 in 1)**
Termite Treatment	**Urban & Rural Structures**	**0.57**	**1 in 7.35 (1 in 3.20, 1 in 71.4)**	**0.21**	**1 in 874 (1 in 11.4, 1 in $1.89x10^9$)**	**21.42**	**1 in 1 (1 in 1, 1 in 1)**	**25.22**	**1 in 1 (1 in 1, 1 in 1)**
Garden Vegetables	**Home & Garden**	**0.42**	**1 in 22.2 (1 in 4.43, 1 in $2.87x10^3$)**	**0.15**	**1 in $9.56x10^3$ (1 in 20.1, 1 in $1.65x10^{13}$)**	**15.52**	**1 in 1 (1 in 1.01, 1 in 1)**	**18.28**	**1 in 1 (1 in 1.01, 1 in 1)**
Garden Nuts and Fruits	**Home & Garden**	**0.64**	**1 in 5.22 (1 in 2.86, 1 in 24.7)**	**0.23**	**1 in 491 (1 in 9.91, 1 in $2.17x10^8$)**	**23.87**	**1 in 1 (1 in 1, 1 in 1)**	**28.11**	**1 in 1 (1 in 1, 1 in 1)**
Garden Nuts and Fruits	**Home & Garden**	**0.64**	**1 in 5.22 (1 in 2.86, 1 in 24.7)**	**0.23**	**1 in 491 (1 in 9.91, 1 in $2.17x10^8$)**	**23.87**	**1 in 1 (1 in 1, 1 in 1)**	**28.11**	**1 in 1 (1 in 1, 1 in 1)**
Barrier Treatment	**Urban & Rural Structures**	**0.25**	**1 in 297 (1 in 8.75, 1 in $3.33x10^7$)**	**0.09**	**1 in $7.91x10^5$ (1 in 54.8, 1 in $4.1x10^{20}$)**	**9.20**	**1 in 1 (1 in 1.03, 1 in 1)**	**10.83**	**1 in 1 (1 in 1.02, 1 in 1)**
Home Garden Fire Ant Treatment	**Home & Garden**	**1.94**	**1 in 1.11 (1 in 1.39, 1 in 1)**	**0.70**	**1 in 4.12 (1 in 2.64, 1 in 12.2)**	**72.36**	**1 in 1 (1 in 1, 1 in 1)**	**85.22**	**1 in 1 (1 in 1, 1 in 1)**
Turf (Granular formulation)	**Home & Garden**	**0.64**	**1 in 5.22 (1 in 2.86, 1 in 24.7)**	**0.23**	**1 in 491 (1 in 9.91, 1 in $2.17x10^8$)**	**23.82**	**1 in 1 (1 in 1, 1 in 1)**	**28.06**	**1 in 1 (1 in 1, 1 in 1)**
Garden Vegetables(Granular formulation)	**Home & Garden**	**0.52**	**1 in 9.94 (1 in 3.51, 1 in 189)**	**0.19**	**1 in $1.71x10^3$ (1 in 13.4, 1 in $2.35x10^{10}$)**	**19.48**	**1 in 1 (1 in 1, 1 in 1)**	**22.94**	**1 in 1 (1 in 1, 1 in 1)**
Down-the Drain	**Household "down-the-drain" applications**	**0.90**	**1 in 2.39 (1 in 2.16, 1 in 2.94)**	N/A		**33.49**	**1 in 1 (1 in 1, 1 in 1)**	N/A	

Table 5.12. Summary of the chance of individual acute effects to aquatic animals based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships. [1,2]									
USE CATEGORY	**USES**	**Acute FW Fish RQ**	**Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI**	**Acute E/M Fish RQ**	**Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI**	**Acute FW Invert. RQ**	**Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI**	**Acute E/M Invert. RQ**	**Chance of Individual Effect at RQ or LOC Based on Probit Slope & Slope's 95% CI**
Down-the Drain	**Household "down-the-drain" applications**	**0.47**	**1 in 14.3 (1 in 3.91, 1 in 1 632)**	N/A		**17.45**	**1 in 1 (1 in 1.01, 1 in 1)**	N/A	
Down-the Drain	**Household "down-the-drain" applications**	**0.11**	**1 in $1.25x10^5$ (1 in 36.2, 1 in $3.19x10^{17}$)**	N/A		**4.25**	**1 in 1 (1 in 1.12, 1 in 1)**	N/A	

[1] Bolded RQs and shaded RQs exceed the Agency's acute listed species LOC (0.05 for aquatic animals). When acute RQs exceeded the Agency's listed species LOC, the chance of individual effects was calculated at the RQ and the LOC, whereas if there was no exceedance, than the chance of individual effects was calculated only at the LOC.

[2] Although an LC_{50} or an EC_{50} has been established for all aquatic taxonomic groups, information is unavailable to estimate probit slopes from the studies from which the endpoints were derived. Therefore, a default slope of 4.5 with an assumed 95% confidence interval of 2 and 9 has been assumed as per original Agency assumptions of typical slope cited in Urban and Cook (1986).

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	**Dietary Category**	**Mammals[2]**		**Terrestrial Invertebrates[3]**			
		Acute Dose-Based RQ[4]	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Small Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Large Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**
N/A	**N/A**	LOC = 0.1	1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})	LOC = 0.05	1 in 1.31×10^{4} (1 in 516, 1 in 7.1×10^{5})	LOC = 0.05	1 in 1.31×10^{4} (1 in 516, 1 in 7.1×10^{5})
Alfalfa (Alfalfa)	**Short Grass**	**0.18**	**1 in 2.49×10^{3} (1 in 14.7, 1 in 9.76×10^{10})**				
	Tall Grass	0.08					
	Broadleaf plants, Small Insects	**0.10**	**1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})**	**194.13**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	0.01				**21.33**	**1 in 1 (1 in 1, 1 in 1)**
Nut Trees (Pistachio)	**Short Grass**	**0.42**	**1 in 22.2 (1 in 4.43, 1 in 2.87×10^{3})**				
	Tall Grass	**0.19**	**1 in 1.71×10^{3} (1 in 13.4, 1 in 2.35×10^{10})**				
	Broadleaf plants, Small Insects	**0.24**	**1 in 378 (1 in 9.3, 1 in 8.22×10^{7})**	**441.60**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	0.03				**49.07**	**1 in 1 (1 in 1, 1 in 1)**
Avocado (Avocado)	**Short Grass**	**0.36**	**1 in 43.6 (1 in 5.34, 1 in3.07×10^{4})**				
	Tall Grass	**0.17**	**1 in 3.74×10^{3} (1 in 16.2, 1 in 4.62×10^{11})**				
	Broadleaf plants, Small Insects	**0.20**	**1 in 1.21×10^{3} (1 in 12.3, 1 in 6.33×10^{9})**	**381.87**	**1 in 1 (1 in 1, 1 in 1)**		

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
	Fruits, Pods, Seeds, Lg Insects	0.02				42.67	1 in 1 (1 in 1, 1 in 1)
Cole Crops (Broccoli)	Short Grass	0.40	1 in 27.3 (1 in 4.69, 1 in 5.85x10^{3})				
	Tall Grass	0.18	1 in 2.49x10^{3} (1 in 14.7, 1 in 9.76x10^{10})				
	Broadleaf plants, Small Insects	0.23	1 in 491 (1 in 9.91, 1 in 2.17x10^{8})	424.00	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				46.93	1 in 1 (1 in 1, 1 in 1)
Corn (Pop corn)	Short Grass	0.33	1 in 66.1 (1 in 5.96, 1 in 1.36x10^{5})				
	Tall Grass	0.15	1 in 9.56x10^{3} (1 in 20.1, 1 in 1.65x10^{13})				
	Broadleaf plants, Small Insects	0.19	1 in 1.71x10^{3} (1 in 13.4, 1 in 2.35x10^{10})	350.93	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.02				38.93	1 in 1 (1 in 1, 1 in 1)
Corn (Sweet corn)	Short Grass	0.45	1 in 16.9 (1 in 4.10, 1 in 1.11x10^{3})				
	Tall Grass	0.21	1 in 874 (1 in 11.4, 1 in 1.89x10^{9})				
	Broadleaf plants, Small Insects	0.25	1 in 297	475.73	1 in 1		

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
			(1 in 8.75, 1 in 3.33x10[7])		(1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				52.80	1 in 1 (1 in 1, 1 in 1)
Forestry (Cottonwood)	Short Grass	0.61	1 in 5.99 (1 in 3.0, 1 in 37.5)				
	Tall Grass	0.28	1 in 156 (1 in 7.44, 1 in 3.07x10[6])				
	Broadleaf plants, Small Insects	0.34	1 in 57.1 (1 in 5.73, 1 in 8.07x10[4])	639.47	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.04				70.93	1 in 1 (1 in 1, 1 in 1)
Fruit Trees (Pear)	Short Grass	0.45	1 in 16.9 (1 in 4.10, 1 in 1.11x10[3])				
	Tall Grass	0.21	1 in 874 (1 in 11.4, 1 in 1.89x10[9])				
	Broadleaf plants, Small Insects	0.25	1 in 297 (1 in 8.75, 1 in 3.33x10[7])	471.47	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				52.27	1 in 1 (1 in 1, 1 in 1)
Fruit Trees (Peach)	Short Grass	0.35	1 in 49.8 (1 in 5.53, 1 in 4.91x10[4])				
	Tall Grass	0.16	1 in 5.85x10[3] (1 in 17.9, 1 in2.53x10[12])				

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]

Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
	Broadleaf plants, Small Insects	0.20	1 in 1.21x10^{3} (1 in 12.3, 1 in 6.33x10^{9})	368.00	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.02				41.07	1 in 1 (1 in 1, 1 in 1)
Garlic & Potatoes (Garlic & Potatoes)	Short Grass	0.31	1 in 90.6 (1 in 6.47, 1 in 4.26x10^{5})				
	Tall Grass	0.14	1 in 1.64x10^{4} (1 in 22.8, 1 in1.31x10^{14})				
	Broadleaf plants, Small Insects	0.18	1 in 2.49x10^{3} (1 in 14.7, 1 in 9.76x10^{10})	331.73	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.02				36.80	1 in 1 (1 in 1, 1 in 1)
Major Leafy Vegetables (Lettuce)	Short Grass	0.36	1 in 43.6 (1 in 5.34, 1 in3.07x10^{4})				
	Tall Grass	0.17	1 in 3.74x10^{3} (1 in 16.2, 1 in 4.62x10^{11})				
	Broadleaf plants, Small Insects	0.20	1 in 1.21x10^{3} (1 in 12.3, 1 in 6.33x10^{9})	381.87	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.02				42.67	1 in 1 (1 in 1, 1 in 1)
Minor Leafy Vegetables	Short Grass	0.80	1 in 3.02 (1 in 2.36, 1 in 5.22)				
	Tall Grass	0.37	1 in 38.5				

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	**Dietary Category**	**Mammals[2]**		**Terrestrial Invertebrates[3]**			
		Acute Dose-Based RQ[4]	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Small Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Large Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**
			(1 in 5.16, 1 in 1.96×10^4)				
	Broadleaf plants, Small Insects	0.45	1 in 16.9 (1 in 4.10, 1 in 1.11×10^3)	844.80	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.05				93.87	1 in 1 (1 in 1, 1 in 1)
Major Cucurbits (Cucumber)	Short Grass	0.43	1 in 20.2 (1 in 4.31, 1 in 2.06×10^3)				
	Tall Grass	0.20	1 in 1.21×10^3 (1 in 12.3, 1 in 6.33×10^9)				
	Broadleaf plants, Small Insects	0.24	1 in 378 (1 in 9.3, 1 in 8.22×10^7)	452.27	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				50.13	1 in 1 (1 in 1, 1 in 1)
Minor Cucurbits (Melons)	Short Grass	0.56	1 in 7.78 (1 in 3.25, 1 in 85.4)				
	Tall Grass	0.26	1 in 236 (1 in 8.27, 1 in 1.43×10^7)				
	Broadleaf plants, Small Insects	0.31	1 in 90.6 (1 in 6.47, 1 in 4.26×10^5)	587.73	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				65.60	1 in 1 (1 in 1, 1 in 1)
Nursery (Pine Seed Orchard- Reduced)	Short Grass	0.38	1 in 34.1 (1 in 4.99, 1 in 1.29×10^4)				

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	**Dietary Category**	**Mammals[2]**		**Terrestrial Invertebrates[3]**			
		Acute Dose-Based RQ[4]	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Small Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Large Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**
	Tall Grass	**0.17**	**1 in 3.74×10^{3} (1 in 16.2, 1 in 4.62×10^{11})**				
	Broadleaf plants, Small Insects	**0.21**	**1 in 874 (1 in 11.4, 1 in 1.89×10^{9})**	**401.60**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	0.02				**44.80**	**1 in 1 (1 in 1, 1 in 1)**
Nursery (Pine Seed Orchard- Maximum)	**Short Grass**	**1.53**	**1 in 1.25 (1 in 1.55, 1 in 1.05)**				
	Tall Grass	**0.70**	**1 in 4.12 (1 in 2.64, 1 in 12.2)**				
	Broadleaf plants, Small Insects	**0.86**	**1 in 2.60 (1 in 2.23, 1 in 3.60)**	**1606.93**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	**0.10**	**1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})**			**178.67**	**1 in 1 (1 in 1, 1 in 1)**
Onions (Onion)	**Short Grass**	**0.54**	**1 in 8.75 (1 in 3.38, 1 in 125)**				
	Tall Grass	**0.25**	**1 in 297 (1 in 8.75, 1 in 3.33×10^{7})**				
	Broadleaf plants, Small Insects	**0.31**	**1 in 90.6 (1 in 6.47, 1 in 4.26×10^{5})**	**572.80**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	0.03				**63.47**	**1 in 1 (1 in 1, 1 in 1)**
Onions (Fennel)	**Short Grass**	**0.80**	**1 in 3.02**				

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]

Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
			(1 in 2.36, 1 in 5.22)				
	Tall Grass	0.37	1 in 38.5 (1 in 5.16, 1 in 1.96×10^{4})				
	Broadleaf plants, Small Insects	0.45	1 in 16.9 (1 in 4.10, 1 in 1.11×10^{3})	844.80	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.05				93.87	1 in 1 (1 in 1, 1 in 1)
Row Crops (Celery)	Short Grass	0.40	1 in 27.3 (1 in 4.69, 1 in 5.85×10^{3})				
	Tall Grass	0.18	1 in 2.49×10^{3} (1 in 14.7, 1 in 9.76×10^{10})				
	Broadleaf plants, Small Insects	0.23	1 in 491 (1 in 9.91, 1 in 2.17×10^{8})	422.40	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				46.93	1 in 1 (1 in 1, 1 in 1)
Row Crops (Rhubarb)	Short Grass	0.61	1 in 5.99 (1 in 3.0, 1 in 37.5)				
	Tall Grass	0.28	1 in 156 (1 in 7.44, 1 in 3.07×10^{6})				
	Broadleaf plants, Small Insects	0.34	1 in 57.1 (1 in 5.73, 1 in 8.07×10^{4})	639.47	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.04				70.93	1 in 1 (1 in 1, 1 in 1)

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]								
Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
Tomato (Tomato)	Short Grass	0.31	1 in 90.6 (1 in 6.47, 1 in 4.26×10^5)				
	Tall Grass	0.14	1 in 1.64×10^4 (1 in 22.8, 1 in1.31×10^{14})				
	Broadleaf plants, Small Insects	0.17	1 in 3.74×10^3 (1 in 16.2, 1 in 4.62×10^{11})	325.87	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.02				36.27	1 in 1 (1 in 1, 1 in 1)
Tomato (Tomatillos)	Short Grass	0.43	1 in 20.2 (1 in 4.31, 1 in 2.06 $\times 10^3$)				
	Tall Grass	0.20	1 in 1.21×10^3 (1 in 12.3, 1 in 6.33×10^9)				
	Broadleaf plants, Small Insects	0.24	1 in 378 (1 in 9.3, 1 in 8.22×10^7)	452.27	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				50.13	1 in 1 (1 in 1, 1 in 1)
Turf (Golf course and Recreational Areas)	Short Grass	1.87	1 in 1.12 (1 in 1.42, 1 in 1.01)				
	Tall Grass	0.86	1 in 2.60 (1 in 2.23, 1 in 3.60)				
	Broadleaf plants, Small Insects	1.05	1 in 1.86 (1 in 1.93, 1 in 1.74)	1968.00	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.12	1 in 5.85×10^4			218.67	1 in 1

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	**Dietary Category**	**Mammals[2]**		**Terrestrial Invertebrates[3]**			
		Acute Dose-Based RQ[4]	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Small Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Large Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**
			(1 in 30.5, 1 in 1.73×10^{16})				**(1 in 1, 1 in 1)**
Ant Mound Treatments (Non-ag, Turf, Recreational, &Ag. Fruit Trees)	**Short Grass**	**1.52**	**1 in 1.26 (1 in 1.56, 1 in 1.05)**				
	Tall Grass	**0.70**	**1 in 4.12 (1 in 2.64, 1 in 12.2)**				
	Broadleaf plants, Small Insects	**0.86**	**1 in 2.60 (1 in 2.23, 1 in 3.60)**	**1603.20**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	**0.10**	**1 in 2.94×10^{5} (1 in 44, 1 in 8.86×10^{18})**			**178.13**	**1 in 1 (1 in 1, 1 in 1)**
Adulticide (Mosquito Control Pre-CFR 2005-1)	**Short Grass**	0.04					
	Tall Grass	0.02					
	Broadleaf plants, Small Insects	0.02		**44.27**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	<0.01				**4.80**	**1 in 1.02 (1 in 1.07, 1.01)**
Adulticide (Mosquito Control Post-CFR 2005-1)	**Short Grass**	<0.01					
	Tall Grass	<0.01					
	Broadleaf plants, Small Insects	<0.01		**1.60**	**1 in 1.38 (1 in 1.48, 1 in 1.30)**		
	Fruits, Pods, Seeds, Lg Insects	<0.01				**0.16**	**1 in 97.3 (1 in 25.9, 1 in 480)**
Soil Barrier Treatment	**Short Grass**	0.02					

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
(Fencerows & Hedgerows)	Tall Grass	0.01					
	Broadleaf plants, Small Insects	0.01		25.60	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	<0.01				2.67	1 in 1.12 (1 in 1.21, 1 in 1.07)
Soil Barrier Treatment (Range Land)	Short Grass	0.24	1 in 378 (1 in 9.3, 1 in $8.22\text{x}10^7$)				
	Tall Grass	0.11	1 in $1.25\text{x}10^5$ (1 in 36.2, 1 in$3.19\text{x}10^{17}$)				
	Broadleaf plants, Small Insects	0.14	1 in $1.64\text{x}10^4$ (1 in 22.8, 1 in$1.31\text{x}10^{14}$)	254.93	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.02				28.27	1 in 1 (1 in 1, 1 in 1)
Residential Turf and Ornamentals (Home and Garden)	Short Grass	7.05	1 in 1 (1 in 1.05, 1 in 1)				
	Tall Grass	3.23	1 in 1.01 (1 in 1.18, 1 in 1)				
	Broadleaf plants, Small Insects	3.96	1 in 1.01 (1 in 1.13, 1 in 1)	7418.67	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.44	1 in 18.4 (1 in 4.20, 1 in $1.50\text{x}10^3$)			826.67	1 in 1 (1 in 1, 1 in 1)
Perimeter Treatment	Short Grass	0.99	1 in 2.03 (1 in 2.01, 1 in 2.06)				

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	Dietary Category	Mammals[2]		Terrestrial Invertebrates[3]			
		Acute Dose-Based RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Small Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI	Large Insects RQ[4]	Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI
(Urban and Rural Structures)	Tall Grass	0.46	1 in 15.5 (1 in 4.00, 1 in 832)				
	Broadleaf plants, Small Insects	0.56	1 in 7.78 (1 in 3.25, 1 in 85.4)	1048.00	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.06				116.27	1 in 1 (1 in 1, 1 in 1)
Termite Treatment (Urban and Rural Structures)	Short Grass	0.53	1 in 9.32 (1 in 3.44, 1 in 153)				
	Tall Grass	0.24	1 in 378 (1 in 9.3, 1 in 8.22×10^7)				
	Broadleaf plants, Small Insects	0.30	1 in 107 (1 in 6.76, 1 in 7.91×10^5)	554.67	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.03				61.87	1 in 1 (1 in 1, 1 in 1)
Garden Vegetables (Home and Garden)	Short Grass	0.75	1 in 3.48 (1 in 2.49, 1 in 7.67)				
	Tall Grass	0.34	1 in 57.1 (1 in 5.73, 1 in 8.07×10^4)				
	Broadleaf plants, Small Insects	0.42	1 in 22.2 (1 in 4.43, 1 in 2.87×10^3)	791.47	1 in 1 (1 in 1, 1 in 1)		
	Fruits, Pods, Seeds, Lg Insects	0.05				88.00	1 in 1 (1 in 1, 1 in 1)
Garden Nuts and Fruits	Short Grass	0.68	1 in 4.43				

Table 5.13. Summary of the chance of individual acute effects to mammals and terrestrial invertebrates exposed to spray applications of permethrin based on acute RQs, the acute listed species LOC, acute toxicity data, and probit slope response relationships.[1]							
Use Category	**Dietary Category**	**Mammals[2]**		**Terrestrial Invertebrates[3]**			
		Acute Dose-Based RQ[4]	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Small Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**	**Large Insects RQ[4]**	**Chance of Individual Effect at RQ or LOC[4] Based on Probit Slope & Slope's 95% CI**
(Home and Garden)			**(1 in 2.71, 1 in 15.2)**				
	Tall Grass	**0.31**	**1 in 90.6 (1 in 6.47, 1 in 4.26×10^5)**				
	Broadleaf plants, Small Insects	**0.38**	**1 in 34.1 (1 in 4.99, 1 in 1.29×10^4)**	**710.93**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	0.04				**78.93**	**1 in 1 (1 in 1, 1 in 1)**
Soil Barrier Treatment (Urban and Rural Structures)	**Short Grass**	**0.12**	**1 in 5.85×10^4 (1 in 30.5, 1 in 1.73×10^{16})**				
	Tall Grass	0.05					
	Broadleaf plants, Small Insects	0.07		**124.80**	**1 in 1 (1 in 1, 1 in 1)**		
	Fruits, Pods, Seeds, Lg Insects	0.01				**13.87**	**1 in 1 (1 in 1, 1 in 1)**

[1] In instances where an LC_{50} or LD_{50} has not been established for a particular taxonomic group and no mortality was observed in the available studies, as is the case for permethrin for birds (and thus, terrestrial-phase amphibians, and reptiles), an individual effects probability was not estimated.
[2] Although an LD_{50} has been established for mammals, information is unavailable to estimate a slope from the study from which the endpoint was derived. Therefore, a default slope of 4.5 with an assumed 95% confidence interval of 2 and 9 has been assumed as per original Agency assumptions of typical slope cited in Urban and Cook (1986).
[3] A probit slope of 2.91 (95% CI of 2.22, 3.60) for honey bees (LD_{50}=0.024μg a.i./bee; MRID 42674501) was used to calculate the chance of individual effects for terrestrial invertebrates.
[4] Bolded RQs and shaded RQs exceed the Agency's acute listed species LOC (0.1 for mammals and 0.05 for terrestrial invertebrates). When acute RQs exceeded the Agency's listed species LOC, the chance of individual effects was calculated at the RQ and the LOC, whereas if there was no exceedance, than the chance of individual effects was calculated only at the LOC.

Table 5.14. Summary of the chronic dietary-based RQs for herpetofauna estimated based on the maximum permethrin foliar spray application scenarios using T-HERPS v1.0.						
Use Category	**App Rate (lbs a.i./A), Interval (Days), # of Apps**	**Chronic RQs[1]**				
		Dietary Category				
		Broadleaf Plants/ Small Insects	**Fruits/Pods/ Seeds/ Large Insects**	**Small Herbivore Mammals**	**Small Insectivore Mammals**	**Small Amphibians**
Alfalfa (Alfalfa)	**0.2, 30, 5**	0.29	0.03	0.34	0.02	0.01
Nut Trees (Pistachio)	**0.3, 10, 3**	0.66	0.07	0.78	0.05	0.02
Avocado (Avocado)	**0.2, 7, 4**	0.57	0.06	0.67	0.04	0.02
Cole Crops (Broccoli)	**0.2, 5, 4**	0.64	0.07	0.75	0.05	0.02
Corn (Pop corn)	**0.2, 5, 3**	0.53	0.06	0.62	0.04	0.02
Corn (Sweet corn)	**0.2, 3, 4**	0.71	0.08	0.84	0.05	0.02
Forestry (Cottonwood)	**0.2, 5 , 10**	0.96	0.11	**1.12**	0.07	0.03
Fruit Trees (Pear)	**0.4, 10, 2**	0.71	0.08	0.83	0.05	0.02
Fruit Trees (Peach)	**0.25, 10, 3**	0.55	0.06	0.65	0.04	0.02
Garlic & Potatoes (Garlic & Potatoes)	**0.2, 10, 4**	0.50	0.06	0.58	0.04	0.02
Major Leafy Vegetables (Lettuce)	**0.2, 7, 4**	0.57	0.06	0.67	0.04	0.02
Minor Leafy Vegetables	**0.2, 3, 10**	**1.27**	0.14	**1.48**	0.09	0.04
Major Cucurbits (Cucumber)	**0.2, 7, 6**	0.68	0.08	0.79	0.05	0.02
Minor Cucurbits (Melons)	**0.24, 7, 8**	0.88	0.10	**1.03**	0.06	0.03
Nursery (Pine Seed Orchard- Reduced)	**0.4, 28, 6**	0.60	0.07	0.71	0.04	0.02
Nursery (Pine Seed Orchard- Maximum)	**1.6, 28, 6**	**2.41**	0.27	**2.82**	0.18	0.08
Onions (Onion)	**0.3, 7, 4**	0.86	0.10	**1.01**	0.06	0.03
Onions (Fennel)	**0.2, 3, 10**	**1.27**	0.14	**1.48**	0.09	0.04
Row Crops (Celery)	**0.2, 7, 5**	0.63	0.07	0.74	0.05	0.02
Row Crops (Rhubarb)	**0.2, 5, 10**	0.96	0.11	**1.12**	0.07	0.03
Tomato (Tomato)	**0.2, 7, 3**	0.49	0.05	0.57	0.04	0.02
Tomato (Tomatillos)	**0.2, 7 , 6**	0.68	0.08	0.79	0.05	0.02
Turf (Golf course and Recreational Areas)	**0.87, 7 , 6**	**2.95**	0.33	**3.46**	0.22	0.10
Ant Mound Treatments (Non-ag, Turf, Recreat., &Ag. Fruit Trees)	**0.84, 7, 4**	**2.40**	0.27	**2.82**	0.18	0.08
Adulticide (Mosquito Control Pre-CFR 2005-1)	**0.003, 1, 52**	0.07	0.01	0.08	0.00	0.00

Adulticide (Mosquito Control Post-CFR 2005-1)	**0.00014, 1, 26**	0.00	0.00	0.00	0.00	0.00
Soil Barrier Treatment (Fencerows & Hedgerows)	**0.01, 7, 10**	0.04	0.00	0.04	0.00	0.00
Soil Barrier Treatment (Range Land)	**0.1, 7, 10**	0.38	0.04	0.45	0.03	0.01
Residential Turf and Ornamentals (Home and Garden)	**4.23, 5, 3**	**11.13**	**1.24**	**13.04**	0.81	0.39
Perimeter Treatment (Urban and Rural Structures)	**1.43, 90, 4**	**1.57**	0.17	**1.84**	0.12	0.05
Termite Treatment (Urban and Rural Structures)	**0.77, N/A, 1**	0.83	0.09	0.97	0.06	0.03
Garden Vegetables (Home and Garden)	**0.25, 3, 6**	**1.19**	0.13	**1.39**	0.09	0.04
Garden Nuts and Fruits (Home and Garden)	**0.4, 10, 5**	**1.07**	0.12	**1.25**	0.08	0.04
Soil Barrier Treatment (Urban and Rural Structures)	**0.1, 7, 2**	0.19	0.02	0.22	0.01	0.01

[1] All bolded and shaded chronic RQs exceed the Agency's chronic risk LOC (1).

5.2.1 California Red-Legged Frog

5.2.1.1 Direct Effects

Aquatic-Phase CRLF, Direct Effects

The aquatic-phase considers life stages of the CRLF 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 permethrin.

There are very little monitoring data for permethrin to compare with modeling results and because these data come from non-targeted studies, they are of limited value for analysis. Therefore, modeled results are used for assessing risks to all species in this assessment. Based on surrogate freshwater fish toxicity data (LC_{50} value of 0.79 µg a.i./L for bluegill sunfish) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for the aquatic-phase CRLF range from 0.06 (Soil Barrier Treatment on Fencerows and Hedgerows) to 6.96 (Nursery Uses and Residential Turf and Ornamentals)(**Table 5.1**); therefore, the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, yielded acute water concentration estimates in excess of the listed species effects benchmark equivalent to one-twentieth of the lowest median lethal concentration for freshwater fish (listed species LOC = 0.05). In addition, 39 of the 48 modeled scenarios yielded acute water concentration estimates in excess of the non-listed species effects benchmark equivalent to one-half of the lowest median lethal concentration for freshwater fish (non-listed species LOC = 0.5), and 11 of the 48 RQs exceed the freshwater fish median lethal concentration.

Permethrin is currently registered for numerous diverse uses in California that span a large variety of use sites and geographical regions, with potential uses including agricultural (in/on food/feed crops); nursery uses; forestry uses; turf uses; indoor/outdoor industrial, commercial, public, and residential uses; fire ant control; control of ectoparasites on domestic animals; and adulticide uses (*i.e.* for mosquito abatement)(refer to **Section 2.4.4**). Although there are a number of agricultural crops with high use (>1000 lb a.i./year, average applied) in California, including alfalfa, almond, pistachio, walnut, broccoli, corn, peach, lettuce, spinach, onion, potato, residential (landscaping), artichoke, celery and tomato (the major uses (*i.e.*, >20,000 lb a.i./year) were almond, pistachio and lettuce), based on CDPR PUR data, the overall trend of increased use of permethrin in California from 1999-2006 was attributed to increased non-agricultural usage (increased from approximately 150,000 to 450,000 lb applied per year), which exceeded the usage of permethrin for agricultural purposes (relatively stable with approximately 100,000 to 150,000 lb applied per year). In California, the greatest average annual usage from 1999-2006 was the use in structural pest control and landscape maintenance (289,272 lb a.i./year). Although peak application of permethrin in agricultural settings appears to occur in the summer (May through September), given the expansive and diverse nature of these use patterns spanning a large variety of use sites and geographical regions, and the large contribution of non-agricultural uses to the overall release of permethrin into the environment, the exact timing, magnitude, and location of permethrin applications is difficult to predict. However, based on the breadth and variety of permethrin uses in agricultural, industrial, commercial, public, and residential settings throughout the entire state of California, as well as the potential for multiple growing seasons of some of the crops that permethrin is registered for use on (*i.e.*, Broccoli, cabbage, Chinese cabbage, cauliflower, and mustard green, Turf (sod farms only), lettuce, endive, fennel, and sweet corn), it is reasonably expected that the possibility of year-round use (**Figure 5.1**) could result in an opportunity for permethrin use in any given area across the state to spatially and temporally coincide with each of the critical life-stages of the aquatic-phase CRLF (**Figure 5.2**) the development cascade from egg to tadpole to young juveniles occurs during the March though August period of the year).

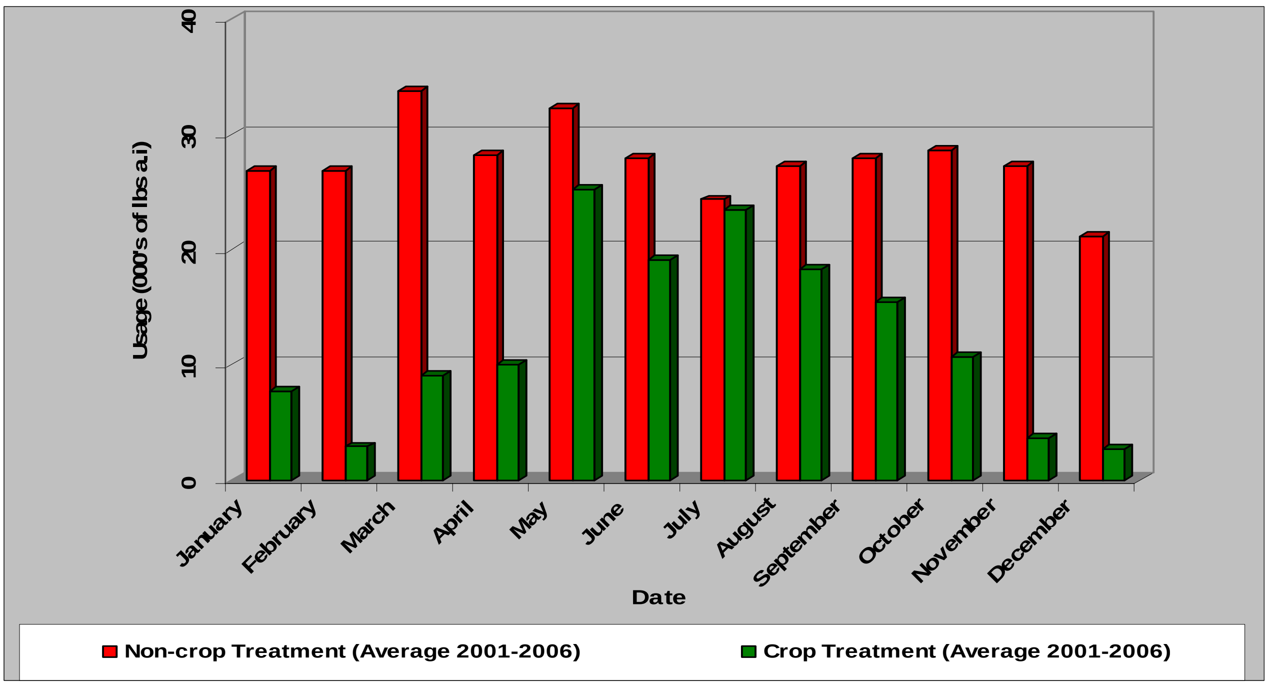


Figure 5.1. Monthly six year's average usage for permethrin in crop and non-crop treatments, based on data obtained from CA-DPR (http://calpip.cdpr.ca.gov/cfdocs/calpip/prod/main.cfm) for the years from 2001 to 2006.

				Young Juveniles							
Tadpoles (except those that over-winter)											
Breeding/Egg Masses											
J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**

Figure 5.2. CRLF reproductive events by month; adults and juveniles can be present all year.

Evidence in support of potential risk to aquatic organisms as a result of permethrin uses includes a large number of ecological incidents reported to the Agency. However, while the majority of ecological incidents involving permethrin occurred in aquatic environments (a total of 26), with approximately half (thirteen) of those resulting from registered use of permethrin, only one case listed as a possible permethrin-related event involved frogs. In this incident, an employee of the Mosquito Control section of the Maryland Department of Agriculture applied permethrin to a residential property approximately 74 feet away from a pond. One day later, 600 fish, crayfish, and frogs were found dead. Because the mosquito adulticide labels at the time required applications to be at least 100 feet from the pond, the incident was labeled as an accidental misuse. In addition, permethrin is implicated as only a possible cause because no tissues or water samples were analyzed. However, it should be noted that interpretation of the Agency's incident database must be done with caution because not all incidents are expected to be reported and in many instances it is difficult to establish a direct cause-effect relationship. Therefore, although a significant number of incidents associated with the use of a certain pesticide may be an indication that the pesticide may pose a higher environmental risk, the lack of reported incidents does not necessarily indicate a lack of incidents or risk. A full list of all aquatic incidents involving permethrin is shown in **Table 4.7**.

As previously mentioned, EFED also estimates the chance of an individual event (*i.e.*, mortality or immobilization) corresponding to the listed species acute LOCs and/or RQs should exposure at the EEC actually occur for a species with sensitivity to permethrin on par with the acute toxicity endpoint selected for RQ calculation. To do this, the Agency uses the EFED spreadsheet IEC (version 1.1.xls) and 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 listed species acute LOCs and/or RQs 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, available information on the 95% confidence interval of the slope is also used to estimate upper and lower estimates of the effects probability to account for variance in the slope, if available. If an LD_{50} or LC_{50} has been established for a particular taxonomic group, but information is unavailable to estimate a slope from a study, a default slope assumption of 4.5 (with upper and lower bounds of 2 and 9, respectively) is used as per original Agency assumptions of typical slope cited in Urban and Cook (1986).

Based on a default slope of 4.5 (with upper and lower bounds of 2 and 9), the LC_{50} of the most sensitive acute freshwater fish (bluegill sunfish; LC_{50} = 0.79 µg a.i./L) and the acute listed species LOC of 0.05, the chance of an individual mortality for aquatic-phase CRLF is ~ 1 in 2.94×10^{5} (with lower and upper bounds of ~ 1 in 44 to ~ 1 in 8.86×10^{18}) (**Table 5.12**). Based on an analysis of the likelihood of individual mortality using the highest acute RQ value for freshwater fish (RQ=6.96, for Nursery Uses and Residential Turf and Ornamentals) and a default slope of 4.5 (with upper and lower bounds of 2 and 9), the likelihood of individual mortality is ~ 1 in 1 (with lower and upper bounds of ~ 1 in 1.05 to 1 in 1). At the lowest RQ value (*i.e.*, RQ = 0.06 for Soil Barrier Treatment on Fencerows and Hedgerows), the likelihood of individual mortality is ~ 1 in 5.22×10^{7} (with lower and upper bounds of ~ 1 in 138 to ~ 1 in 5.04×10^{27}).

Given the high probability of an individual mortality occurrence using the highest acute RQ (~1 in 1), acute RQs that are above the acute listed species LOC (for all modeled scenarios) and the acute non-listed species LOC (for 39 of the 48 modeled scenarios), and the potential for spatial and temporal overlap of permethrin usage with each of the critical life-stages of the aquatic-phase CRLF, it appears that permethrin is likely to cause direct adverse effects to aquatic-phase CRLFs should exposure at the predicted EECs actually occur for a CRLF with sensitivity to permethrin on par with the acute freshwater fish LC_{50} (bluegill sunfish; LC_{50} = 0.79 µg a.i./L) selected for RQ calculation.

However, it must be noted that the endpoint selected for RQ calculation was the most sensitive acute endpoint available for all freshwater fish and other less sensitive endpoints were available for this species as well as for 7 other species of fish. The review of available data also reveals that freshwater fish LC_{50} values range from 0.79 to 72 µg a.i./L; in other words, other LC_{50} values are up to one hundred times less sensitive than the rainbow trout endpoint used in RQ calculations. Because there is potential that rainbow trout, other fish species, or the CRLF may not truly be affected at levels suggested by the most conservative LC_{50} (bluegill sunfish; LC_{50} = 0.79 µg a.i./L) selected for RQ calculation, it is important to gauge how sensitive risk conclusions are to the selection of a given endpoint among those available for freshwater fish. To do this, a geometric mean of all definitive LC_{50} values available for a given species with one or more LC_{50} endpoints from tests initially available to the Agency (does not include open literature) was determined. In total, there were eight different fish species for which one or more definitive LC_{50} values were available (bluegill sunfish, rainbow trout, brook trout, fathead minnow, channel catfish, carp, Atlantic salmon, and Coho salmon; **Table 5.15**). This suite of acute endpoints was compared with the EECs available from acute aquatic residue estimates for all use scenarios to determine the number of modeled scenarios for which the acute listed species LOC (0.05) would be exceeded based on the calculated geometric mean LC_{50} for each tested species. **Table 5.15** summarizes the results of these comparisons, which suggest that even relying on the geometric mean LC_{50} for the least sensitive species tested (Coho salmon and carp), the listed species acute LOC would still be exceeded for approximately 25% of the modeled scenarios. After Coho salmon and carp, the next least sensitive species was rainbow trout; based on the geometric mean LC_{50} for rainbow trout, the listed species acute LOC was exceeded for approximately 75% of the modeled scenarios.

Table 5.15. Results of acute and chronic permethrin EECs compared with distribution of freshwater fish LC_{50} and estimated NOAEC values.					
SPECIES	**NUMBER OF ACUTE VALUES USED TO CALCULATE THE SPECIES MEAN LC_{50} VALUE**	**SPECIES GEOMETRIC MEAN ACUTE LC_{50} VALUE (µg a.i./L)**	**ESTIMATED CHRONIC NOAEC BASED ON GEOMETRIC MEAN & FATHEAD MINNOW ACUTE-TO-CHRONIC RATIO**	**# OF MODELED SCENARIOS FOR WHICH ACUTE LISTED SPECIES LOC OF 0.05 WOULD BE EXCEEDED (# OF SCENARIOS EXCEEDING NON-LISTED SPECIES ACUTE RISK LOC OF 0.5)**	**# OF MODELED SCENARIOS FOR WHICH CHRONIC LOC WOULD BE EXCEEDED**
Rainbow trout *(Oncorhynchus mykiss)*	15	8.62	0.56	36 of 48 (5 of 48)	6 of 48
Coho Salmon *(Oncorhynchus kisutch)*	1	17	1.11	11 of 48 (0 of 48)	2 of 48
Atlantic salmon (*Salmo salar*)	1	1.5	0.10	47 of 48 (12 of 48)	31 of 48
Brook trout (*Salvelinus fontinalis*)	4	3.50	0.23	45 of 48 (7 of 48)	12 of 48
Bluegill sunfish *(Lepomis macrochirus)*	23	8.06	0.53	39 of 48 (5 of 48)	6 of 48
Carp (*Cyprinus carpio*)	1	15	0.98	12 of 48 (0 of 48)	2 of 48
Channel catfish (*Ictalurus punctatus*)	2	6.24	0.41	41 of 48 (6 of 48)	6 of 48
Fathead minnow (*Pimephales promelas*)	3	4.60	0.30	41 of 48 (6 of 48)	9 of 48

Consistent with the process identified in the Overview Document (USEPA 2004) evaluated by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (Williams and Hogarth 2004), the potential for permethrin to result in direct acute mortality of aquatic-phase CRLF is based on toxicity data for the most sensitive fish. However, the results of a few open literature studies, while not considered sufficiently robust to use quantitatively for risk assessment purposes for reasons previously covered in **Section 4.1.5**, do demonstrate that the tested species may be less sensitive to permethrin than fish. Dwyer et al 2005 (ECOTOX Ref. # 81380) reported a 96-hr LC_{50} value of >10 µg a.i./L for the boreal toad (*Bufo boreas boreas*), while Jolly et al 1978 (ECOTOX Ref. # 5181) reported a 96-hr LC_{50} value of 7033 µg /L for bullfrogs (*Rana catesbeiana*), Thurston et al 1985 (ECOTOX Ref. #12004) reported an LC_{50} value of 115 µg a.i./L for bullfrog tadpoles (*Rana catesbiana*), Johansson et al 2006 (ECOTOX Ref. #88266) reported an LC_{50} value of 2.5 µg a.i./L for *Rana temporaria* from a previous study, and Fort et al 1999 (ECOTOX Ref. # 89641) reported an LC_{50} value of 693 µg a.i./L and an EC_{50} value of 59.4 µg a.i./L (for effects on gut and neural development) for *Xenopus laevis*. Therefore, although the results of these studies cannot be used quantitatively, they provide evidence that the Agency's use of fish acute toxicity values may result in a conservative estimate of risk for aquatic-phase CRLF and other amphibians.

Although the degree to which toxicity and risk estimates for aquatic-phase frogs are over- or under-estimated based on the most sensitive available freshwater fish endpoint is indiscernible based on the available suite of data, if acute risk estimates for direct effects to the aquatic-phase CRLF were based on the most sensitive available acute amphibian toxicity data for permethrin (LC_{50} >10 µg a.i./L from ECOTOX Ref. # 81380; although an LC_{50} value of 2.5 µg a.i./L was reported in another study, it did not provide a source for those data), acute RQ values could still potentially exceed the listed species acute risk LOC (0.05) for 27 of the 48 modeled scenarios and the non-listed species acute risk LOC (0.5) for 4 of the 48 scenarios (although there would be another uncertainty due to RQs being reported as "less than" because of the use of the non-definitive toxicity value). Therefore, the potential for effects to the aquatic-phase CRLF could not be precluded and risk conclusions would not be substantially altered.

There are adequate lines of evidence to conclude that labeled permethrin use can produce water exposure levels with high probability to be lethal to individual larval frogs and that the use sites associated with permethrin coincide spatially with areas potentially inhabited by aquatic phase frogs. While permethrin peak usage in California may not fully coincide with the larval life stage of the frog, there is still temporal overlap of the larval stages with periods of permethrin use and one cannot preclude the reasonable possibility of exposures of larval frogs to lethal permethrin concentrations. Moreover, juvenile and adult frogs may also be present in water, and information on the life cycle suggests that these stages may be present in water at time periods of peak permethrin use in California. Insofar as the available acute toxicity data for freshwater fish is used to characterize toxic risks to all aquatic phases of the CRLF, there is evidence to suggest that individual adult and juvenile frogs are at lethal risk from permethrin use.

In addition to aquatic-phase CRLFs being at lethal risk from permethrin use, based on 60-day EECs for the various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.0515 µg a.i./L, all chronic RQs for the aquatic-phase CRLF range from 0.14 (Soil Barrier Treatment on Fencerows and Hedgerows) to 61.17 (Nursery Uses based on the current maximum label rate for pine seed orchards).

While 40 of the 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for the aquatic-phase CRLF, 8 of the 48 modeled scenarios did not (**Table 5.1**). The eight scenarios that did not exceed the Agency LOCs were the scenarios for onions, soil barrier treatment on fencerows and hedgerows, barrier treatment on urban and rural structures, termite treatment, garden vegetables, turf and garden vegetables (granular formulations), and the "down-the-drain" scenario assuming 94% removal. However, there were still numerous exceedances for various agricultural, nursery, forestry, residential, commercial, and mosquito adulticide uses.

There are two major areas of uncertainty with the assessment of direct chronic effects to the aquatic phase of the CRLF. The first area of uncertainty involves the estimation of the chronic NOAEC employed for determining chronic risk to fish and aquatic-phase amphibians using an acute-to-chronic ratio. Only a single acceptable life-cycle study on fathead minnows (*Pimephales promelas*) was available to the Agency to evaluate the effects of chronic exposure to permethrin (95.7% a.i.) on freshwater fish (MRID 00110666). Although a NOAEC and LOAEC of 0.30 µg a.i./L and 0.41 µg a.i./L, respectively, based on reduction in the number of surviving fry, was established in a life-cycle study with fathead minnows (MRID 00110666), the fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a bluegill sunfish chronic toxicity value because it is the most acutely sensitive freshwater fish species and no chronic toxicity data are available for it. The resulting estimated NOAEC of 0.0515 µg a.i./L for bluegill sunfish was approximately five times more sensitive than the fathead minnow value. Based on the less sensitive observed NOAEC of 0.30 µg a.i./L, 9 of the 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA would still result in an exceedance of the Agency's chronic risk LOC (RQ≥1) for the aquatic-phase CRLF and risk conclusions would not be substantially altered.

The second uncertainty involves the extrapolation of the available chronic fish data to aquatic phase amphibians. While amphibian eggs and larvae are in direct contact with the water for extended periods, adult frogs may or may not be. However, fish chronic effects data are from tests which involve direct exposure of eggs and developing fry of fish to the toxicant and not just adult stage breeding organisms. Therefore, given the nature of the testing methods and the large RQ values for the majority of permethrin uses, there is insufficient evidence to dismiss the potential for direct chronic effects to frogs in this assessment. But still, the degree to which fish and aquatic-phase amphibians share a similar range in sensitivity to permethrin with regards to chronic/reproductive effects will remain an uncertainty until suitable comparative chronic toxicity evaluations become available to the Agency.

However, it is noted that a similar analysis as to what was performed above to evaluate the impact of selecting alternative acute endpoints on the overall risk conclusions can be performed for characterization of potential for chronic risk to frogs as well. To do this, extrapolated NOAEC values were estimated for each estimated acute toxicity endpoint for a given fish species using the fathead minnow ACR of 15.34, as was done for the RQ calculations (**Table 5.15**). The suite of eight estimated chronic NOAECs for various species (bluegill sunfish, rainbow trout, brook trout, fathead minnow, channel catfish, carp, Atlantic salmon, and Coho salmon) was compared with the EECs available from chronic aquatic residue estimates for all use scenarios to determine the number of modeled scenarios for which the chronic LOC (1) would be exceeded. While there is considerable uncertainty in using a uniform ACR for all species, it does allow for an evaluation of the number of modeled scenarios that would trigger chronic risk concerns based on NOAECs for various species with differing sensitivities to permethrin exposure. **Table 5.15** summarizes the results of these comparisons, which suggest that relying on the extrapolated NOAEC for the least sensitive species tested (Coho salmon and carp), the chronic LOC would still be exceeded for approximately 5% of the modeled scenarios. After Coho salmon and carp, the next least sensitive species was rainbow trout; based on the estimated NOAEC for rainbow trout, the chronic LOC was exceeded for approximately 13% of the modeled scenarios.

Since the majority of modeled scenarios (>75% of the modeled scenarios) assessed, including those still spanning a diverse array of uses, triggered concerns for chronic effects in aquatic-phase frogs based on the estimated NOAEC of 0.0515 µg a.i./L, and because patterns of permethrin use throughout the entire state of California overlap spatially and temporally with CRLF critical life stages in the reproduction cycle, there are adequate lines of evidence to conclude that labeled permethrin use can produce water exposures at levels likely to cause chronic toxicity to the CRLF, and the use sites associated with permethrin coincide spatially with areas inhabited by aquatic phase frogs. Even based on a NOAEC value estimated for the least sensitive species of fish, there would still be exceedances of the chronic risk LOC for approximately 5% of modeled scenarios. Therefore, labeled permethrin use does have the potential to directly affect the aquatic-phase CRLF via both acute and chronic toxic effects.

Terrestrial-Phase CRLF, Direct Effects

As previously mentioned, although T-REX has the capability to generate dietary estimates of acute exposure and risk, and dose-based estimates of acute exposure and risk for a variety of body-sizes of birds (surrogate for terrestrial-phase amphibians and reptiles), acute estimates of risk for birds (and thus, terrestrial-phase CRLF) were not generated because the acute avian effects data show no treatment-related mortality to bobwhite quail at the highest tested level of permethrin in the sub-acute avian dietary studies (LC_{50} >10,000 mg/kg-diet). In addition, no treatment-related mortality was observed in the acute oral toxicity study establishing the most sensitive acute LD_{50} value for birds (mallard duck LD_{50}> 9,869 mg/kg-bw).

The fact that definitive acute toxicity endpoints are unavailable for acute risk estimation presents an area of uncertainty in this assessment with respect to the potential for direct effects to the terrestrial-phase CRLF. Although Agency policy is to not calculate acute risk estimates for a chemical if it can be classified as practically non-toxic and no mortality was observed in the acute toxicity tests at the highest treatment level, there still may be some uncertainties with regards to risk if predicted dose- and dietary-based EECs based on relevant food items for the terrestrial-phase CRLF exceed or approach the highest tested levels.

To characterize this uncertainty for the terrestrial-phase CRLF, the model T-HERPS was run using the most sensitive non-definitive endpoints (LC_{50} >10,000 mg/kg-diet and LD_{50}> 9,869 mg/kg-bw) for avian species, for spray applications only because those are the uses that are expected to pose the largest risk to terrestrial wildlife. The model T-HERPS is a modified form of T-REX, which is designed to be more reflective of the food requirements of amphibians and allow for an estimation of food intake for poikilotherms using the same basic procedure as T-REX. This involves adjusting daily food intake with an allometric model that accounts for the lower food intake of poikilothermic reptiles and amphibians. The net effect of this approach is a reduction in pesticide exposure due to reduced food consumption. An example output from T-HERPS is available in **APPENDIX L**.

Based on the runs of T-HERPS with the non-definitive endpoints, only the theoretical acute dose-based RQ for medium CRLFs (37g) consuming small herbivorous mammals (RQ<0.16) and theoretical acute dietary-based RQs for CRLFs consuming small insects (RQ<0.14) or small herbivorous mammals (RQ<0.16) may marginally exceed the acute listed species LOC (0.1) for the maximum exposure scenario considered in this assessment (Residential Turf and Ornamentals); all RQs are "less than" the reported values because the toxicity endpoints upon which they are based are "greater than" the reported values. For all relevant acute RQs for frogs to definitively be below the Agency's listed species acute risk LOC (0.1) for all modeled scenarios, the avian LD_{50} and LC_{50} values for permethrin would have to be established as >16,500 mg a.i./kg-bw and >17,500 mg a.i./kg-diet, respectively. Although it cannot definitively be stated that estimated exposures are less than one-tenth the median lethal dose (or concentration) estimates because they have not yet been established, given that the theoretical RQs are based on test levels at which zero mortality was observed, the dose/response curve for mortality to birds would have to be unusually steep for permethrin for predicted exposures to actually exceed the listed species concern levels. In addition, at such high dose levels, it would be uncertain whether any observed effects were due to extreme dosing volume rather than the inherent toxicity of permethrin. Lastly, when tests have evaluated toxicity at high enough levels, LD_{50} values of >16,500 mg a.i./kg-bw (*i.e.*, starlings and Japanese quail), and LC_{50} values of >17,500 mg a.i./kg-diet have been established for some avian species (*i.e.*, mallards, ring-necked pheasants, and Japanese quail). Subsequently, the Agency did not calculate the chance of an individual event (*i.e*., mortality or immobilization) corresponding to the listed species acute LOCs and/or RQs for birds, reptiles, or terrestrial-phase amphibians.

An analysis of ecological incidents results in no reported effects to terrestrial-phase amphibians involving permethrin exposures. However, since birds are used as surrogates for the terrestrial-phase CRLF, incidents involving birds are considered relevant to this assessment. A full list of all terrestrial animal incidents involving permethrin is shown in **Table 4.5**. Two incidents were reported to the Agency involving birds; however, one of the incidents involving the death of three birds was only listed as possible and multiple pesticides were implicated as the possible cause. The other incident was also listed as possible and involved the death of four parakeets following home treatment with permethrin; however, no analytical evidence linking the deaths to permethrin was reported. Due to the lack of information establishing a cause-and-effect relationship, these two incidents provide nothing more than anecdotal information, and do not provide substantial evidence suggesting the potential for direct effects to the terrestrial-phase CRLF. Therefore, the available data suggest that the potential for acute lethality of permethrin to terrestrial-phase amphibians is unlikely for all uses of permethrin, and permethrin use in California is not likely to directly affect the terrestrial-phase CRLF via acute toxicity.

Direct chronic exposure of the terrestrial-phase CRLF was evaluated based on the dietary-based EECs estimated using various approaches (*i.e.*, T-REX for foliar spray applications and the fugacity-based model for insectivorous wildlife) for birds consuming small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates, or soil-dwelling invertebrates because those are the only relevant dietary items that have been identified as potential terrestrial-phase CRLF food sources for which the available screening-level models can estimate EECs.

Based on surrogate avian toxicity data (NOAEC = 125 mg/kg-diet for mallards), the maximum allowable application rate (3 applications, 4.23 lbs a.i./acre/application, 5-day application interval), the foliar dissipation half-life of 15.4 days for permethrin from Willis and McDowell (1987), and upper bound Kenaga values from T-REX, there is a potential for direct adverse effects the terrestrial-phase CRLF individuals from foliar spray applications of permethrin in CA (**Table 5.6**). The dietary-based chronic RQs range from <0.01 to 11.13 and from <0.01 to 1.24 for the broadleaf plants/small insects and fruits/pods/seeds/large insects dietary categories, respectively. While 9 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on broadleaf plants/small insects, only 1 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on fruits/pods/seeds/large insects. RQs for granular applications of permethrin do not exceed the Agency's chronic risk LOC of 1 (RQs ≤ 0.43) (**Table 5.8**).

The initial screening-level risk assessment methods using avian effects data and an avian exposure model as surrogates suggests concern for direct chronic toxic risks to frogs. In such situations where conservative screening-level methods trigger concerns, additional evaluation of potential direct effects on terrestrial-phase frogs is accomplished through the application of T-HERPS, which is more reflective of the food requirements of amphibians than T-REX, as previously described. **Table 5.14** presents the results of the T-HERPS model run with surrogate avian toxicity data (NOAEC of 125 mg a.i./kg-diet) and the attendant RQ calculations for chronic effects. However, because dose-based estimates of chronic toxicity are not available for birds or terrestrial-phase amphibians, refinements typically performed by T-HERPS by accounting for differences in food intake for poikilotherms, could not be done (*i.e.*, daily food intake is adjusted using an allometric model only for dose-based estimates of exposure and risk). Instead, results of T-HERPS simply present dietary EECs and RQs for the additional food categories; small herbivorous mammals, small insectivorous mammals, and small amphibians. Based on this more species-specific risk model, consumption of small insects, large insects, and small herbivorous mammals poses chronic risk at levels exceeding the chronic LOC for 9 out of the 34, 1 out of the 34, and 13 out of the 34 scenarios modeled to represent all of the agricultural and non-agricultural uses of permethrin in CA, respectively.

One source of uncertainty with respect to the potential for direct effects to the terrestrial-phase CRLF via chronic toxicity is due to the reliance on the NOAEC of 125 mg a.i./kg-diet for mallards (MRID 42322901), based on non-statistically significant effects at the 500 mg a.i./kg-diet treatment level, to derive chronic risk estimates. Although the effects were not statistically significant, given the magnitude of effects (overall decrease in egg production by 13.2% relative to the controls), the associated increase in occurrences of regressed ovaries (8 hens in the 500 mg a.i./kg-diet treatment group compared to 2 in control), and the acknowledgment by the study authors that the effects may be treatment-related, the NOAEC and LOAEC for this study have been set at 125 and 500 mg a.i./kg-diet, respectively. However, had the refined RQ estimates with T-HERPS been calculated using the highest treatment level (500 mg a.i./kg-diet) instead of the set NOAEC, there still would have been exceedances of the Agency's chronic risk LOC (1) for terrestrial-phase CRLFs that consume small insects (RQ = 2.78) and small herbivorous mammals (RQ = 3.26) for the maximum exposure scenario considered in this assessment (Residential Turf and Ornamentals).

Because there is some evidence of the potential for bioconcentration of permethrin in aquatic organisms, an additional exposure pathway that should be considered in this assessment for frogs, is the consumption of contaminated food items (*e.g.,* fish or aquatic invertebrates) that have bioconcentrated permethrin dissolved in water. The maximum bioconcentration factor (BCF) for whole fish tissues is reported as 610 (mL/g) for permethrin, the estimated time to reach 90% of steady state is 15-16 days, and the estimated time for 50% depuration is approximately 4.7 days (MRID 41300401, 41300402, 41300403). In addition, a metabolism study with rats submitted to and reviewed by HED indicated that permethrin is rapidly absorbed and excreted (HED RED for permethrin, April 4th 2006; DP Barcode D324993). The World Health Organization report (1990) also suggested that permethrin administration to mammals was rapidly metabolized and almost completely eliminated from the body within a short period of time (HED RED for permethrin, April 4th 2006; DP Barcode D324993). These results suggest two important things. First, it is likely that permethrin concentrations in tissues of aquatic organisms should track closely with concentrations found dissolved in water. Second, the potential for bioaccumulation and magnification up the food chain appears to be limited.

Still, an evaluation of the potential significance of the exposure pathway involving the consumption of aquatic food items that have bioconcentrated permethrin can be evaluated by using a laboratory derived BCF in fish and estimated water concentrations from PRZM/EXAMS. Based on the maximum peak water EEC for all modeled scenarios considered in this assessment and the maximum whole fish tissue BCF, the estimated peak concentration in aquatic organisms based on this approach is:

Permethrin concentration in aquatic organism =
BCF (mL/g) x peak EEC of permethrin in water (µg/L) x (1 L/1000 mL)

= 610 mL/g x 5.5 µg/L (solubility limit of permethrin) x (1 L/1000 mL) = 3.4 µg/g (ppm)

A comparison of this tissue concentration to maximum EECs for spray applications estimated from T-REX and T-HERPS for small insects (1391 ppm for Residential Turf and Ornamentals) reveals that this exposure pathway results in substantially lower estimates of exposure relative to the consumption of contaminated dietary items found in the terrestrial environment. In fact, only two of the 34 scenarios modeled in T-REX produced EECs in terrestrial food items lower than this estimated value for tissue concentrations in aquatic organisms; EECs for all dietary items under the Adulticide (Mosquito Control Post-CFR 2005-1) scenario and EECs for large insects under the Soil Barrier treatment (Urban and Rural Structures) scenario.

A comparison of the aquatic organism tissue EEC estimated based on the peak water concentration and the maximum whole fish tissue BCF, to the acute and chronic avian toxicity endpoints (conservative approach; LC_{50} >10,000 mg/kg-diet and NOAEC = 125 mg/kg-diet) demonstrates that the estimated peak EEC in aquatic organisms (3.4 ppm) is an order of magnitude or more lower than both. In addition, because peak water EECs were used to derive aquatic organism EECs rather than 60-day water concentrations, the estimate of chronic risk for this pathway is considered to be conservative. Also, given that permethrin is very highly toxic and may cause lethality in aquatic organisms at very low concentrations, it is quite possible that permethrin may never even reach levels this high in many aquatic organisms. However, if there are tolerant aquatic species that can survive high exposure concentrations and are able to bioconcentrate permethrin to these levels, it still appears as though risk estimates for frogs resulting from this exposure pathway are substantially lower than the Agency's acute and chronic LOCs. Subsequently, risk estimates for frogs consuming a variety of terrestrial dietary food items will tend to drive the risk conclusions for direct effects to terrestrial-phase frogs.

Therefore, given the weight-of-evidence involving chronic risk LOC exceedances based on T-REX and the refined T-HERPS model, and spatial overlap of permethrin uses in California and CRLF habitat, there is potential for labeled permethrin use to cause direct adverse effects to the terrestrial-phase CRLF via chronic toxicity, despite the conclusion that direct acute lethality to the terrestrial-phase CRLF appears to be unlikely.

5.2.1.2 Indirect Effects (*via Reductions in Prey Base*)

As discussed previously in **Section 2.5**, the diet of aquatic-phase CRLF tadpoles is composed primarily of unicellular aquatic plants (i.e., algae and diatoms) and detritus, while the diet of terrestrial-phase CRLF includes terrestrial and aquatic invertebrates, mammals, frogs, and fish. The main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic and terrestrial invertebrates. However, life history data for terrestrial-phase CRLFs indicate that large adult frogs also consume terrestrial vertebrates, including mice and frogs.

Algae (non-vascular plants)

Based on the most sensitive surrogate aquatic non-vascular plant toxicity data (EC_{50} value of 68 µg a.i./L for the marine alga, Skeletonema costatum) and the maximum aquatic peak EEC of all use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all RQs for aquatic non-vascular plants are ≤0.08 (**Table 5.5**). Since the RQs do not exceed the Agency's LOC (1) for aquatic non-vascular plants based on the most sensitive data available to the Agency, labeled permethrin use in California appears not likely to indirectly affect the aquatic-phase CRLF via effects to aquatic non-vascular plant food sources. Therefore, only fish, aquatic invertebrates, and frogs will be characterized for potential indirect effects to the aquatic-phase CRLF.

Freshwater Fish and Aquatic-phase Frogs

The potential for direct effects to listed fish and aquatic-phase frogs is discussed above in **Section 5.2.1.1**. Because fish and frogs are also considered potential prey items for the aquatic-phase CRLF, indirect effects via potential prey item reduction are also considered here. As previously mentioned, based on freshwater fish toxicity data (LC_{50} value of 0.79 µg a.i./L for bluegill sunfish) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for fish and aquatic-phase frogs range from 0.06 (Soil Barrier Treatment on Fencerows and Hedgerows) to 6.96 (Nursery Uses and Residential Turf and Ornamentals)(**Table 5.1**); therefore, 39 of the 48 modeled scenarios yielded acute water concentration estimates in excess of the non-listed species effects benchmark equivalent to one-half of the lowest median lethal concentration for freshwater fish (non-listed species LOC = 0.5).

Based on additional analyses, the likelihood of individual mortality using the highest acute RQ value for freshwater fish and a default slope of 4.5 (with upper and lower bounds of 2 and 9), is ~ 1 in 1 (with lower and upper bounds of ~ 1in 1.05 to 1 in 1). In addition, based on an evaluation of how sensitive risk conclusions are to the selection of a given acute endpoint among those available for freshwater fish, it appears that while relying on the geometric mean LC_{50} for the least sensitive species of the eight tested (Coho salmon and carp) would not result in any exceedances of the non-listed species acute LOC, approximately 10% or more of the scenarios would result in an exceedances of the acute non-listed species LOC for the rest of the tested species (6 of 8, or 75%).

As previously covered in **Section 5.2.1.1,** the potential for permethrin to result in acute mortality of fish and aquatic-phase frogs is based on toxicity data for the most sensitive fish. However, the results of a few open literature studies, while not considered sufficiently robust to use quantitatively for risk assessment purposes for reasons previously covered in **Section 4.1.5**, do demonstrate that the tested aquatic-amphibian species may be less sensitive to permethrin than fish. Despite those results, if acute risk estimates for effects to aquatic-phase amphibians were based on the most sensitive available acute amphibian toxicity data for permethrin (LC_{50} >10 µg a.i./L from ECOTOX Ref. # 81380; although an LC_{50} value of 2.5 µg a.i./L was reported in another study, it did not provide a source for those data) rather than on surrogate freshwater fish data, acute RQ values could still potentially exceed the non-listed species acute risk LOC (0.5) for 4 of the 48 scenarios; therefore, the potential for effects to aquatic-phase frogs could not be precluded.

In addition to fish and aquatic-phase frogs being at lethal risk from permethrin use, it was determined that 40 of the 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for fish and aquatic-phase frogs (RQs ranged from 0.14 to 61.17). Even based on the less sensitive observed NOAEC of 0.30 µg a.i./L, rather than the extrapolate NOAEC used for risk estimation, 9 of the 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA would still result in an exceedance of the Agency's chronic risk LOC (RQ≥1) and risk conclusions would not be substantially altered. In addition, based on an evaluation of how sensitive risk conclusions are to the selection of an extrapolated chronic endpoint among a number of those available for various species of freshwater fish differing in sensitivity to permethrin, it was determined that even relying on the extrapolated NOAEC for the least sensitive species tested (Coho salmon and carp), the chronic LOC would still be exceeded for approximately 5% of the modeled scenarios. After Coho salmon and carp, the next least sensitive species was rainbow trout; based on the estimated NOAEC for rainbow trout, the chronic LOC was exceeded for approximately 13% of the modeled scenarios.

Supporting the predicted effects to the CRLF aquatic-phase frog and fish prey base, are the large number of ecological incidents involving permethrin occurring in aquatic environments; twenty-six aquatic incidents caused by permethrin have been reported to the EPA since 1994. A full list of all aquatic incidents involving permethrin is shown in **Table 4.7**. Of these incidents, twenty-four affected fish species, and seven are listed as highly probable, ten as probable, and seven as possible. Approximately eleven of the incidents associated with fish kills resulted from registered use of permethrin, while association of five of the incidents to legal permethrin use were unknown, and eight were misuses. The registered uses that the incidents were linked to run a wide gamut of the uses that permethrin is registered for in California and included: application to residential lawns, application to commercial buildings, use for termite control, miscellaneous residential uses, use for mosquito vector control, and application to crops. In addition, as previously mentioned, not all incidents are expected to be reported, and therefore, these may only represent a fraction of those that occurred due to permethrin use. However, given that there are a significant number of incidents associated with registered uses of permethrin, it does lend credence to the exposure and risk estimates generated in this risk assessment.

In conclusion, based on the weight of evidence and assuming that the distribution of tested fish species endpoints reasonably approximates the distribution of sensitivities of fish/aquatic-phase frogs in CRLF habitats, it appears that there is a potential for indirect effects to the aquatic-phase CRLF from loss of fish/aquatic amphibian prey as result of labeled permethrin use in California.

Freshwater Invertebrates

Based on surrogate freshwater invertebrate toxicity data (EC_{50} value of 0.0212 µg a.i./L for scuds) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for freshwater invertebrates range from 2.11 (Soil Barrier Treatment on Fencerows and Hedgerows) to 259.43 (Nursery Uses and Residential Turf and Ornamentals); therefore, the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, yielded acute water concentration estimates well in excess of the non-listed species effects benchmark equivalent to one-half of the lowest median lethal concentration for freshwater invertebrates (non-listed species acute LOC = 0.5). In addition, all RQs for every scenario even exceed the freshwater invertebrate median lethal concentration, and in some case by more than two orders of magnitude (**Table 5.2**). This would suggest that mortality levels, regardless of the slope of the dose response function for the tested species, are in excess of 50% for this species.

In fact, based on a default slope of 4.5 (with upper and lower bounds of 2 and 9), the EC_{50} of the most sensitive acute freshwater invertebrates (scud; EC_{50} = 0.0212 µg a.i./L) and the highest acute RQ value for freshwater invertebrates (RQ = 259.43, for Nursery Uses and Residential Turf and Ornamentals), the chance of an individual mortality for freshwater invertebrates is ~ 1 in 1 (with lower and upper bounds of ~ 1in 1 to 1 in 1). At the lowest RQ value (RQ = 2.11 for Soil Barrier Treatment on Fencerows and Hedgerows), the likelihood of individual mortality is ~ 1 in 1.08 (with lower and upper bounds of ~ 1 in 1.35 to ~ 1 in 1) (**Table 5.12**).

As was done for freshwater fish, the endpoint selected for RQ calculation was the most sensitive acute endpoint available for all freshwater invertebrates and other less sensitive endpoints were available for other species of invertebrates. The review of available data reveals that definitive freshwater invertebrate EC_{50} values range from 0.0212 to 210 µg a.i./L; in other words, other EC_{50} values are up to ten thousand times less sensitive than the scud endpoint used in RQ calculations. Because there is potential that scuds or other freshwater invertebrate species may not truly be affected at levels suggested by the most conservative EC_{50} selected for RQ calculation, the same approach that was done for the analysis of available freshwater fish data was performed for available freshwater invertebrate data. In total, there were six different invertebrate species for which one or more definitive EC_{50} values were available (waterfleas, mayflies, crayfish, scuds-*Hyalella*, scuds-*Gammarus,* and midges; **Table 5.16**). This suite of acute endpoints was compared with the EECs available from acute aquatic residue estimates for all use scenarios to determine the number of modeled scenarios for which the acute non-listed species LOC (0.5) would be exceeded based on the EC_{50} for each tested species. **Table 5.16** summarizes the results of these comparisons, which suggest that relying on the EC_{50} for the least sensitive species tested (crayfish), the non-listed species acute risk LOC would not be exceeded for any of the modeled scenarios, suggesting low potential for acute effects to the freshwater invertebrate prey base. However, after crayfish, the next least sensitive species was the waterflea (*Daphnia magna*); based on the geometric mean EC_{50} for waterfleas, the non-listed species acute risk LOC was exceeded for approximately 46% of the modeled scenarios. For the rest of the tested species, 85% or more of the modeled scenarios would result in an exceedance of the non-listed species acute risk LOC.

Table 5.16. Results of acute and chronic permethrin EECs compared with distribution of freshwater invertebrates EC_{50} and estimated NOAEC values.

SPECIES	NUMBER OF ACUTE VALUES USED TO CALCULATE THE SPECIES MEAN EC_{50} VALUE	SPECIES GEOMETRIC MEAN ACUTE EC_{50} VALUE (µg a.i./L)	ESTIMATED CHRONIC NOAEC BASED ON EC_{50} & FATHEAD MINNOW ACUTE-TO-CHRONIC RATIO	# OF MODELED SCENARIOS FOR WHICH NON-LISTED SPECIES ACUTE RISK LOC OF 0.5 WOULD BE EXCEEDED	# OF MODELED SCENARIOS FOR WHICH CHRONIC LOC WOULD BE EXCEEDED
Waterfleas (*Daphnia magna*)	10	1.044	0.0681	22 of 48	43 of 48

Table 5.16. Results of acute and chronic permethrin EECs compared with distribution of freshwater invertebrates EC_{50} and estimated NOAEC values.					
SPECIES	**NUMBER OF ACUTE VALUES USED TO CALCULATE THE SPECIES MEAN EC_{50} VALUE**	**SPECIES GEOMETRIC MEAN ACUTE EC_{50} VALUE (µg a.i./L)**	**ESTIMATED CHRONIC NOAEC BASED ON EC_{50} & FATHEAD MINNOW ACUTE-TO-CHRONIC RATIO**	**# OF MODELED SCENARIOS FOR WHICH NON-LISTED SPECIES ACUTE RISK LOC OF 0.5 WOULD BE EXCEEDED**	**# OF MODELED SCENARIOS FOR WHICH CHRONIC LOC WOULD BE EXCEEDED**
Mayfly (*Hexagenia bilineuta*)	1	0.1	0.0065	47 of 48	48 of 48
Crayfish (*Procambarus blandingii*)	1	210	13.6897	0 of 48	0 of 48
Scud (*Gammarus pseudolimnaeus*)	1	0.17	0.0111	47 of 48	47 of 48
Midge (*Chironomus plumosus*)	1	0.56	0.0365	41 of 48	46 of 48
Scud (*Hyalella aztec*)	1	0.0212	0.0014	48 of 48	48 of 48

In addition to freshwater invertebrates being at lethal risk from permethrin use, based on 21-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.0014 µg a.i./L, all chronic RQs for freshwater invertebrates range from 6.66 (Soil Barrier Treatment on Fencerows and Hedgerows) to 3271.43 (Nursery Uses based on the current maximum label rate for pine seed orchards); therefore, the entire set of 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's chronic risk LOC (RQ$\geq$1) for freshwater invertebrates (**Table 5.2**).

The one major area of uncertainty with the assessment of chronic effects to the freshwater invertebrate prey base of the aquatic-phase CRLF involves the estimation of the chronic NOAEC using an acute-to-chronic ratio. While there are a total of two chronic exposure studies with permethrin involving freshwater invertebrates, the most sensitive LOAEC in these studies (LOAEC = 0.084 µg a.i./L based on based on 14% and 4% reductions in the number of young produced per female and length, respectively; MRID 43745701) was less sensitive than the most sensitive acute toxicity value for freshwater invertebrates and was not for the most acutely sensitive species tested. Therefore, the previously described fathead minnow acute to chronic ratio (ACR=15.34) was used to estimate a scud (*Hyalella azteca*) chronic NOAEC value of 0.0014; this value is approximately thirty times more sensitive than the most sensitive reported NOAEC value from the chronic tests with *Daphnia magna*. While the application of a uniform ACR across taxonomic groups does introduce uncertainty into risk estimation, in the absence of a reliable chronic NOAEC for this taxonomic group it does allow for a reasonable approximation of chronic risk. However, even based on the less sensitive reported NOAEC of 0.039 µg a.i./L, 46 of the 48 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA would still result in an exceedance of the Agency's chronic risk LOC (RQ≥1) for freshwater invertebrates and risk conclusions would not be substantially altered.

In addition, based on an evaluation of how sensitive risk conclusions are to the selection of an extrapolated chronic endpoint among a number of those available for various species of freshwater invertebrates differing in sensitivity to permethrin (please refer to the characterization of direct effects to the aquatic-phase CRLF for additional information), it was determined that the chronic risk LOC would not be exceeded for any of the modeled scenarios if the extrapolated NOAEC for the least sensitive species tested (crayfish) was relied upon for risk estimation. Although this would suggest low potential for chronic effects to the freshwater invertebrate prey base, after crayfish, the next least sensitive species was the waterflea (*Daphnia magna*); based on the extrapolated NOAEC for waterfleas and the remaining species, the chronic risk LOC was exceeded for approximately 90% or more of the modeled scenarios (**Table 5.16**).

It is interesting to note that the three freshwater invertebrate incidents reported to the Agency involve crayfish, and two are a result of registered uses that were linked to the incidents as "highly probable", despite that the analyses aimed at evaluating the sensitivity of risk conclusions to the selection of acute and chronic endpoint among those available freshwater invertebrate species varying in sensitivity to permethrin indicate that acute and chronic effects to crayfish as a result of permethrin use appear to be unlikely. Therefore, this would suggest that either exposure estimates in this assessment under predict potential concentrations in non-target water bodies, or the available toxicity test with crayfish substantially underestimate the toxicity of permethrin to crayfish. Regardless, while the results of these exploratory analyses for crayfish contradict reported aquatic incidents, the incidents do support the conclusion that there is potential for effects to the freshwater invertebrate prey base as a whole resulting from labeled permethrin use in California.

In conclusion, based on the exceedances of non-listed species acute and chronic risk LOCs for freshwater invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence using both the highest and lowest acute RQ for freshwater invertebrates (~1 in 1 and ~1 in 1.08, respectively), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CRLF habitat, and the reported aquatic incidents involving the least sensitive tested freshwater invertebrate, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the aquatic-phase CRLF from loss of freshwater invertebrate prey as result of labeled permethrin use in California should exposure at the predicted EECs actually occur for invertebrates with sensitivity to permethrin reasonably represented by the distribution of tested invertebrate species endpoints.

Commonly, aquatic risk assessments involve a down stream dilution assessment for determining the extent of the indirectly affected offsite lotic aquatic habitats (flowing water). To do this, the greatest ratio of the RQ to the LOC for any endpoint for aquatic organisms for each use category is used to determine the distance downstream for concentrations to be diluted below levels that would be of concern (*i.e*. result in RQs less than the LOC).

In addition, when considering lentic (non-flowing) aquatic habitats, spray drift from pesticide use sites onto non-target areas could potentially result in exposures of the assessed species, their prey, and their habitat. Therefore, it is also often necessary to estimate the distance from the application site where spray drift exposures do not result in LOC exceedances for organisms within aquatic lentic habitats at highest risk. For this assessment, both of these analyses would apply to RQs for exposures of permethrin to aquatic invertebrates.

However, for permethrin there are such extensive and diverse labeled uses that are much more varied than many pesticides in potential use site geography and include: agricultural uses (in/on food/feed crops); rights of way uses; nursery uses; forestry uses; turf uses; indoor/outdoor industrial, commercial, public health, and residential uses; fire ant control; control of ectoparasites on domestic animals; and adulticide uses (*i.e.* for mosquito abatement). Therefore, it was assumed that an assessment to determine the down stream distance required for concentrations in lotic habitats to be diluted below levels that would be of concern, or an assessment of the distance from the application site where spray drift exposures do not result in LOC exceedances for organisms within aquatic lentic habitats, while suitable for evaluating a single use site of a pesticide, in this case, was probably of limited utility because direct application of permethrin throughout the entire state of California was possible, and would tend to dominate the risk conclusions for all of the listed species considered in this assessment.

Terrestrial Invertebrates

As previously stated, permethrin is a broad spectrum insecticide that targets adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects. Therefore, most terrestrial invertebrates are very sensitive to this insecticide.

Based on the lowest available acute contact LD_{50} of 0.024 µg a.i./bee (converted to 0.1875 µg a.i./g of bee) for honey bees, EECs in ppm (µg a.i./g of bee) calculated by T-REX for small and large insects for foliar spray applications of permethrin, EECs (mg a.i./kg-bw) in earthworms estimated using the fugacity-based approach for granular applications of permethrin, and the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05), permethrin use in CA does have the potential to adversely effect terrestrial invertebrates (**Tables 5.6** and **5.8**). RQs for terrestrial invertebrates exceed the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05) based on EECs for both small and large insects for all permethrin spray application scenarios considered in this assessment (RQs based on EECs for small insects and large insects range from 1.60 to 7418.67 and 0.16 to 826.67, respectively), and RQs for soil-dwelling terrestrial invertebrates exceed the Agency's interim LOC (RQ≥0.05) for listed terrestrial invertebrates based on EECs in earthworms for all permethrin granular applications considered in this assessment (RQs range from 59.41 to 286.35).

Based on a slope of 2.91 (with upper and lower bounds of 2.22 and 3.60), the LD_{50} of the most sensitive terrestrial invertebrate (honey bee; LD_{50} = 0.1875 µg a.i./g of bee) and the highest RQ value for terrestrial invertebrates (RQ = 7418.67), the chance of an individual mortality for terrestrial invertebrates is ~ 1 in 1 (with lower and upper bounds of ~ 1in 1 to 1 in 1). At the lowest RQ value (RQ = 0.16), the likelihood of individual mortality is ~ 1 in 97.3 (with lower and upper bounds of ~ 1 in 25.9 to ~ 1 in 480) (**Table 5.13**).

Due to differences in study design, routes of exposure, and too few definitive endpoints, a meaningful species sensitivity distribution could not be calculated for terrestrial invertebrates. However, a total of three terrestrial invertebrate data values are available in the EFED ECOTOXICITY database relevant to contact exposures of honeybees to permethrin. Available LD_{50} values are 0.05, 0.16, and 0.024 µg a.i./bee (MRIDs 00045044, 00045046, and 42674501, respectively). The highest LD_{50} (0.16 µg a.i./bee) is equivalent to 1.25 µg a.i./g (of bee). Comparison of this value to EECs for small and large terrestrial invertebrates demonstrates that RQs would range from 0.024 to 1112.8 if the highest available LD_{50} for honeybees was relied upon for risk estimation for terrestrial invertebrates. Theoretical RQs for every modeled scenario would exceed the Agency's interim LOC for listed terrestrial invertebrates (RQ≥0.05) except for large invertebrates under the Adulticide (Mosquito Control Post-CFR 2005-1) scenario.

The current lowest modeled application rate is 0.00014 lb a.i./A for adulticide uses (Mosquito Control Post-CFR 2005-1). A single application at that rate is enough to result in EECs for small insects that are one-tenth the magnitude of the most sensitive terrestrial invertebrate LD_{50} (honey bee; LD_{50} = 0.1875 µg a.i./g of bee); in other words, it results in an RQ roughly twice as high as the Agency's interim listed species acute risk LOC for insects (0.05). Therefore, in order for there to be no exceedances of the Agency's LOCs for insects for any use, all uses would have to be limited to a single application at a rate of 0.000069 lb a.i./A or lower.

A review of the ecological incident database for permethrin reveals three reported incidents of effects to bees or other non-target insects. Affected species include honey bees and monarch and other unspecified butterflies. The incident involving butterflies involved a registered use of permethrin. Specifically, it was an incident in which hundreds to thousands of dead butterflies were found by residents of the area shortly after application of permethrin to a municipality. The involvement of permethrin was classified as "highly probable," as analysis of butterfly samples showed concentrations of 20-37 ppm permethrin. Although the exact use was not reported, it is informative to note that reported concentrations in butterflies (20-37 ppm) align fairly closely to the EECs predicted by T-REX for large insects under the modeled perimeter treatment scenario for urban and rural structures (21.8 ppm; **Table 3.8**). The reported EECs and the fact that it was a result of a registered use lend support to the modeling efforts and the predicted exposure concentrations and resulting risk estimates for terrestrial invertebrates. The other two incidents involving bees were a result of an accidental misuse and an unknown use. The certainty of the involvement of permethrin in the accidental misuse incident was highly probable, while the certainty of the unknown use incident was possible. A full list of all incidents involving permethrin is shown in **Table 4.5**.

In conclusion, based on the fact that permethrin is a highly efficacious broad spectrum insecticide, the exceedances of the Agency's interim LOC for listed terrestrial invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence based on the highest acute RQ for terrestrial invertebrates (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CRLF habitat, the reported terrestrial incidents involving terrestrial invertebrates, and the extremely low single application rate required (0.000069 lb a.i./A or lower) in order for there to be no exceedances of the Agency's LOCs for insects for any use, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the terrestrial-phase CRLF from loss of terrestrial invertebrate prey as result of labeled permethrin use in California.

When considering terrestrial habitats, spray drift from pesticide use sites onto non-target areas could potentially result in exposures of the assessed species, their prey, and their habitat. Therefore, a common component of terrestrial risk assessments is an analysis estimating the distance from the application site where spray drift exposures do not result in LOC exceedances for organisms within the neighboring terrestrial habitats at highest risk. For this assessment, this analysis would apply to RQs for exposures of permethrin to terrestrial invertebrates. However, as previously discussed, there are extensive and diverse labeled uses for permethrin that are much more varied than many pesticides in potential use site geography. Therefore, it was assumed that an assessment to determine the distance from the application site where spray drift exposures to non-target areas do not result in LOC exceedances, while suitable for evaluating a single use site of a pesticide, in this case, was probably of limited utility because direct application of permethrin throughout the entire state of California was possible, and would tend to dominate the risk conclusions for all of the listed species considered in this assessment.

Small Terrestrial Vertebrates

For permethrin spray applications, dietary-based and dose-based exposures of terrestrial-phase CRLF potential small terrestrial vertebrate prey (mammals and amphibians) are assessed when possible using small mammals (15 g) which consume short grass, and small birds (20g; they represent terrestrial-phase amphibians that it may consume) which consume small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of any small terrestrial vertebrate prey items that may be exposed to granular permethrin (15 g mammals or terrestrial-phase amphibians) or seed treatments (15 g mammals) were assessed when possible.

RQ values representing direct exposures of permethrin to terrestrial-phase CRLFs are also used to represent exposures of permethrin to amphibians in terrestrial habitats that may serve as prey for the CRLF. For terrestrial-phase amphibians, as described in **Section 5.2.1.1**, the Agency determined that based on the weight-of-evidence involving chronic risk LOC exceedances with T-REX and the refined T-HERPS model, and spatial overlap of permethrin uses in California and CRLF habitat, there is potential for labeled permethrin use to cause adverse effects to terrestrial-phase amphibians via chronic toxicity, despite that acute lethality to terrestrial-phase amphibians appears to be unlikely.

Please refer to **Section 5.2.1.1** for additional discussion and characterization of potential risks to terrestrial-phase amphibians that may serve as prey for the terrestrial-phase CRLF.

For small mammalian prey items, based on surrogate toxicity data (LD_{50}=152 mg/kg-bw and NOAEL = 2.77 mg/kg-bw/day), the maximum allowable application rate (3 applications, 4.23 lbs a.i./acre/application, 5-day application interval), the foliar dissipation half-life of 15.4 days for permethrin from Willis and McDowell (1987), and upper bound Kenaga values from T-REX, RQs for mammals exceed the Agency's non-listed species acute risk LOC (RQ≥0.5) and chronic risk LOC (RQ≥1) for mammals, and therefore, there is a potential for adverse effects to mammals from foliar spray applications of permethrin in CA (**Table 5.6**).

Although EECs for small mammals feeding or short grass yield the highest risk estimates and provide the basis by which risk conclusions are reached for the mammalian prey base, it appears that the impacts of permethrin use to mammals potentially extend beyond 15g mammals that eat short grass. The dose-based acute RQs range from <0.01 to 7.05, from <0.01 to 3.23, from <0.01 to 3.96, and from <0.01 to 0.44, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. For acute dose-based RQs, 14 of the 34 modeled scenarios used resulted in an exceedance of the Agency's non-listed species acute risk LOC (RQ≥0.5) for mammals that feed on short grass, 4 of the 34 modeled scenarios resulted in an exceedance of the Agency's non-listed species acute risk LOC (RQ≥0.5) for mammals that feed on tall grass, 5 of the 34 modeled scenarios resulted in an exceedance of the Agency's non-listed species acute risk LOC (RQ≥0.5) for mammals that feed on broadleaf plants/small insects, and 0 of the 34 modeled scenarios resulted in an exceedance of the Agency's non-listed species acute risk LOC (RQ≥0.5) for mammals that feed on fruits/pods/seeds/large insects.

The dose-based chronic RQs range from 0.08 to 387.30, from 0.04 to 177.51, from 0.05 to 217.86, and from 0.01 to 24.21, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. For chronic dose-based RQs, 33 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on short grass, 32 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on tall grass or broadleaf plants/small insects, and 28 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on fruits/pods/seeds/large insects.

The dietary-based chronic RQs range from 0.01 to 44.64, from <0.01 to 20.46, from 0.01 to 25.11, and from <0.01 to 2.79, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. For chronic dietary-based RQs, 30 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on short grass, 25 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on tall grass, 28 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on broadleaf plants/small insects, and 1 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on fruits/pods/seeds/large insects.

The $LD_{50}ft^{-2}$ and fugacity-based approaches resulted in RQs for granular permethrin applications that exceed the Agency's non-listed species acute risk LOC (RQ≥0.5) and chronic risk LOC (RQ≥1) for mammals, respectively (**Tables 5.7** and **5.7**; acute RQs range fro 0.41 to 2.07; chronic dose-based RQs range from 1.74 to 8.38; chronic dietary-based RQs range from 0.20 to 0.97); therefore, there is a potential for adverse effects to mammals from granular applications of permethrin in CA.

The T-REX seed treatment analysis resulted in RQs for permethrin seed treatments that exceed the Agency's chronic risk LOC (RQ≥1), but not the non-listed species acute risk LOC (RQ≥0.5) for mammals (**Table 5.9**; acute RQs Based on Available A.I. <0.01; acute RQs Based on Nagy Dose= 0.20; Chronic RQs Based on Maximum Seed Application Rate =5.65); therefore, there is a potential for adverse effects to mammals from seed treatment uses of permethrin in CA via chronic toxicity.

Based on a default slope of 4.5 (with upper and lower bounds of 2 and 9), the most sensitive LD_{50} available for mammals (LD_{50}=152 mg/kg-bw) and the highest and lowest acute RQ values for mammals (RQ = 7.05 and <0.01, respectively), the chance of an individual mortality for mammals ranges from ~ 1 in 1 (with lower and upper bounds of ~ 1 in 1.05 to 1 in 1) to <~1 in 8.86×10^{18} (with lower and upper bounds of <~ 1 in 3.16×10^{4} to <1 in 1.03×10^{72}); the likelihood of individual mortality for each use is available in **Table 5.13**.

An analysis of ecological incidents results in no relevant reported effects to small mammals involving permethrin exposures. Only one incident involving the death of a dog following direct treatment with permethrin and cypermethrin was reported. A full list of all terrestrial incidents involving permethrin is shown in **Table 4.5**.

The biggest sources of uncertainties for the assessment of potential effects to small mammals stem from the selection of acute and chronic endpoints used to estimate risk. For estimation of acute risk to mammals, the LD_{50} value estimated from a study that exposed 8-day old neonatal rats exposed via gavage was used. While it has been acknowledged that the toxicity endpoint and the associated approximated risk estimates for free-feeding wild mammals based on 8-day old neonatal rats exposed via gavage may represent a conservative scenario, it has also been noted that some small mammals, some members of the Muridae Family for example, are weaned within the first week following birth (Whitaker and Hamilton, 1998). While the Agency maintains this position and will rely on the conservative estimates of toxicity and risk for mammals in order to be as protective of the assessed species as is reasonable, additional characterization is provided to gauge how the overall risk conclusions for spray applications of permethrin could be altered if a different approach had been taken. Alternative possibilities are only evaluated for spray applications because those are the uses that are expected to pose the largest risk to terrestrial wildlife.

While the small number of species for which definitive endpoints have been established inhibits the generation of a meaningful species sensitivity distribution for mammals, there were a total of four mammalian acute data values available for this assessment that were based on oral gavage exposure of young adult/mature rats. These reported LD_{50} values are 570, 1500.0, 2280, and 8900, mg a.i./kg-bw (see **Section 4.2.2** for details). If the two highest young adult/mature rat LD_{50} values (8900 and 2800 mg a.i./kg-bw) had been used to estimate acute risk, the Agency's non-listed species acute risk LOC ($RQ \geq 0.5$) would not have been exceeded even for the modeled scenario expected to result in the largest exposure to terrestrial wildlife (Residential Turf and Ornamentals; maximum theoretical dose-based acute RQ = 0.12 and 0.38, respectively). However, if the lowest open literature and registrant-submitted toxicity values for young adult/mature rats were used (1500 and 570 mg a.i./kg-bw, respectively) instead of the 8-day old rat LD_{50} value, the Agency's non-listed species acute risk LOC ($RQ \geq 0.5$) would have still been exceeded for the modeled scenario expected to result in the largest exposure to terrestrial wildlife (Residential Turf and Ornamentals; maximum theoretical dose-based acute RQ = 0.72 and 1.88, respectively). Since there would be no clear explanation for selecting one of the less sensitive young adult/mature rat LD_{50} values over the most sensitive young adult/mature rat LD_{50} value of 570 mg a.i./kg-bw (*e.g.*, different exposure route or different age group), it can be reasonably concluded that risk conclusions would not be substantially altered had an LD_{50} value for a less sensitive age group of rats been used to assess potential acute effects to small mammals as result of permethrin exposure.

For estimation of chronic risk to mammals, a NOAEL value (2.77 mg/kg-bw/day) estimated from a reproduction study with mice that exposed 10-week old mice by gavage before mating for 5 days a week for 4 weeks was used. As previously discussed, the 2-generation reproduction studies with rats that are submitted to the Agency typically expose rats via treated feed. Therefore, the dosing regime in the study with mice represents one that is intensified as compared to what the Agency normally receives for reasons previously discussed in **Section 4.2.2**. However, because the degree to which the exposures in this study are representative of actual high-end exposure scenarios encountered is uncertain, the Agency maintains its position of relying on the conservative estimates of toxicity and risk for mammals in order to be as protective of the assessed species as is reasonable. Additional characterization is provided to gauge how the overall risk conclusions for spray applications of permethrin could be altered if a different approach had been taken. Again, alternative possibilities are only evaluated for spray applications because those are the uses that are expected to pose the largest risk to terrestrial wildlife.

Only one acceptable/guideline three generation reproduction study with rats that exposed animals via treated feed was available to the Agency for this assessment. Even if chronic RQs for mammals were based on the highest concentration tested in this study (2500 ppm or 125 mg/kg-bw/day), at which tremors were observed in adults (no other observed effects), the Agency's chronic risk LOC ($RQ \geq 1$) would have still been exceeded for the modeled scenario expected to result in the largest exposure to terrestrial wildlife (Residential Turf and Ornamentals; maximum theoretical dose-based chronic RQ = 8.58). In addition, it should be noted that one of the major deficiencies noted for this study was a lack of homogeneity and stability of the compound in the test diets, suggesting that the estimated exposure levels and estimates of toxicity in this study may be unreliable. Subsequently, the potential for effects could not be precluded and it can be reasonably concluded that risk conclusions would not be substantially altered if a NOAEL derived from a reproduction study with rats that exposed test subjects via a less intense exposure regime (*i.e.*, treated feed), had been used to assess potential chronic effects to small mammals as result of permethrin exposure.

As discussed for direct effects to frogs that may consume aquatic organisms in **Section 5.2.1.1**, because there is some evidence of the potential for bioconcentration of permethrin in aquatic organisms, an additional exposure pathway that should be considered for mammals is the consumption of contaminated food items (*e.g.*, fish or aquatic invertebrates) that have bioconcentrated permethrin dissolved in water. A comparison of the estimated tissue concentration in aquatic organisms (3.4 ppm) to maximum EECs for spray applications estimated from T-REX and T-HERPS, reveals that this pathway results in substantially lower estimates of exposure relative to the consumption of contaminated dietary items found in the terrestrial environment. In fact, only two of the 34 scenarios modeled in T-REX produced EECs for terrestrial food items lower than this estimated value for tissue concentrations in aquatic organisms; EECs for all dietary items under the Adulticide (Mosquito Control Post-CFR 2005-1) scenario and EECs for large insects under the Soil Barrier treatment (Urban and Rural Structures) scenario. Therefore, it is expected that risk estimates for mammals consuming a variety of terrestrial dietary food items will tend to drive the risk conclusions for mammals. Regardless, based on the conservative comparison of tissue EECs estimated using *peak* water EECs and the maximum whole fish tissue BCF, with the most sensitive chronic NOAEC for mammals (55.4 mg a.i./kg-diet), the risk estimate for mammals resulting from this exposure pathway (RQ = 0.06) is below not only the Agency's chronic risk LOC, but also below the Agency's listed species acute LOC for mammals (RQ≥0.1). Therefore, it is believed that this exposure pathway does not pose a significant acute or chronic risk to mammals relative to other potential routes considered in this assessment.

In conclusion, based on the exceedances of the Agency's non-listed species acute risk LOC (RQ≥0.5) and chronic risk LOC (RQ≥1) for small mammals feeding on a variety of terrestrial food items for the various permethrin seed, spray, and granular application scenarios considered, the high probability of an individual mortality occurrence based on the highest acute RQ for mammals (~1 in 1), the relative insensitivity of risk conclusions to selection of less conservative acute and chronic endpoints, and the spatial overlapping of patterns of permethrin use throughout the entire state of California with CRLF habitat, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the terrestrial-phase CRLF from loss of terrestrial vertebrate prey as a result of labeled permethrin use in California.

5.2.1.3 Indirect Effects (*via Habitat Effects*)

Aquatic (Vascular and Non-vascular) and Terrestrial Plants

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 aquatic species.

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.

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production are typically assessed using RQs from freshwater aquatic vascular and non-vascular plant data, as well as terrestrial plant data. Historically, however, aquatic and terrestrial plant toxicity studies and associated risk analysis of plants were not required for registration of a pesticide unless it met specific use and pesticide classification criteria which would trigger potential concerns, and no plant studies have been submitted by the registrants for permethrin. Only a couple of toxicity studies with aquatic non-vascular plants were available to the Agency for quantitative use in this assessment. Based on the most sensitive surrogate aquatic non-vascular plant toxicity data (EC_{50} value of 68 µg a.i./L for the marine alga, *Skeletonema costatum*) and the maximum aquatic peak EEC of all use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all RQs for aquatic non-vascular plants are $\leq$0.08 (**Table 5.5**).

No such data are available to reliably quantitatively evaluate the effects and the potential risks of permethrin to vascular aquatic plants or terrestrial plants. However, aquatic non-vascular plants are not particularly sensitive to permethrin; permethrin has a neural toxic mode of action; and no studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. In addition, since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants (all terrestrial plants), and none have reliably linked permethrin to the observed effects with a certainty index of “probable” or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Therefore, although effects to vascular aquatic and terrestrial plants cannot be quantified due to the lack of data, since the RQs do not exceed the Agency’s LOC (1) for aquatic non-vascular plants based on the most sensitive data available to the Agency, and because available lines of evidence provide no compelling reason to believe that permethrin will affect any type of plants to the extent that it would affect the habitat integrity of the CRLF, labeled permethrin use in California is not likely to indirectly affect the CRLF via impacts to habitat and/or primary production.

5.2.1.4 Modification to Designated Critical Habitat

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 effects to aquatic and terrestrial plants are used to determine whether modification to critical habitat may occur. As discussed above for aquatic plants and terrestrial plants (**Section 5.2.1.3**), labeled permethrin use in California appears not likely to indirectly affect the CRLF via impacts to habitat and/or primary production.

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. Based on the analyses discussed above, there is a potential for habitat modification via impacts to aquatic-phase CRLFs (**Sections 5.2.1.1**) and effects to freshwater invertebrates and fish as food items (**Sections 5.2.1.2**) from permethrin use in California.

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 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.

As discussed above for terrestrial plants (**Section 5.2.1.3**), labeled permethrin use in California appears not likely to indirectly affect the CRLF via impacts to habitat and/or primary production.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of permethrin on this PCE, acute and chronic toxicity endpoints for terrestrial invertebrates, mammals, and terrestrial-phase amphibians are used as measures of effects. Based on the potential for a reduction in mammalian, terrestrial invertebrate, and amphibious prey items (**Section 5.2.1.2**), the Agency concludes there is a potential for habitat modification via indirect effects to terrestrial-phase CRLFs via reduction in prey base.

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. Based on the preceding discussions, the Agency concludes there is a potential for habitat modification via direct (**Section 5.2.1.1**) and indirect effects (**Section 5.2.1.2**) to terrestrial-phase CRLFs.

5.2.2 California Clapper Rail

5.2.2.1 Direct Effects

There are very little monitoring data for permethrin to compare with modeling results and because these data come from non-targeted studies, they are of limited value for analysis. Therefore, modeled results are used for assessing risks to all species in this assessment.

As previously discussed in **Section 5.2.1.1**, permethrin is currently registered for numerous diverse uses (agricultural, industrial, commercial, public, and residential) that span a large variety of use sites and geographical regions throughout the entire state of California and allow for the potential for year-round use (**Figure 5.1**). Therefore, there is the potential for permethrin use in any given area across the state to spatially and temporally coincide with the CCR breeding season.

In addition, as there are two peaks in nesting activity in late April to early May and late June to early July, when the CCR typically nest in lower marsh zones along tidal creeks where cordgrass is abundant, there is potential for periods of nesting activity to overlap temporally with peak usage of permethrin (May through September). Incubation of the eggs lasts from 23 to 29 days, parents continue to care for or accompany the nestlings after hatch for up to eight weeks, and the young are chased by their parents from the parents' territory once there are able to feed on their own, typically after 35 to 42 days. Juveniles fledge (gain feathers for flight) at ten weeks and can breed during the spring after they hatch.

As previously discussed in **Section 5.2.1.1**, where the potential for direct effects to the terrestrial-phase CRLF was considered, although T-REX has the capability to generate dietary estimates of acute exposure and risk, and dose-based estimates of acute exposure and risk for a variety of body-sizes of birds, acute estimates of risk for birds were not generated because the acute avian effects data show no treatment-related mortality to bobwhite quail at the highest tested level of permethrin in the sub-acute avian dietary studies (LC_{50} >10,000 mg/kg-diet). In addition, no treatment-related mortality was observed in the acute oral toxicity study establishing the most sensitive acute LD_{50} value for birds (mallard duck LD_{50}> 9,869 mg/kg-bw).

The fact that definitive acute toxicity endpoints are unavailable for acute risk estimation presents an area of uncertainty in this assessment with respect to the potential for direct effects to the CCR. Although Agency policy is to not calculate acute risk estimates for a chemical if it can be classified as practically non-toxic and no mortality was observed in the acute toxicity tests at the highest treatment level, there still may be some uncertainties with regards to risk if predicted dose- and dietary-based EECs based on relevant food items for the CCR exceed or approach the highest tested levels.

To characterize this uncertainty for the CCR, the model T-REX was run using the most sensitive non-definitive endpoints (LC_{50} >10,000 mg/kg-diet and LD_{50}> 9,869 mg/kg-bw) for avian species for spray applications, seed treatments, and granular applications. For seed treatments, none of the theoretical acute RQs exceeded the Agency's listed species acute risk LOC (RQ ≥0.1). For granular applications, only the theoretical acute RQ for small birds (20g) for the maximum granular exposure scenario (Residential) considered in this assessment meets the Agency's listed species acute risk LOC of 0.1 (RQ =0.1). For permethrin spray applications, based on the run of T-REX with the non-definitive endpoints and the maximum exposure scenario considered in this assessment (Residential Turf and Ornamentals), the theoretical acute dose-based RQs exceed the Agency's listed species acute risk LOC (RQ ≥0.1) for small birds (20g) consuming short grass (RQ<0.55), tall grass (RQ<0.25), and broadleaf plants/small insects (RQ<0.31), but not for small birds (20g) consuming fruits/pods/seeds/large insects (RQ<0.03). In addition, theoretical acute dose-based RQs exceed the listed species acute risk LOC (RQ ≥0.1) for medium birds (100g) consuming short grass (RQ<0.25), tall grass (RQ=0.11), and broadleaf plants/small insects (RQ<0.14), but not for medium birds (100g) consuming fruits/pods/seeds/large insects (RQ<0.02). Lastly, theoretical acute dietary-based RQs exceed the listed species acute risk LOC (RQ ≥0.1) for birds consuming short grass (RQ<0.25), tall grass (RQ<0.11), and broadleaf plants/small insects (RQ<0.14), but not for birds consuming fruits/pods/seeds/large insects (RQ<0.02). The only other theoretical RQs that would marginally exceed the Agency's listed species acute risk LOC (RQ ≥0.1) are dose-based acute RQs for small birds (20g) consuming short grass under the Turf (Golf Course and Recreational Areas), Nursery (Pine Seed Orchard-

Maximum), and Ant Mound Treatments (Non-ag, Turf, Recreational, & Ag. Fruit Trees) scenarios (RQs< 0.15, 0.12, and 0.12, respectively). All RQs are "less than" the reported values because the toxicity endpoints upon which they are based are "greater than" the reported values.

For all acute RQs to definitively be below the Agency's listed species acute risk LOC (0.1) for all modeled scenarios and uses (*i.e.*, spray or granular uses) except the Residential Turf and Ornamentals spray application scenario, the avian LD_{50} value for permethrin would have to be established as >16,000 mg a.i./kg-bw. Because there are only marginal exceedances for those scenarios based on test levels at which zero mortality was observed, and LD_{50} values of >16,000 mg a.i./kg-bw have been established for some avian species in studies that set test levels high enough (*i.e.*, starlings and Japanese quail), it seems likely that for all exposure scenarios considered besides Residential Turf and Ornamentals, the risk of direct acute lethality to the CCR is low. However, it is difficult to reach similar conclusions for the Residential Turf and Ornamentals spray application scenario, for which the LD_{50} and LC_{50} values for permethrin would have to be established as roughly >58,000 mg a.i./kg-bw and >27,000 mg a.i./kg-diet, respectively, for all acute RQs to definitively be below the Agency's listed species acute risk LOC (0.1).

Although permethrin is of very low acute toxicity to birds, it is within the realm of possibility given the current established thresholds of acute toxicity for the most sensitive species tested, that the LD_{50} and LC_{50} values for permethrin could be <58,000 mg a.i./kg-bw and <27,000 mg a.i./kg-diet, respectively, thus triggering concerns of acute lethality to birds for the highest exposure scenario possible for permethrin. The LC_{50} and LD_{50} values for birds in studies that have tested the highest exposure levels are >23,000 mg a.i./kg-diet and >42,706 mg a.i./kg-bw, respectively. Subsequently, risk of direct acute lethality to the CCR under this exposure scenario cannot be precluded given the potential for very high exposure levels resulting from use on Residential Turf and Ornamentals.

An analysis of ecological incidents reveals two incidents were reported to the Agency involving birds; however, one of the incidents involving the death of three birds was only listed as possible and multiple pesticides were implicated as the possible cause. The other incident was also listed as possible and involved the death of four parakeets following home treatment with permethrin; however, no analytical evidence linking the deaths to permethrin was reported. These incidents provide nothing more than anecdotal information, and do not provide substantial evidence suggesting the potential for direct effects to the CCR. However, as previously noted, a lack of reported incidents does not necessarily indicate a lack of risk. Although permethrin is classified as practically non-toxic to birds and is not likely to pose a risk of direct effects to the CCR for most uses, should exposure occur at levels on par with those predicted by T-REX for the Residential Turf and Ornamentals scenario, it is not possible to preclude the potential for direct effects to the CCR based on the available lines of evidence.

Direct chronic exposure of juvenile and adult CCR in terrestrial environments was evaluated based on the dietary-based EECs estimated using various approaches (*i.e.*, T-

REX for foliar spray applications, T-REX seed treatment analysis, and the fugacity-based model for insectivorous wildlife) for birds consuming a variety of dietary items. All estimated EECs (*i.e.*, EECs for short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, seeds, and soil dwelling invertebrates) were considered relevant for evaluation because the CCR has been observed feeding on seeds, worms, insects, and plant material.

Based on surrogate avian toxicity data (NOAEC = 125 mg/kg-diet for mallards), the maximum allowable application rate (3 applications, 4.23 lbs a.i./acre/application, 5-day application interval), the foliar dissipation half-life of 15.4 days for permethrin from Willis and McDowell (1987), and upper bound Kenaga values from T-REX, there is a potential for direct adverse effects to CCR individuals from foliar spray applications of permethrin in CA (**Table 5.6**). The dietary-based chronic RQs range from <0.01 to 19.78, from <0.01 to 9.07, from <0.01 to 11.13, and from <0.01 to 1.24, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. While 24 of the 34 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on short grass, 9 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on broadleaf plants/small insects, 7 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on tall grass, 1 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for birds that feed on fruits/pods/seeds/large insects, and 10 of the 34 modeled scenarios resulted in no exceedances of the Agency's chronic risk LOC (RQ≥1).

Based on RQs for permethrin seed treatments (chronic RQs= 2.50) exceeding the Agency's chronic risk LOC (RQ≥1), there is a potential for direct adverse effects on CCR individuals that feed on seeds as result of permethrin seed treatments in CA (**Table 5.9**). RQs for granular applications of permethrin do not exceed the Agency's chronic risk LOC of 1 (RQs ≤ 0.43) (**Table 5.8**).

T-HERPS can also be used for evaluating the potential for direct chronic toxic risks to the CCR resulting from spray applications of permethrin. While T-HERPS is a form of T-REX modified to be more reflective of the food requirements of amphibians and allow for an estimation of food intake for poikilotherms, it can also be used to estimate dietary-based EECs and RQs (not dose-based since daily food intake in T-HERPS is adjusted using an allometric model for poikilotherms) for additional relevant food categories for the CCR; small herbivorous mammals and small insectivorous mammals. **Table 5.14** presents the results of the T-HERPS model run with surrogate avian toxicity data (NOAEC of 125 mg a.i./kg-diet) and the attendant RQ calculations for chronic effects. Based on the results of T-HERPS run for the CCR, consumption of small herbivorous mammals also poses direct chronic risk at levels exceeding the chronic LOC for 13 out of the 34 scenarios modeled to represent all of the agricultural and non-agricultural uses of permethrin in CA.

As previously discussed in **Section 5.2.1.1**, where the potential for direct effects to the terrestrial-phase CRLF was considered, one source of uncertainty with respect to the potential for direct effects to the CCR via chronic toxicity is due to the reliance on the NOAEC of 125 mg a.i./kg-diet for mallards (MRID 42322901), based on non-statistically significant effects at the 500 mg a.i./kg-diet treatment level, to derive chronic risk estimates. Although the effects were not statistically significant, given the magnitude of effects (overall decrease in egg production by 13.2% relative to the controls), the associated increase in occurrences of regressed ovaries (8 hens in the 500 mg a.i./kg-diet treatment group compared to 2 in control), and the acknowledgment by the study authors that the effects may be treatment-related, the NOAEC and LOAEC for this study have been set at 125 and 500 mg a.i./kg-diet, respectively. However, had the RQ estimates been calculated using the highest treatment level (500 mg a.i./kg-diet) instead of the set NOAEC, there still would have been exceedances of the Agency's chronic risk LOC (1) for the CCR consuming short grass for 4 of the 34 modeled scenarios for spray applications of permethrin; there would be no exceedances for seed treatments or granular applications. In addition, for the maximum spray application exposure scenario considered in this assessment (Residential Turf and Ornamentals), there would have been exceedances of the Agency's chronic risk LOC (1) for the CCR consuming tall grass, broadleaf plants/small insects, and small herbivorous mammals.

There is some evidence of the potential for bioconcentration of permethrin in aquatic organisms. Therefore, because the CCR consumes fish and aquatic invertebrates, an additional exposure pathway that should be considered in this assessment for the CCR is the consumption of contaminated food items that have bioconcentrated permethrin dissolved in water. As discussed in **Section 5.2.1.1** for direct effects to the terrestrial-phase CRLF, a comparison of the aquatic organism tissue EEC estimated based on the peak water concentration and the maximum whole fish tissue BCF, to the acute and chronic avian toxicity endpoints (conservative approach; LC_{50} >10,000 mg/kg-diet and NOAEC = 125 mg/kg-diet) demonstrates that the estimated peak EEC in aquatic organisms (3.4 ppm) is an order of magnitude or more lower than both. In addition, because peak water EECs were used to derive aquatic organism EECs rather than 60-day water concentrations, the estimate of chronic risk for this pathway is considered to be conservative. Also, given that permethrin is very highly toxic and may cause lethality in aquatic organisms at very low concentrations, it is quite possible that permethrin may never even reach levels this high in many aquatic organisms. However, if there are tolerant aquatic species that can survive high exposure concentrations and are able to bioconcentrate permethrin to these levels, it still appears as though risk estimates for the CCR resulting from this exposure pathway are substantially lower than the Agency's acute and chronic LOCs. Subsequently, risk estimates for birds consuming a variety of terrestrial dietary food items will tend to drive the risk conclusions for direct effects to the CCR.

Therefore, given the weight-of-evidence involving chronic risk LOC exceedances based on the T-REX and T-HERPS models for the majority of the modeled use scenarios in this assessment (~70% of the scenarios for spray applications had at least one exceedance of the chronic risk LOC for various dietary items), the inability to preclude risk of acute lethality to the CCR should exposure occur at levels on par with those predicted by T-REX for the Residential Turf and Ornamentals scenario, and spatial overlap of permethrin use sites throughout California and CCR habitat, there is potential for labeled permethrin use to cause direct adverse effects to the CCR.

5.2.2.2 Indirect Effects (*via Reductions in Prey Base*)

As discussed previously in **Section 2.5**, CCRs are generalist and opportunistic feeders that forage for food in tidal sloughs and channels. Although their diet are comprised primarily of freshwater and estuarine marine invertebrates, it may also include seeds, worms, mussels, snails, clams, crabs, crayfish, various other crustaceans, insects, spiders, small birds and mammals, and dead fish. In addition, while the CCR is primarily carnivorous, a study examining the stomach contents of 18 CCRs in South San Francisco Bay showed that the CCR diet may contain up to 15% plant material.

Freshwater Fish

RQ values representing exposures of permethrin to freshwater fish that may serve as prey for the aquatic-phase CRLF, are also used to represent exposures of permethrin to freshwater fish that may serve as prey for the CCR. As described in **Section 5.2.1.2**, the Agency determined that based on the assumption that the distribution of tested freshwater fish species endpoints reasonably approximates the distribution of sensitivities of freshwater fish in CCR habitats, and exceedances of non-listed species acute (39 of 48 modeled scenarios) and chronic risk (40 of the 48 modeled scenarios) LOCs for freshwater fish, the high probability of an individual mortality occurrence using the highest acute RQ for freshwater fish (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CCR habitat, and the reported aquatic incidents involving fish, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the CCR from loss of freshwater fish prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to freshwater fish that may serve as prey for the CCR.

Freshwater Invertebrates

RQ values representing exposures of permethrin to freshwater invertebrates that may serve as prey for the aquatic-phase CRLF, are also used to represent exposures of permethrin to freshwater invertebrates that may serve as prey for the CCR. As described in **Section 5.2.1.2**, the Agency determined that based on the exceedances of non-listed species acute and chronic risk LOCs for freshwater invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence using both the highest and lowest acute RQ for freshwater invertebrates (~1 in 1 and ~1 in 1.08, respectively), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CCR habitat, and the reported aquatic incidents involving the least sensitive tested freshwater invertebrate, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the CCR from loss of freshwater invertebrate prey as result of labeled permethrin use in California should exposure at the predicted EECs actually occur for invertebrates with sensitivity to permethrin reasonably represented by the distribution of tested invertebrate species endpoints. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to freshwater invertebrates that may serve as prey for the CCR.

Estuarine/Marine Fish

Based on surrogate estuarine/marine fish toxicity data (LC_{50} value of 2.2 µg a.i./L for Atlantic silverside) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for estuarine/marine fish range from 0.02 (Soil Barrier Treatment on Fencerows and Hedgerows) to 2.50 (Nursery Uses and Residential Turf and Ornamentals). Of the 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, 10 resulted in an exceedance of the Agency's non-listed species acute risk LOC ($RQ \geq 0.5$) for estuarine/marine fish (**Table 5.3**).

Currently, there are no ecological incidents reported to the Agency specifically for estuarine/marine fish; however, there are freshwater fish incidents reported. As previously discussed in **Section 5.2.1.2**, these incidents may support the predicted effects to the fish prey base. Of the twenty-six total reported aquatic incidents, twenty-four affected fish species, and seven are listed as highly probable, ten as probable, and seven as possible. Approximately eleven of the incidents associated with fish kills resulted from registered use of permethrin, while association of five of the incidents to legal permethrin use were unknown, and eight were misuses. The registered uses that the incidents were linked to run a wide gamut of the uses that permethrin is registered for in California and included: application to residential lawns, application to commercial buildings, use for termite control, miscellaneous residential uses, use for mosquito vector control, and application to crops. Given the significant number of incidents associated with a wide gamut of registered uses of permethrin, it does lend credence to the exposure and risk estimates generated in this risk assessment.

Based on a default slope of 4.5 (with upper and lower bounds of 2 and 9), the LC_{50} of the most sensitive acute estuarine/marine fish (Atlantic silverside; LC_{50} = 2.2 µg a.i./L) and the highest acute RQ value for estuarine/marine fish (RQ=2.50, for Nursery Uses and Residential Turf and Ornamentals), the likelihood of individual mortality is ~ 1 in 1.04 (with lower and upper bounds of ~ 1 in 1.27 to 1 in 1)(**Table 5.12**).

As was done for the CCR's freshwater fish prey base, the most sensitive acute endpoint available for estuarine/marine fish was used to quantitatively evaluate risk to this taxonomic group. However, other less sensitive definitive endpoints were available for four other species of estuarine/marine fish, and definitive LC_{50} values for all tested species range from 2.2 to 7.8 µg a.i./L; in other words, other LC_{50} values are up to three times less sensitive than the Atlantic silverside endpoint used in RQ calculations. Because there is potential that Atlantic silversides and other fish species may not truly be affected at levels suggested by the most conservative LC_{50} selected for RQ calculation, the same approach that was done previously for the analysis of available freshwater fish data was performed for available estuarine/marine fish data (please refer to previous description of approach in **Section 5.2.1.1**). In total, there were four different fish species for which one or more definitive LC_{50} values were available (inland silverside, Atlantic silverside, sheepshead minnow, and striped mullet; **Table 5.17**). This suite of acute endpoints was compared with the EECs available from acute aquatic residue estimates for all use scenarios to determine the number of modeled scenarios for which the acute non-listed species LOC (0.5) would be exceeded based on the LC_{50} for each tested species. **Table 5.17** summarizes the results of these comparisons, which suggest that even relying on the LC_{50} for the least sensitive species tested (sheepshead minnow), the non-listed species acute risk LOC would still be exceeded for approximately 11% of the modeled scenarios (5 of 45). For the rest of the tested species (3 of 4), 13% or more of the modeled scenarios would result in an exceedance of the non-listed species acute risk LOC.

Table 5.17. Results of acute and chronic permethrin EECs compared with distribution of estuarine/marine fish LC_{50} and estimated NOAEC values.

SPECIES	NUMBER OF ACUTE VALUES USED TO CALCULATE THE SPECIES MEAN LC_{50} VALUE	SPECIES GEOMETRIC MEAN ACUTE LC_{50} VALUE (µg a.i./L)	ESTIMATED CHRONIC NOAEC BASED ON GEOMETRIC MEAN & FATHEAD MINNOW ACUTE-TO-CHRONIC RATIO	# OF MODELED SCENARIOS FOR WHICH NON-LISTED SPECIES ACUTE RISK LOC OF 0.5 WOULD BE EXCEEDED	# OF MODELED SCENARIOS FOR WHICH CHRONIC LOC WOULD BE EXCEEDED
Inland Silverside (*Menidia beryllina*)	2	6.4	0.4172	6 of 45	6 of 45
Sheepshead Minnow *(Cyprinodon variegatus)*	1	7.8	0.5085	5 of 45	6 of 45
Atlantic Silverside *(Menidia menidia)*	1	2.2	0.1434	10 of 45	18 of 45
Striped Mullet (*Mugil cephalus*)	1	5.5	0.3585	6 of 45	6 of 45

In addition to estuarine/marine fish being at lethal risk from permethrin use, based on 60-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.1434 µg a.i./L, all chronic RQs for estuarine/marine fish range from 0.05 (Soil Barrier Treatment on Fencerows and Hedgerows) to 21.97 (Nursery Uses based on the current maximum label rate for pine seed orchards). While 18 of the 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA resulted in an exceedance of the Agency’s chronic risk LOC (RQ≥1) for estuarine/marine fish, 27 of the 45 modeled scenarios did not (**Table 5.3**).

The one major area of uncertainty with regards to the assessment of chronic effects to the estuarine/marine fish prey base of the CCR involves the estimation of the chronic NOAEC employed for determining chronic risk to fish using an acute-to-chronic ratio. Although a single early life-stage study with sheepshead minnows (*Cyprinodon variegatus*) was available to the Agency to evaluate the effects of chronic exposure to permethrin, the study was considered unacceptable for quantitative risk estimation purposes because a NOAEC could not be established due to observed effects (reduced survival) at the lowest tested concentration of 10 µg a.i./L (NOAEC < 10 µg a.i./L). In addition, no other information regarding the magnitude of observed effects was reported in the study to evaluate whether the LOAEC in this instance may reasonably approximate the NOAEC. Therefore, a NOAEC of 0.1434 µg a.i./L was estimated for Atlantic silversides, the most acutely sensitive estuarine/marine fish, based on the fathead minnow acute to chronic ratio (ACR=15.34). The resulting estimated NOAEC of 0.1434 µg a.i./L for Atlantic silversides was approximately seventy times more sensitive than the sheepshead minnow LOAEC. While the application of a uniform ACR across taxonomic groups does introduce uncertainty into risk estimation, in the absence of a reliable chronic NOAEC for this taxonomic group it does allow for a reasonable approximation of chronic risk. If risk had been based on the LOAEC of 10 µg a.i./L, the uncertainties would have been perhaps even greater because all RQ values would have been preceded by a greater than sign due to the lack of a defined NOAEC. If the LOAEC were used for risk estimation purposes, none of the modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA would have resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) because all estimated exposure concentrations were below the limit of solubility of permethrin (~5.5 µg a.i./L).

However, it is noted that a similar analysis as to what was performed above to evaluate the impact of selecting alternative acute endpoints on the overall risk conclusions can be performed for characterization of potential for chronic risk to estuarine/marine fish as well. Based on an evaluation of how sensitive risk conclusions are to the selection of an extrapolated chronic endpoint among a number of those available for various species of estuarine/marine fish differing in sensitivity to permethrin (please refer to previous description of approach in **Section 5.2.1.1**), it was determined that the chronic risk LOC would be exceeded for 6 of the 45 modeled scenarios if the extrapolated NOAEC for three of the four tested species were relied upon for risk estimation (**Table 5.17**). In other words, one-third of the modeled scenarios that resulted in exceedances of the chronic risk LOC when based on the most sensitive tested species (Atlantic silverside), exceeded when based on extrapolated NOAEC values for less sensitive species.

In conclusion, based on the exceedances of non-listed species acute and chronic risk LOCs for estuarine/marine fish for over 10% of the modeled scenarios assessed regardless of the species endpoints selected for risk estimation purposes, the high probability of an individual mortality occurrence using the highest acute RQ for estuarine/marine fish (~1 in 1.04), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CCR habitat, and a number of reported aquatic incidents for fish, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the CCR from loss of estuarine/marine fish prey as result of labeled permethrin use in California should exposure at the predicted EECs actually occur for fish with sensitivity to permethrin reasonably represented by the distribution of tested fish species endpoints.

<u>Estuarine/Marine Invertebrates</u>

Based on surrogate estuarine/marine invertebrate toxicity data (EC_{50} value of 0.018 µg a.i./L for stone crabs) and modeled aquatic peak EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all acute RQs for estuarine/marine invertebrates range from 2.48 (Soil Barrier Treatment on Fencerows and Hedgerows) to 305.56 (Nursery Uses and Residential Turf and Ornamentals); therefore, the entire set of 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, yielded acute water concentration estimates well in excess of the non-listed species effects benchmark equivalent to one-half of the lowest median lethal concentration for estuarine/marine invertebrates (non-listed species acute LOC = 0.5). In addition, all RQs for every scenario even exceed the estuarine/marine invertebrate median lethal concentration, and in some case by more than two orders of magnitude (**Table 5.4**). This would suggest that mortality levels, regardless of the slope of the dose response function for the tested species, are in excess of 50% for this species.

In fact, based on a default slope of 4.5 (with upper and lower bounds of 2 and 9), the EC_{50} of the most sensitive acute estuarine/marine invertebrate (stone crab; EC_{50} = 0.018 µg a.i./L) and the highest acute RQ value for estuarine/marine invertebrates (RQ = 305.56, for Nursery Uses and Residential Turf and Ornamentals), the chance of an individual mortality for freshwater invertebrates is ~ 1 in 1 (with lower and upper bounds of ~ 1 in 1 to 1 in 1). At the lowest RQ value (RQ = 2.48 for Soil Barrier Treatment on Fencerows and Hedgerows), the likelihood of individual mortality is ~ 1 in 1.05 (with lower and upper bounds of ~ 1 in 1.27 to ~ 1 in 1) (**Table 5.12**).

As was done for freshwater invertebrates, the endpoint selected for RQ calculation was the most sensitive acute endpoint available for all estuarine/marine invertebrates and other less sensitive endpoints were available for other species of invertebrates. The review of available data reveals that definitive estuarine/marine invertebrate EC_{50} values range from 0.018 to 6500 µg a.i./L; in other words, other EC_{50} values are over 360 thousand times less sensitive than the most sensitive endpoint used in RQ calculations. Because there is potential that stone crabs or other estuarine/marine invertebrate species may not truly be affected at levels suggested by the most conservative EC_{50} selected for RQ calculation, the same approach that was done previously for the analysis of available freshwater invertebrate data was performed for available estuarine/marine invertebrate data (please refer to previous description of approach in **Section 5.2.1.1**). In total, there were six different invertebrate species for which one or more definitive EC_{50} values were available (mysid, brown shrimp, pink shrimp, fiddler crab, stone crab, and Pacific oysters; **Table 5.18**). This suite of acute endpoints was compared with the EECs available from acute aquatic residue estimates for all use scenarios to determine the number of modeled scenarios for which the acute non-listed species LOC (0.5) would be exceeded based on the EC_{50} for each tested species. **Table 5.18** summarizes the results of these comparisons, which suggest that relying on the EC_{50} for the least sensitive species tested (Pacific oyster), the non-listed species acute risk LOC would not be exceeded for any of the modeled scenarios, suggesting low potential for acute effects to the estuarine/marine invertebrate prey base. However, the Pacific oyster may not be the most representative of all estuarine/marine invertebrates because it has the ability, unlike many other taxa, to reduce its exposure during acute toxicity tests by temporarily shutting its shell. After Pacific oysters, the next least sensitive species was the fiddler crab; based on the geometric mean EC_{50} for fiddler crabs, the non-listed species acute risk LOC was exceeded for approximately 13% of the modeled scenarios. For the rest of the tested species (4 of 6), 95% or more of the modeled scenarios would result in an exceedance of the non-listed species acute risk LOC.

Table 5.18. Results of acute and chronic permethrin EECs compared with distribution of estuarine/marine invertebrate EC_{50} and estimated NOAEC values.

SPECIES	NUMBER OF ACUTE VALUES USED TO CALCULATE THE SPECIES MEAN EC_{50} VALUE	SPECIES GEOMETRIC MEAN ACUTE EC_{50} VALUE (µg a.i./L)	ESTIMATED CHRONIC NOAEC BASED ON EC_{50} & FATHEAD MINNOW ACUTE-TO-CHRONIC RATIO	# OF MODELED SCENARIOS FOR WHICH NON-LISTED SPECIES ACUTE RISK LOC OF 0.5 WOULD BE EXCEEDED	# OF MODELED SCENARIOS FOR WHICH CHRONIC LOC WOULD BE EXCEEDED
Mysid (*Americamysis bahia*)	4	0.034	0.0022	45 of 45	45 of 45
Brown Shrimp (*Penaeus aztecus*)	1	0.34	0.0222	43 of 45	44 of 45
Pink Shrimp (*Penaeus duorarum*)	3	0.340	0.0222	43 of 45	44 of 45
Fiddler Crab (*Uca pugilator*)	3	3.638	0.2372	6 of 45	15 of 45
Stone Crab (*Menippe mercenaria*)	1	0.018	0.0012	45 of 45	45 of 45
Pacific Oyster (*Crassostrea gigas*)	1	6500	423.73	0 of 45	0 of 45

In addition to estuarine/marine invertebrates being at lethal risk from permethrin use, based on 21-day EECs for various use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, and the estimated NOAEC of 0.0012 µg a.i./L, all chronic RQs for estuarine/marine invertebrates range from 7.77 (Soil Barrier Treatment on Fencerows and Hedgerows) to 3816.67 (Nursery Uses based on the current maximum label rate for pine seed orchards); therefore, the entire set of 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, resulted in an exceedance of the Agency's chronic risk LOC ($RQ \geq 1$) for estuarine/marine invertebrates (**Table 5.4**).

The one major area of uncertainty with the assessment of chronic effects to the estuarine/marine invertebrate prey base of the CCR involves the estimation of the chronic NOAEC using an acute-to-chronic ratio. While there is one chronic exposure study with permethrin involving estuarine/marine invertebrates (MRID 41315701) available to the Agency, this life-cycle study with mysids (*Americamysis bahia*) reports NOAEC and LOAEC values of 0.011 and 0.024 µg a.i./L, respectively, based on a 20% increase in mortality at the LOAEC relative to the control. Since the chronic endpoints for mysids are less sensitive than the most sensitive acute toxicity value (the acute EC_{50} for stone crabs was reported to be 0.018 µg a.i./L), and because the chronic study was not performed using the most acutely sensitive estuarine/marine invertebrate, a chronic NOAEC value of 0.0012 µg a.i./L was estimated for stone crabs (*Menippe mercenaria*) using a fathead minnow acute to chronic ratio (ACR=15.34) in the same manner as for freshwater invertebrates; this value is approximately ten times more sensitive than the most sensitive reported NOAEC value from the chronic tests with mysids. While the application of a uniform ACR across taxonomic groups does introduce uncertainty into risk estimation, in the absence of a reliable chronic NOAEC for this taxonomic group it does allow for a reasonable approximation of chronic risk. However, even based on the less sensitive reported NOAEC of 0.011 µg a.i./L, 44 of the 45 modeled scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA would still result in an exceedance of the Agency's chronic risk LOC (RQ≥1) for estuarine/marine invertebrates and risk conclusions would not be substantially altered.

Based on an evaluation of how sensitive risk conclusions are to the selection of an extrapolated chronic endpoint among a number of those available for various species of estuarine/marine invertebrates differing in sensitivity to permethrin (please refer to previous description of approach in **Section 5.2.1.1**), it was determined that the chronic risk LOC would not be exceeded for any of the modeled scenarios if the extrapolated NOAEC for the least sensitive species tested (Pacific oyster) was relied upon for risk estimation. Although this would suggest low potential for chronic effects to the estuarine/marine invertebrate prey base, the next least sensitive species was the fiddler crab; based on the extrapolated NOAEC for fiddler crabs, the chronic risk LOC was exceeded for approximately 33% of the modeled scenarios (**Table 5.18**). For the rest of the tested species (4 of 6), 98% or more of the modeled scenarios would result in an exceedance of the chronic risk LOC.

Currently, there are no ecological incidents reported to the Agency specifically for estuarine/marine invertebrates. However, there are three freshwater invertebrate incidents reported for freshwater crayfish. As previously discussed in **Section 5.2.1.2**, two of these three incidents link the observed effects to registered uses of permethrin with a certainty index of "highly probable". Therefore, the incidents do support the conclusion that there is potential for effects to the aquatic invertebrate prey base as a whole resulting from labeled permethrin use in California.

In conclusion, based on the exceedances of non-listed species acute and chronic risk LOCs for estuarine/marine invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence using both the highest and lowest acute RQ for estuarine/marine invertebrates (~1 in 1 and ~1 in 1.05, respectively), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CCR habitat, and the reported aquatic incidents for a relatively insensitive tested aquatic invertebrate, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the CCR from loss of estuarine/marine invertebrate prey as result of labeled permethrin use in California should exposure at the predicted EECs actually occur for invertebrates with sensitivity to permethrin reasonably represented by the distribution of tested invertebrate species endpoints.

Terrestrial Invertebrates

RQ values representing exposures of permethrin to terrestrial invertebrates that may serve as prey for the terrestrial-phase CRLF, are also used to represent exposures of permethrin to terrestrial invertebrates that may serve as prey for the CCR. As described in **Section 5.2.1.2**, the Agency determined that based on the fact that permethrin is a highly efficacious broad spectrum insecticide, the exceedances of the Agency's interim LOC for listed terrestrial invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence based on the highest acute RQ for terrestrial invertebrates (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with CCR habitat, the reported terrestrial incidents involving terrestrial invertebrates, and the extremely low single application rate required (0.000069 lb a.i./A or lower) in order for there to be no exceedances of the Agency's LOCs for insects for any use, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the CCR from loss of terrestrial invertebrate prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to terrestrial invertebrates that may serve as prey for the CCR.

Small Terrestrial Vertebrates

For permethrin spray applications, dietary-based and dose-based exposures of CCR potential small terrestrial vertebrate prey (birds and mammals) are assessed when possible using small mammals (15 g) and small birds (20 g) which consume short grass. In addition, exposure of any small terrestrial vertebrate prey items that may be exposed to granular permethrin (15 g mammals and 20 g birds) or seed treatments (15 g mammals and 20 g birds) were assessed when possible.

RQ values representing direct exposures of permethrin to CCRs are also used to represent exposures of permethrin to small birds (20 g) in terrestrial habitats that may serve as prey for the CCR. As described in **Section 5.2.2.1**, the Agency determined that given the weight-of-evidence involving chronic risk LOC exceedances based on the T-REX and T-HERPS models for the majority of the modeled use scenarios in this assessment (~70% of the scenarios for spray applications had at least one exceedances of the chronic risk LOC for various dietary items), and spatial overlap of permethrin uses in California and CCR habitat, there is potential for labeled permethrin use to cause indirect effects to the CCR via adverse chronic effects to the CCR's avian prey base. Please refer to **Section 5.2.2.1** for additional discussion and characterization of potential risks to small birds that may serve as prey for the CCR.

Although a theoretical acute dose-based RQ based on the non-definitive LD_{50} value of 9,869 mg a.i./kg-bw exceeds the Agency's non-listed species acute risk LOC (RQ $\geq$0.5) for small birds (20g) consuming short grass (RQ<0.55) for the Residential Turf and Ornamentals scenario (refer to **Section 5.2.2.1**), it is based on test levels at which zero mortality was observed. Therefore, the dose/response curve for mortality to birds would have to be unusually steep for permethrin for predicted exposures to actually exceed the non-listed species concern levels; if the avian LD_{50} value for permethrin was established to be >11,000 mg a.i./kg-bw, there would be no exceedances of the non-listed species acute risk LOC (RQ $\geq$0.5). Because LD_{50} values of >11,000 mg a.i./kg-bw when tests have evaluated toxicity at high enough levels (3 of the 4 tested species; *i.e.,* starlings, ring-necked pheasants, and Japanese quail), it seems reasonable to conclude that the potential for indirect effects to the CCR via acute lethality to its avian prey base is unlikely.

RQ values representing exposures of permethrin to small mammals (15g) that may serve as prey for the terrestrial-phase CRLF, are also used to represent exposures of permethrin to small mammals (15g) in terrestrial habitats that may serve as prey for the CCR. As described in **Section 5.2.1.2**, the Agency determined that based on the exceedances of the Agency's non-listed species acute risk LOC (RQ≥0.5) and chronic risk LOC (RQ≥1) for small mammals feeding on a variety of terrestrial food items for the various permethrin seed, spray, and granular application scenarios considered, the high probability of an individual mortality occurrence based on the highest acute RQ for mammals (~1 in 1), the relative insensitivity of risk conclusions to selection of less conservative acute and chronic endpoints, and the spatial overlapping of patterns of permethrin use throughout the entire state of California with CCR habitat, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the CCR from loss of mammalian prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to small mammals that may serve as prey for the CCR.

Aquatic (Vascular and Non-vascular) and Terrestrial Plants

As previously mentioned, while the CCR is primarily carnivorous, a study examining the stomach contents of 18 CCRs in South San Francisco Bay showed that the CCR diet may contain up to 15% plant material. Therefore, indirect effects to the CCR via loss of plant food items were evaluated. In **Section 5.2.1.3**, where indirect effects to the CRLF via habitat effects were evaluated, it was stated that based on the most sensitive surrogate aquatic non-vascular plant toxicity data (EC_{50} value of 68 µg a.i./L for the marine alga, Skeletonema costatum) and the maximum aquatic peak EEC of all use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all RQs for aquatic non-vascular plants are ≤0.08 (**Table 5.5**).

In addition, it was noted in **Section 5.2.1.3** that no such data are available to reliably quantitatively evaluate the effects and the potential risks of permethrin to vascular aquatic plants or terrestrial plants. However, aquatic non-vascular plants are not particularly sensitive to permethrin, permethrin has a neural toxic mode of action, and no studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. In addition, since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants (all terrestrial plants), and none have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Therefore, although effects to vascular aquatic and terrestrial plants cannot be quantified due to the lack of data, since the RQs do not exceed the Agency's LOC (1) for aquatic non-vascular plants based on the most sensitive data available to the Agency and a large portion of the CCR diet (85%) is comprised primarily of animal food items, available lines of evidence provide no compelling reason to believe that there is a potential for indirect effects to the CCR from loss of plant food items as result of labeled permethrin use in California.

5.2.2.3 Indirect Effects (*via Habitat Effects*)

<u>Aquatic (Vascular and Non-vascular) and Terrestrial Plants</u>
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 aquatic species.

Terrestrial plants serve several important habitat-related functions for the CCR. In addition to providing habitat and cover for invertebrate and vertebrate prey items of the CCR, terrestrial vegetation also provides nesting material, shelter for the CCR, 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.

As stated in **Section 5.2.1.3** covering the evaluation of potential indirect effects to the CRLF via habitat effects, although effects to vascular aquatic and terrestrial plants cannot be quantified due to the lack of data, since the RQs do not exceed the Agency's LOC (1) for aquatic non-vascular plants based on the most sensitive data available to the Agency, and because available lines of evidence provide no compelling reason to believe that permethrin will affect any type of plants to the extent that it would affect the habitat integrity of the CCR, labeled permethrin use in California appears not likely to indirectly affect the CCR via impacts to habitat and/or primary production. Please refer to **Section 5.2.1.3** for additional discussion and characterization of potential risks to plants that may be foraged upon by the CCR.

5.2.3 San Francisco Garter Snake

5.2.3.1 Direct Effects

As previously discussed in **Section 5.2.1.1**, permethrin is currently registered for numerous diverse uses (agricultural, industrial, commercial, public, and residential) that span a large variety of use sites and geographical regions throughout the entire state of California and allow for the potential for year-round use (**Figure 5.1**). Therefore, there is the potential for permethrin use in any given area across the state to spatially and temporally coincide with the SFGS breeding season in the spring and fall.

SFGSs mate in the spring (March and April) and fall (September through November), with mating being heavily concentrated in the first few warm days of March. Female SFGS can store the male's sperm over the winter and can retain viable sperm for periods ranging from 3 to 53 months. Ovulation in the common garter snake typically occurs in late spring with pregnancy resulting in early summer. The young are typically born about three to four months after successful mating. SFGS are ovoviviparous, and females give birth from June through September with young typically born in July or August; however, young can be born as late as early September. Typically, neonate snakes, 18 to 20 cm in length, are born in the upland areas near the aquatic feeding habitats and disperse immediately after they are born.

As previously discussed in **Section 5.2.1.1**, where the potential for direct effects to the terrestrial-phase CRLF was considered, although T-REX has the capability to generate dietary estimates of acute exposure and risk, and dose-based estimates of acute exposure and risk for a variety of body-sizes of birds (surrogate for terrestrial-phase amphibians and reptiles), acute estimates of risk for birds (and thus, SFGS) were not generated because the acute avian effects data show no treatment-related mortality to bobwhite quail at the highest tested level of permethrin in the sub-acute avian dietary studies (LC_{50} >10,000 mg/kg-diet). In addition, no treatment-related mortality was observed in the acute oral toxicity study establishing the most sensitive acute LD_{50} value for birds (mallard duck LD_{50}> 9,869 mg/kg-bw).

However, direct chronic exposure of the SFGS in terrestrial environments was evaluated based on the dietary-based EECs estimated using various approaches (*i.e.,* T-REX for foliar spray applications and the fugacity-based model for insectivorous wildlife) for birds consuming small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates, or soil-dwelling invertebrates because those are the only relevant dietary items that have been identified as a potential SFGS food source for which the available screening-level models can estimate EECs.

Thus, direct acute and chronic exposures of the SFGS were evaluated using the same approaches employed for estimating direct exposures to the terrestrial-phase CRLF. In addition, toxicity estimates for both listed species, the terrestrial-phase CRLF and the SFGS, are based on the same surrogate avian toxicity data. Therefore, RQ values representing the potential for direct exposures and effects of permethrin to the terrestrial-phase CRLF, are also used to represent the potential for direct exposures and effects of permethrin to the SFGS.

Given the reasoning outlined in **Section 5.2.1.1**, where the potential for direct effects to the terrestrial-phase CRLF was considered, the Agency has determined that based on the weight-of-evidence involving chronic risk LOC exceedances with T-REX and the refined T-HERPS model, and spatial overlap of permethrin uses in California and the SFGS habitat, there is potential for labeled permethrin use to cause direct adverse effects to the

SFGS via chronic toxicity, despite that acute lethality to the SFGS appears to be unlikely. Please refer to **Section 5.2.1.1** for additional discussion and characterization of potential direct risks to the SFGS.

5.2.3.2 Indirect Effects (*via Reductions in Prey Base*)

Newborn and juvenile SFGS prey almost exclusively on Pacific tree frogs in temporary pools during the spring and early summer to the point that the SFGS may be so dependent on their anuran prey that they are not able to switch to other available prey sources if necessary to survive. SFGS under 500 mm snout-to-vent length (SVL) require Pacific tree frogs in various stages of metamorphosis, whereas individuals over 500 mm SVL can consume Pacific tree frog, CRLF, and bullfrog tadpoles and adults.

The main diet of adult SFGS consists of CRLF. Adult SFGSs may also feed on smaller juvenile non-native bullfrogs (*Rana catesbeiana*). Immature California newts (*Taricha torosa*), California toads (*Bufo boreas halophilus*) recently metamorphosed western toads (*Bufo boreas*), threespine stickleback (*Gasterosteus aculeatus*), and non-native mosquito fish (*Gambusia affinis*) are also known to be consumed by SFGS. Small mammals, reptiles, amphibians, possibly invertebrates, and some fish species may also be consumed by the SFGS.

<u>Freshwater Fish and Aquatic-phase Amphibians</u>

RQ values representing exposures of permethrin to freshwater fish and aquatic-phase amphibians that may serve as prey for the aquatic-phase CRLF, are also used to represent exposures of permethrin to freshwater fish and aquatic-phase amphibians that may serve as prey for the SFGS. As described in **Section 5.2.1.2**, the Agency determined that based on the assumption that the distribution of tested freshwater fish species endpoints reasonably approximates the distribution of sensitivities of freshwater fish and aquatic-phase amphibians in SFGS habitats, and exceedances of non-listed species acute (39 of 48 modeled scenarios) and chronic risk (40 of the 48 modeled scenarios) LOCs for freshwater fish and aquatic-phase amphibians, the high probability of an individual mortality occurrence using the highest acute RQ for freshwater fish and aquatic-phase amphibians (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with SFGS habitat, and the reported aquatic incidents involving fish, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SFGS from loss of freshwater fish and aquatic-phase frog prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to freshwater fish that may serve as prey for the SFGS.

<u>Freshwater Invertebrates</u>

RQ values representing exposures of permethrin to freshwater invertebrates that may serve as prey for the aquatic-phase CRLF are also used to represent exposures of permethrin to freshwater invertebrates that may serve as prey for the SFGS. As described in **Section 5.2.1.2**, the Agency determined that based on the exceedances of non-listed species acute and chronic risk LOCs for freshwater invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence using both the highest and lowest acute RQ for freshwater invertebrates (~1 in 1 and ~1 in 1.08, respectively), the spatial overlapping of patterns of permethrin use throughout the entire state of California with SFGS habitat, and the reported aquatic incidents involving the least sensitive tested freshwater invertebrate, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SFGS from loss of freshwater invertebrate prey as result of labeled permethrin use in California should exposure at the predicted EECs actually occur for invertebrates with sensitivity to permethrin reasonably represented by the distribution of tested invertebrate species endpoints. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to freshwater invertebrates that may serve as prey for the SFGS.

Terrestrial Invertebrates

RQ values representing exposures of permethrin to terrestrial invertebrates that may serve as prey for the terrestrial-phase CRLF, are also used to represent exposures of permethrin to terrestrial invertebrates that may serve as prey for the SFGS. As described in **Section 5.2.1.2**, the Agency determined that based on the fact that permethrin is a highly efficacious broad spectrum insecticide, the exceedances of the Agency's interim LOC for listed terrestrial invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence based on the highest acute RQ for terrestrial invertebrates (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with SFGS habitat, the reported terrestrial incidents involving terrestrial invertebrates, and the extremely low single application rate required (0.000069 lb a.i./A or lower) in order for there to be no exceedances of the Agency's LOCs for insects for any use, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SFGS from loss of terrestrial invertebrate prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to terrestrial invertebrates that may serve as prey for the SFGS.

Small Terrestrial Vertebrates

For permethrin spray applications, dietary-based and dose-based exposures of SFGS potential small terrestrial vertebrate prey (mammals, amphibians, and reptiles) are assessed when possible using small mammals which consume short grass (15 g; they serve as prey items and provide burrows for habitat) and small birds (20 g; they represent terrestrial-phase amphibians and reptiles that it may consume) which consume small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of any small terrestrial vertebrate prey items that may be exposed to granular permethrin (15 g mammals, terrestrial-phase amphibians, and reptiles) or seed treatments (15 g mammals) were assessed when possible.

For indirect effects of permethrin spray applications to the terrestrial-phase CRLF via effects to the terrestrial vertebrate prey base, dietary-based and dose-based exposures of mammals and terrestrial-phase amphibians were assessed when possible using small mammals (15 g) which consume short grass and small birds (20g; they represent terrestrial-phase amphibians that it may consume) which consume small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) invertebrates. In addition, exposure of 15 g mammals and terrestrial-phase amphibians exposed to granular permethrin, and 15 g mammals exposed to permethrin seed treatments, were assessed. In other words, RQ values representing exposures of permethrin to small terrestrial vertebrates that may serve as prey for the terrestrial-phase CRLF, can also be used to represent exposures of permethrin to small terrestrial vertebrates that may serve as prey for the SFGS.

As described in **Section 5.2.1.1** and **Section 5.2.1.2** for the terrestrial-phase CRLF, the Agency determined that based on the weight-of-evidence involving chronic risk LOC exceedances with T-REX and the refined T-HERPS model, and spatial overlap of permethrin uses in California and SFGS habitat, there is potential for labeled permethrin use to cause adverse effects to terrestrial-phase amphibians and reptiles via chronic toxicity, despite that acute lethality to terrestrial-phase amphibians appears to be unlikely. Please refer to **Section 5.2.1.1** and **Section 5.2.1.2** for additional discussion and characterization of potential risks to terrestrial-phase amphibians and reptiles that may serve as prey for the SFGS.

As described in **Section 5.2.1.2** for the terrestrial-phase CRLF, the Agency determined that based on the exceedances of the Agency's non-listed species acute risk LOC ($RQ \geq 0.5$) and chronic risk LOC ($RQ \geq 1$) for small mammals feeding on a variety of terrestrial food items for the various permethrin seed, spray, and granular application scenarios considered, the high probability of an individual mortality occurrence based on the highest acute RQ for mammals (~1 in 1), the relative insensitivity of risk conclusions to selection of less conservative acute and chronic endpoints, and the spatial overlapping of patterns of permethrin use throughout the entire state of California with SFGS habitat, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SFGS from loss of small mammalian prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to small mammals that may serve as prey for the SFGS.

5.2.3.3 Indirect Effects (*via Habitat Effects*)

Aquatic (Vascular and Non-vascular) and Terrestrial Plants

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 aquatic species.

Terrestrial plants serve several important habitat-related functions for the SFGS. In addition to providing habitat and cover for invertebrate and vertebrate prey items of the SFGS, terrestrial vegetation also provides shelter for the SFGS 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.

As stated in **Section 5.2.1.3** covering the evaluation of potential indirect effects to the CRLF via habitat effects, although effects to vascular aquatic and terrestrial plants cannot be quantified due to the lack of data, since the RQs do not exceed the Agency's LOC (1) for aquatic non-vascular plants based on the most sensitive data available to the Agency, and because available lines of evidence provide no compelling reason to believe that permethrin will affect any type of plants to the extent that it would affect the habitat integrity of the SFGS, labeled permethrin use in California appears not likely to indirectly affect the SFGS via impacts to habitat and/or primary production. Please refer to **Section 5.2.1.3** for additional discussion and characterization of potential risks to plants that may be foraged upon by the SFGS.

Mammals

In addition to mammals serving as prey items for the SFGS, they also can potentially aid in providing suitable habitat; successful SFGS breeding populations are typically found in densely vegetated ponds near open hillsides where they can sun themselves, feed, and find shelter in rodent burrows. Rodent burrows are used for shelter and aestivation when the ponds become dry and the temperatures become hot, and the SFGS may also forage for amphibians in the rodent burrows during the summer. These burrows are also used for hibernation, since SFGSs found along the coast will hibernate during the winter. Therefore, the potential for indirect effects to the SFGS via affects to small mammals that may help to provide suitable habitat was evaluated.

RQ values representing exposures of permethrin to small mammals that may serve as prey for the terrestrial-phase CRLF, are also used to represent exposures of permethrin to small mammals that may help to provide suitable habitat for the SFGS. As described in **Section 5.2.1.2** for the terrestrial-phase CRLF, the Agency determined that based on the exceedances of the Agency's non-listed species acute risk LOC ($RQ \geq 0.5$) and chronic risk LOC ($RQ \geq 1$) for small mammals feeding on a variety of terrestrial food items for the various permethrin seed, spray, and granular application scenarios considered, the high probability of an individual mortality occurrence based on the highest acute RQ for mammals (~1 in 1), the relative insensitivity of risk conclusions to selection of less conservative acute and chronic endpoints, and the spatial overlapping of patterns of permethrin use throughout the entire state of California with SFGS habitat, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SFGS from loss of small mammals that may help to provide suitable habitat (burrows) as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to small mammals that that may help to provide suitable habitat for the SFGS.

5.2.4 Salt Marsh Harvest Mouse

5.2.4.1 Direct Effects

As previously discussed in **Section 5.2.1.1**, permethrin is currently registered for numerous diverse uses (agricultural, industrial, commercial, public, and residential) that span a large variety of use sites and geographical regions throughout the entire state of California and allow for the potential for year-round use (**Figure 5.1**). Therefore, there is the potential for permethrin use in any given area across the state to spatially and temporally coincide with the SMHM breeding season.

In addition, as the SMHM breeds from spring through the fall, there is strong potential for periods of breeding activity to overlap temporally with peak usage of permethrin (May through September). While male SMHM are described as reproductively active from April through September, with some active throughout the year, female SMHM have a long breeding season that extends from as early as March to November. In general, the northern subspecies of SMHM breeds from May to November and the southern subspecies breeds from March to November. Despite the long breeding season, the SMHM is characterized as having a low reproductive potential, with each female typically having only one or two litters per year with an average litter size of about three or four.

Direct exposure of the SMHM and the resulting risks in terrestrial environments were evaluated based on dose- and dietary-based EECs estimated using various approaches (*i.e.*, T-REX for foliar spray applications, T-REX $LD_{50}ft^{-2}$ analysis for granular applications, T-REX seed treatment analysis, and the fugacity-based model for insectivorous wildlife) for small mammals (15 g) consuming a variety of dietary items. All estimated EECs (*i.e.*, EECs for short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, seeds, and soil dwelling invertebrates) were considered relevant for evaluation of direct effects because the SMHM has been known to feed on leaves, seeds, plant stems, insects, and grasses.

Based on surrogate toxicity data (LD_{50}=152 mg/kg-bw and NOAEL = 2.77 mg/kg-bw/day), the maximum allowable application rate (3 applications, 4.23 lbs a.i./acre/application, 5-day application interval), the foliar dissipation half-life of 15.4 days for permethrin from Willis and McDowell (1987), and upper bound Kenaga values from T-REX, there is a potential for direct adverse effects on SMHM individuals from foliar spray applications of permethrin in CA (**Table 5.6**). Although EECs for small mammals feeding on short grass yield the highest risk estimates, it appears that the impacts of permethrin use to the SMHM potentially extend beyond those feeding on short grass.

For spray applications of permethrin, the dose-based acute RQs range from <0.01 to 7.05, from <0.01 to 3.23, from <0.01 to 3.96, and from <0.01 to 0.44, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. For acute dose-based RQs, 31 of the 34 modeled scenarios resulted in an exceedance of the Agency's acute listed species LOC ($RQ \geq 0.1$) for mammals that feed on short grass, 30 of the 34 modeled scenarios resulted in an exceedance of the Agency's acute listed species LOC (RQ≥0.1) for mammals that feed on tall grass or broadleaf plants/small insects, and 4 of the 34 modeled scenarios resulted in an exceedance of the Agency's acute listed species LOC (RQ≥0.1) for mammals that feed on fruits/pods/seeds/large insects.

The dose-based chronic RQs range from 0.08 to 387.30, from 0.04 to 177.51, from 0.05 to 217.86, and from 0.01 to 24.21, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. For chronic dose-based RQs, 33 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on short grass, 32 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on tall grass or broadleaf plants/small insects, and 28 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on fruits/pods/seeds/large insects.

The dietary-based chronic RQs range from 0.01 to 44.64, from <0.01 to 20.46, from 0.01 to 25.11, and from <0.01 to 2.79, for the short grass, tall grass, broadleaf plants/small insects, and fruits/pods/seeds/large insects dietary categories, respectively. For chronic dietary-based RQs, 30 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on short grass, 25 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on tall grass, 28 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on broadleaf plants/small insects, and 1 of the 34 modeled scenarios resulted in an exceedance of the Agency's chronic risk LOC (RQ≥1) for mammals that feed on fruits/pods/seeds/large insects. Therefore, RQs for mammals exceed the Agency's acute listed species LOC (RQ≥0.1) and chronic risk LOC (RQ≥1) for mammals (**Table 5.6**) for foliar spray applications of permethrin.

The $LD_{50}ft^{-2}$ and fugacity-based approach result in RQs for granular permethrin applications that exceed the Agency's acute listed species LOC (RQ≥0.1) and chronic risk LOC (RQ≥1) for mammals, respectively (**Tables 5.7** and **5.8**; acute RQs range from 0.41 to 2.07; chronic dose-based RQs range from 1.74 to 8.38; chronic dietary-based RQs range from 0.20 to 0.97); therefore, there is a potential for direct adverse effects to SMHM individuals from granular applications of permethrin in CA.

The T-REX seed treatment analysis resulted in RQs for permethrin seed treatments that exceed the Agency's acute listed species LOC (RQ≥0.1) and chronic risk LOC (RQ≥1) for mammals (**Table 5.9**; acute RQs Based on Available A.I. <0.01; acute RQs Based on Nagy Dose= 0.20; Chronic RQs Based on Maximum Seed Application Rate =5.65); therefore, there is a potential for direct adverse effects on SMHM individuals from seed treatment uses of permethrin in CA.

All of these preceding RQ values and exceedances representing direct exposures of permethrin to the SMHM, have also been discussed and characterized in **Section 5.2.1.2** as they pertain to small mammals that may serve as prey for the terrestrial-phase CRLF; please refer to that section for additional discussion and characterization of the potential for direct effects to the SMHM. In conclusion, as covered in **Section 5.2.1.2,** based on the exceedances of the Agency's listed species acute risk LOC (RQ$\geq$0.1) and chronic risk LOC (RQ$\geq$1) for small mammals feeding on a variety of terrestrial food items for the various permethrin seed, spray, and granular application scenarios considered, the high probability of an individual mortality occurrence based on the highest acute RQ for mammals (~1 in 1), the relative insensitivity of risk conclusions to selection of less conservative acute and chronic endpoints, and the spatial overlapping of patterns of permethrin use throughout the entire state of California with SMHM habitat, it appears that there are adequate lines of evidence to conclude that there is a potential for direct effects to the SMHM as result of labeled permethrin use in California.

5.2.4.2 Indirect Effects (*via Reductions in Prey Base*)

Potential forage items of the SMHM include leaves, seeds, plant stems, and insects, although seasonal variation has been observed in SMHM stomach contents with fresh green grasses more prevalent in the winter, and pickleweed and saltgrass dominating during the rest of the year.

<u>Terrestrial Invertebrates</u>

RQ values representing exposures of permethrin to terrestrial invertebrates that may serve as prey for the terrestrial-phase CRLF, are also used to represent exposures of permethrin to terrestrial invertebrates that may serve as prey for the SMHM. As described in **Section 5.2.1.2**, the Agency determined that based on the fact that permethrin is a highly efficacious broad spectrum insecticide, the exceedances of the Agency's interim LOC for listed terrestrial invertebrates for all of the modeled scenarios assessed, the high probability of an individual mortality occurrence based on the highest acute RQ for terrestrial invertebrates (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with SMHM habitat, the reported terrestrial incidents involving terrestrial invertebrates, and the extremely low single application rate required (0.000069 lb a.i./A or lower) in order for there to be no exceedances of the Agency's LOCs for insects for any use, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SMHM from loss of terrestrial invertebrate prey as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to terrestrial invertebrates that may serve as prey for the SMHM.

<u>Aquatic (Vascular and Non-vascular) and Terrestrial Plants</u>

In **Section 5.2.1.3**, where indirect effects to the CRLF via habitat effects were evaluated, it was stated that based on the most sensitive surrogate aquatic non-vascular plant toxicity data (EC_{50} value of 68 µg a.i./L for the marine alga, Skeletonema costatum) and the maximum aquatic peak EEC of all use scenarios used to represent all of the agricultural and non-agricultural uses of permethrin in CA, all RQs for aquatic non-vascular plants are ≤0.08 (**Table 5.5**).

In addition, it was noted in **Section 5.2.1.3** that no such data are available to reliably quantitatively evaluate the effects and the potential risks of permethrin to vascular aquatic plants or terrestrial plants. However, aquatic non-vascular plants are not particularly sensitive to permethrin, permethrin has a neural toxic mode of action, and no studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. In addition, since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants (all terrestrial plants), and none have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Therefore, although effects to vascular aquatic and terrestrial plants cannot be quantified due to the lack of data, the available lines of evidence provide no compelling reason to believe that there is a potential for indirect effects to the SMHM from loss of plant food items as result of labeled permethrin use in California.

5.2.4.3 Indirect Effects (*via Habitat Effects*)

Aquatic (Vascular and Non-vascular) and Terrestrial Plants
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 aquatic species.

Terrestrial plants serve several important habitat-related functions for the SMHM. In addition to providing habitat and cover for invertebrate prey items of the SMHM, terrestrial vegetation also provides nesting material, shelter, 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.

As stated in **Section 5.2.1.3** covering the evaluation of potential indirect effects to the CRLF via habitat effects, although effects to vascular aquatic and terrestrial plants cannot be quantified due to the lack of data, since the RQs do not exceed the Agency's LOC (1) for aquatic non-vascular plants based on the most sensitive data available to the Agency, and because available lines of evidence provide no compelling reason to believe that permethrin will affect any type of plants to the extent that it would affect the habitat integrity of the SMHM, labeled permethrin use in California appears not likely to indirectly affect the SMHM via impacts to habitat and/or primary production. Please refer to **Section 5.2.1.3** for additional discussion and characterization of potential risks to plants that may be foraged upon by the SMHM.

Birds and Mammals

SMHM do not burrow, but some winter nests may be constructed in burrows and small crevices. SMHM nests are described as minimal, and the SMHM may build over old birds' nests or use nests built by Suisun shrews, after the young shrews have dispersed. Therefore, the potential for indirect effects to the SMHM via affects to small mammals and birds that may help to provide suitable habitat was evaluated.

RQ values representing exposures of permethrin to small mammals that may serve as prey for the terrestrial-phase CRLF, are also used to represent exposures of permethrin to small mammals that may help to provide suitable habitat (nests) for the SMHM. As described in **Section 5.2.1.2** for the terrestrial-phase CRLF, the Agency determined that based on the exceedances of the Agency's non-listed species acute risk LOC ($RQ \geq 0.5$) and chronic risk LOC ($RQ \geq 1$) for small mammals feeding on a variety of terrestrial food items for the various permethrin seed, spray, and granular application scenarios considered, the high probability of an individual mortality occurrence based on the highest acute RQ for mammals (~1 in 1), the relative insensitivity of risk conclusions to selection of less conservative acute and chronic endpoints, and the spatial overlapping of patterns of permethrin use throughout the entire state of California with SMHM habitat, it appears that there are adequate lines of evidence to conclude that there is a potential for indirect effects to the SMHM from loss of small mammals that may help to provide suitable habitat (nests) as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to small mammals that may help to provide suitable habitat for the SMHM.

RQ values representing direct exposures of permethrin to CCRs are also used to represent exposures of permethrin to small birds that may help to provide suitable habitat (nests) for the SMHM. As described in **Section 5.2.2.1**, the Agency determined that given the weight-of-evidence involving chronic risk LOC exceedances based on the T-REX and T-HERPS models for the majority of the modeled use scenarios in this assessment (~70% of the scenarios for spray applications had at least one exceedance of the chronic risk LOC for various dietary items), and spatial overlap of permethrin uses in California and SMHM habitat, there is a potential for indirect effects to the SMHM from loss of small birds that may help to provide suitable habitat (nests) as result of labeled permethrin use in California. Please refer to **Section 5.2.2.1** for additional discussion and characterization of potential risks to small birds that may help to provide suitable habitat for the SMHM.

5.2.5 Bay Checkerspot Butterfly

5.2.5.1 Direct Effects

The BCB's life cycle is closely tied with the biology of its host plants. The host plants germinate anytime from early October to late December and senesce from early April to mid May, and most of the active parts of the BCB life cycle also occur during this time

(**Figure 5.3**). The BCB reproduces once and dies within a single year. Adults emerge from pupae, feed on nectar, mate and lay eggs during a flight season that lasts 4 to 6 weeks from late February to early May. While females normally (although not always) only mate once, males emerge up to 10 days prior to the emergence of females and may mate several times before dying. Adults of both sexes live on average for 10 days (with a maximum adult life span of over 3 weeks reported). Females lay up to 5 egg masses (250 eggs/mass) typically in March and April. Eggs are deposited primarily near the base of dwarf plantain plants, and less commonly on purple owl's-clover and exserted paintbrush.

Larvae hatch from eggs in roughly 10 days and grow to the 4th instar in about two weeks. Once reaching the 4th instar, the larvae then spend a period of dormancy (diapause) under rocks or in soil cracks that lasts through the summer. The larvae resume activity with the start of the rainy season and the germination of dwarf plantain plants. The post-diapause larvae are more mobile than the pre-diapause larvae and may travel tens of meters in search of food and/or warm microclimates to bask or pupate in. Larvae pupate, with the pupae suspended few meters above the ground on vegetation, once they reach a weight of 300 - 500 milligrams. Adults emerge within 15 to 30 days depending on thermal conditions, although there is some evidence that a few larvae in very dry years may enter into a second diapause and complete their development the second spring after hatching.

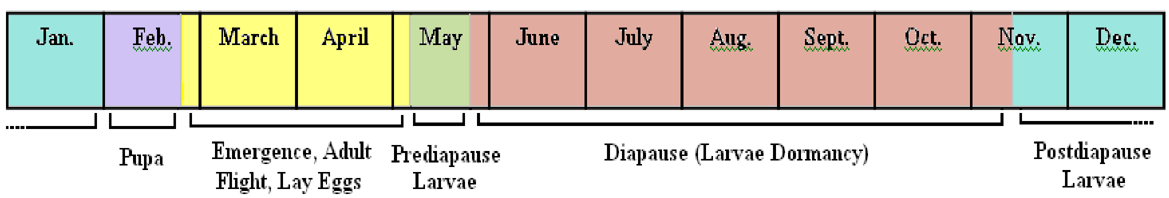


Figure 5.3. General annual life-history parameters for the BCB.

As previously discussed in **Section 5.2.1.1**, permethrin is currently registered for numerous diverse uses (agricultural, industrial, commercial, public, and residential) that span a large variety of use sites and geographical regions throughout the entire state of California and allow for the potential for year-round use (**Figure 5.1**). Therefore, there is the potential for permethrin use in any given area across the state to spatially and temporally coincide with all of the critical life-stages of the BCB, and disrupt its life-cycle at various points. In addition, there may be a short overlap of peak usage with the occurrence of pre-diapause larvae in May, prior to larvae going into dormancy during the rest of months of peak usage of permethrin (May through September).

For the purposes of evaluating direct exposure and effects to the BCB, larvae for the BCB were considered 'small insects' in this assessment, while the adults of this species were considered 'large insects'. Therefore, the potential for direct exposure and effects specifically to the BCB resulting from permethrin spray applications was evaluated by considering the lowest available acute contact toxicity endpoint for terrestrial invertebrates along with the T-REX estimated EECs for small (broadleaf plants/small insects dietary category) and large (fruits/pods/seeds/large insects dietary category) insects. The potential for direct exposure of the BCB resulting from seed treatments was not quantitatively evaluated. In addition, the potential for direct exposure and effects specifically to the BCB resulting from granular permethrin applications was not quantitatively evaluated based on EECs generated using the fugacity-based approach because those EECs are expected to be representative of soil-dwelling invertebrates that actively move and feed in soil (although BCB larvae are found in the soil, they are in dormancy and are generally found in very rocky, dry soils, which the EECs from the fugacity model may not be representative of). However, that is not to say that it is expected that larvae in diapause in soil will not be exposed to permethrin. In fact, given the diversity of uses and use sites of permethrin throughout the state of California, the potential for some uses to be applied to the ground surface or incorporated, the high k_{oc} of permethrin and the potential to bind (mean Koc = 76,800 L/kg) and persist in soil for an extended period of time (Aerobic Soil Metabolism Half-Life ($t_{½}$) of 37 days), it appears quite reasonable to assume that some exposure will occur. However, due to limitations in the capabilities of available models, these exposures could not be quantified.

RQ values representing exposures of permethrin to terrestrial invertebrates that may serve as prey for the terrestrial-phase CRLF, are also used to represent direct exposures of permethrin to the BCB. As described in **Section 5.2.1.2**, the Agency determined that based on the fact that permethrin is a highly efficacious broad spectrum insecticide, the exceedances of the Agency's interim LOC for listed terrestrial invertebrates for all of the modeled scenarios assessed (for both large (adult BCB) and small (BCB larvae) insects), the high probability of an individual mortality occurrence based on the highest acute RQ for terrestrial invertebrates (~1 in 1), the spatial overlapping of patterns of permethrin use throughout the entire state of California with BCB habitat, the reported terrestrial incidents involving terrestrial invertebrates (including butterflies) and registered uses of permethrin, the relative insensitivity of risk conclusions to selection of less conservative toxicity endpoints, and the extremely low single application rate required (0.000069 lb a.i./A or lower) in order for there to be no exceedances of the Agency's LOCs for insects for any use, it appears that there are adequate lines of evidence to conclude that there is a potential for direct effects to the BCB as result of labeled permethrin use in California. Please refer to **Section 5.2.1.2** for additional discussion and characterization of potential risks to the BCB.

5.2.5.2 Indirect Effects (*via Reduction in Prey Base & Habitat Effects*)

The primary diet for the BCB larvae are dwarf plantain plants (although they may also feed on purple owl's-clover or exserted paintbrush if the dwarf plantains senesce before the larvae pupate). Adults feed on the nectar of a variety of plants found in association with serpentine grasslands [*e.g.*, California goldfields, tidy-tips, desertparsley, scytheleaf (*Allium falcifolium*), sea muilla (*muilla maritime*), false babystars (*Linanthus androsaceus*), and intermediate fiddleneck (*Amsinckia intermedia*)].

In addition to serving as the primary dietary item of the BCB, terrestrial plants serve several important habitat-related functions that are described below in **Section 5.2.5.3** in detail with regards to critical habitat. Therefore, the potential for indirect effects to the BCB via loss of terrestrial plant food items and impacts to habitat and/or primary production was considered.

Terrestrial Plants
For the purposes of this assessment, the potential for indirect effects to the BCB via loss of terrestrial plant food items and impacts to habitat and/or primary production was assessed by considering effects to terrestrial plants. As noted in **Section 5.2.1.3,** there were no data to reliably quantitatively evaluate the effects and the potential risks of permethrin to terrestrial plants. However, aquatic non-vascular plants are not particularly sensitive to permethrin, permethrin has a neural toxic mode of action, and no studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. In addition, since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants, and none have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Therefore, although effects to terrestrial plants cannot be quantified due to the lack of data, the available lines of evidence provide no compelling reason to believe that there is a potential for indirect effects to the BCB via loss of terrestrial plant food items and impacts to habitat and/or primary production as result of labeled permethrin use in California.

5.2.5.3 Modification to Designated Critical Habitat

The primary constituent elements (PCEs) of the BCB include:

- The presence of annual or perennial grasslands with little to no overstory that provide north/south and east/west slopes with a tilt of more than 7 degrees for larval host plant survival during periods of atypical weather (e.g., drought).
- The presence of the primary larval host plant, dwarf plantain (*Plantago erecta*) (a dicot) and at least one of the secondary host plants, purple owl's-clover or exserted paintbrush, are required for reproduction, feeding, and larval development.
- The presence of adult nectar sources for feeding.
- Aquatic features such as wetlands, springs, seeps, streams, lakes, and ponds and their associated banks, that provide moisture during periods of spring drought; these features can be ephemeral, seasonal, or permanent.
- Soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar soils (Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) that provide areas with fewer aggressive, nonnative plant species for larval host plant and adult nectar plant survival and reproduction.
- The presence of stable holes and cracks in the soil, and surface rock outcrops that provide shelter for the larval stage of the bay checkerspot butterfly during summer diapause.

For the purposes of this assessment, the potential for indirect effects to the BCB as result of effects to the PCEs of its designated critical habitat is assessed by considering effects to terrestrial plants. Similar to what was noted in **Section 5.2.5.2** above, in which the potential for indirect effects to the BCB via loss of terrestrial plant food items and impacts to habitat and/or primary production was assessed, although effects to terrestrial plants cannot be quantified due to the lack of data, the Agency concludes that the weight-of-evidence suggests that effects to terrestrial plants as a result of labeled permethrin use in California are not expected to the extent that there will be modification of BCB designated critical habitat.

6. Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

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

6.1.2 Multiple Crop Seasons

Although the application rates and number of applications stated on many of the labels were specified on a seasonal basis, for this risk assessment, EFED assumed that the rates and number of applications were reported on an annual basis and modeled them accordingly. If there are conditions under which there is more than one growing season for a crop within a single year, exposure estimates and risk to aquatic and terrestrial organisms could be significantly underestimated. However, although the degree to which exposure and risk estimates are underestimated remains an uncertainty, risk quotients for most taxonomic groups are already exceeding the Agency's levels of concern. Therefore, had exposure and risk based on multiple growing seasons been quantitatively evaluated in this assessment, risk estimates would only increase further above the levels of concern, and risk conclusions would not be substantially altered. Crops that permethrin is used on that have the potential for multiple growing seasons in CA are presented in **Table 6.1** below.

Table 6.1. Crops that permethrin is used on that have the potential for multiple growing seasons in California.		
Crop	**Region (Potential # of Crops Grown per Year)**	**Potential Changes to Modeling Approach**
(1) Broccoli, cabbage, Chinese cabbage, cauliflower, and mustard green	**Broccoli:** Imperial (1), Coastal valleys (2), San Joaquin Valley (2)	Seasonal rate modeled for cole crops would increase by two, three, or four times
	Cabbage & Chinese cabbage: Up to 3 depending on region and variety	
	Cauliflower: Imperial (1), Coastal valleys (2 Or more), San Joaquin Valley (1)	
	Collards: (2-3)	
	Kale & mustard greens: (3-4)	
(2) Lettuce & Endive	Central coast, central valley, San Joaquin Valley (up to 2), Other regions (1)	Seasonal rate modeled for major leafy vegetables would increase by two times
(3) Turf (sod farms only)	**Sod farms turf:** Up to 2 , generally 1	Seasonal rate modeled for sod farms would increase by two times
(4) Corn (sweet)	**Sweet corn** : Southern desert regions (2), Other regions (normally 2-3)	Seasonal rate modeled for sweet corn would increase by three times
(5) Fennel	**Fennel**: (2)	Seasonal rate modeled for fennel would increase by two times

6.1.3 Aquatic Exposure Modeling of Permethrin

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, some organisms may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than the EXAMS pond. 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).

The standard pond pH was assumed to be neutral (pH=7). However, permethrin is not more prone to degradation in high or low pH environments (a variety of synthetic pyrethroids degrade faster in high pH water in which case, the EECs could be smaller than predicted by PRZM/ EXAMS). On the other hand, permethrin's degradation is possibly a function of the redox potential, with the chemical being more stable in negative redox potential environments. In general, static waters with low aeration could show higher EECs than predicted by PRZM/ EXAMS. In addition, permethrin's EECs may be different than actually predicted if the temperature is different than 20-25°C, which is the temperature used frequently in laboratory studies.

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.

Unlike spray drift, tools are currently not available to evaluate the effectiveness of a vegetative setback on runoff and loadings. The effectiveness of vegetative setbacks is highly dependent on the condition of the vegetative strip. For example, a well-established, healthy vegetative setback can be a very effective means of reducing runoff and erosion from agricultural fields. Alternatively, a setback of poor vegetative quality or a setback that is channelized can be ineffective at reducing loadings. Until such time as a quantitative method to estimate the effect of vegetative setbacks on various conditions on pesticide loadings becomes available, the aquatic exposure predictions are likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

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 permethrin concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (e.g. application rates and timing, crops) associated with the agricultural areas are unknown, however, they are assumed to be representative of potential permethrin use areas. Maximum surface waters concentration of cis-permethrin detected of any site in California was 0.195 ug/L. The maximum peak water column concentration estimated using modeling was 5.50 ug/L (CA nursery scenario). This value is the water solubility of permethrin (Laskowski, 2002) and it is approximately 28 times larger than the maximum surface water concentration detected through monitoring. It appears that modeling provides suitable conservative estimates of exposure concentration (EECs).

The “down-the-drain” module of E-FAST is a model that provides screening-level estimate concentrations of chemicals in surface waters. There is uncertainty regarding the resultant EECs because the model does not account for degradation, binding or partitioning of a chemical with the sediment. Permethrin degrades at moderate rates in aerobic aquatic environments and relatively slowly in anaerobic environments, but it is known to bind strongly with soil/ sediment and is expected to partition in aquatic environments.

6.1.4 Usage Uncertainties

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

6.1.5 Terrestrial Exposure Modeling of Permethrin

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.

6.1.6 Spray Drift Modeling

Spray drift modeling was performed in this assessment as previously discussed in the "Problem Formulation" (**Section 2**) and "Exposure Assessment" (**Section 3**) sections of the document. The uncertainties associated with use of spray drift modeling are described below.

Although there may be multiple permethrin 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 permethrin from multiple applications, each application of permethrin 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 Medium' both for orchard and other agricultural uses, as specified in the label), the application method (*e*.g., aerial), release heights and wind speeds. Alterations in any of these inputs would change the area of potential effect.

Because spray drift from pesticide use sites onto non-target areas could potentially result in exposures of the assessed species, their prey, and their habitat, an additional component commonly included in risk assessments for terrestrial or lentic (non-flowing) aquatic habitats is an analysis estimating the distance from the application site where spray drift exposures do not result in LOC exceedances for non-target organisms at highest risk. However, as previously discussed, permethrin has such extensive and diverse labeled uses that are much more varied than many pesticides in potential use site geography and include: agricultural uses (in/on food/feed crops); rights of way uses; nursery uses; forestry uses; turf uses; indoor/outdoor industrial, commercial, public health, and residential uses; fire ant control; control of ectoparasites on domestic animals; and adulticide uses (*i.e.* for mosquito abatement). Therefore, it was assumed that an assessment to determine the distance from the application site where spray drift exposures to non-target areas (terrestrial or lentic aquatic habitats) do not result in LOC exceedances, while suitable for evaluating a single use site of a pesticide, in this case, was probably of limited utility because direct application of permethrin throughout the entire state of California was possible, and would tend to dominate the risk conclusions for all of the listed species considered in this assessment.

6.1.7 Uncertainties Regarding Potential Groundwater Contributions to Surface Water Chemical Concentrations

Evidence of laboratory studies and monitoring of ground waters suggest that permethrin is unlikely to leach to subsurfaces significantly (K_{FOC}>10,000), even though, permethrin is persistent to hydrolysis at neutral pHs and in anaerobic environments. Although the potential impact of discharging groundwater on CRLF or other populations is not explicitly delineated, it should be noted that groundwater could provide a source of pesticide to surface water bodies – especially low-order streams, headwaters, and groundwater-fed pools. This is particularly likely if the chemical is persistent and mobile. Soluble chemicals that are primarily subject to photolytic degradation will be very likely to persist in groundwater, and can be transportable over long distances. Similarly, many chemicals degrade slowly under anaerobic conditions (common in aquifers) and are thus more persistent in groundwater. Much of this groundwater will eventually be discharged to the surface – often supporting stream flow in the absence of rainfall. Continuously flowing low-order streams in particular are sustained by groundwater discharge, which can constitute 100% of stream flow during baseflow (no runoff) conditions. Thus, it is important to keep in mind that pesticides in groundwater may have a major (detrimental) impact on surface water quality, and on CRLF or other habitats.

SCI-GROW may be used to determine likely ‘high-end’ groundwater vulnerability, with the assumption (based upon persistence in sub- and anoxic conditions, and mobility) that much of the compound entering the groundwater will be transported some distance and eventually discharged into surface water. Although concentrations in a receiving water body resulting from groundwater discharge cannot be explicitly quantified, it should be assumed that significant attenuation and retardation of the chemical will have occurred prior to discharge. Nevertheless, groundwater could still be a significant consistent source of chronic background concentrations in surface water, and may also add to surface runoff during storm events (as a result of enhanced groundwater discharge typically characterized by the ‘tailing limb’ of a storm hydrograph).

6.1.8 Uncertainties Regarding Dilution and Chemical Transformations in Estuaries

PRZM-EXAMS modeled EECs are intended to represent exposure of aquatic organisms in relatively small ponds and low-order streams. Therefore it is likely that EECs generated from the PRZM-EXAMS model will over-estimate potential concentrations in larger receiving water bodies such as estuaries, embayments, and coastal marine areas because chemicals in runoff water (or spray drift, etc.) should be diluted by a much larger volume of water than would be found in the ‘typical’ EXAMS pond. However, as chemical constituents in water draining from freshwater streams encounter brackish or other near-marine-associated conditions, there is potential for important chemical transformations to occur. Many chemical compounds can undergo changes in mobility, toxicity, or persistence when changes in pH, Eh (redox potential), salinity, dissolved oxygen (DO) content, or temperature are encountered. For example, desorption and re-mobilization of some chemicals from sediments can occur with changes in salinity (e.g., Means 1995; Swarzenski et al. 2003; Jordan et al. 2008), changes in pH (e.g., Wood and Baptista 1993; Parikh et al. 2004; Fernandez et al. 2005), Eh changes (Wood and Baptista 1993; Velde and Church 1999), and other factors. Thus, although chemicals in discharging rivers may be diluted by large volumes of water within receiving estuaries and embayments, the hydrochemistry of the marine-influenced water may negate some of the attenuating impact of the greater water volume; for example, the effect of dilution may be confounded by changes in chemical mobility (and/or bioavailability) in brackish water. In addition, freshwater contributions from discharging streams and rivers do not instantaneously mix with more saline water bodies. In these settings, water will commonly remain highly stratified, with fresh water lying atop denser, heavier saline water – meaning that exposure to concentrations found in discharging stream water may propagate some distance beyond the outflow point of the stream (especially near the water surface). Therefore, it is not assumed that discharging water will be rapidly diluted by the entire water volume within an estuary, embayment, or other coastal aquatic environment. PRZM-EXAMS model results should be considered consistent with concentrations that might be found near the head of an estuary unless there is specific information – such as monitoring data – to indicate otherwise. Conditions nearer to the mouth of a bay or estuary, however, may be closer to a marine-type system, and thus more subject to the notable buffering, mixing, and diluting capacities of an open marine environment. Conversely, tidal effects (pressure waves) can propagate much further upstream than the actual estuarine water, so discharging river water may become temporarily partially impounded near the mouth (discharge point) of a channel, and resistant to mixing until tidal forces are reversed.

The Agency does not currently have sufficient information regarding the hydrology and hydrochemistry of estuarine aquatic habitats to develop alternate scenarios for assessed listed species that inhabit these types of ecosystems. The Agency acknowledges that there are unique brackish and estuarine habitats that may not be accurately captured by PRZM-EXAMS modeling results, and may, therefore, under- or over-estimate exposure, depending on the aforementioned variables.

6.2 Effects Assessment Uncertainties

6.2.1 Sediment Toxicity

Permethrin, like other pyrethroids, is a lipophilic compound that can adsorb readily to particulate and sediment (mean Koc = 76,800 L/kg). Due to its soil binding properties and persistence in anaerobic aquatic environments (anaerobic aquatic metabolism half-life ranges from 113 to 175 days, respectively), sediment can act as a reservoir for permethrin, thereby increasing its toxic exposure in the benthos of aquatic systems. Exposure of aquatic organisms to sediment contaminated with permethrin can result in a direct impact to aquatic life through respiration, ingestion, dermal contact, as well as indirect impact through alterations of the food chain. In fact, the EFED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin (Dated April 5th 2006; DP Barcode D326784) and the subsequent Addendum to the Revised EFED RED Chapter for Permethrin (Dated April 5th 2006; DP Barcode D328142) previously found that permethrin exposure in both the water column and sediment/ pore water, can potentially occur at levels that exceed the Agency's levels of concern (LOCs).

Supporting this concern, permethrin has been specifically identified as the most widely used pyrethroid in agriculture and most prevalent pyrethroid found in the sediment of aquatic systems in agriculture-dominated areas in California, occurring in 66% of samples collected at 42 sites throughout Central Valley California (Weston et al. 2004). In addition, recent work has also suggested that pyrethroids from products used for structural pest control or for lawn and garden care can be found in sufficient enough quantities in the sediment of aquatic systems in residential and urban areas of California to cause acute toxicity to benthic organisms (Amweg et al. 2006, Weston et al. 2005, Bacey et al. 2005).

In light of the potential for risk to invertebrates resulting from exposure to permethrin associated with the benthic compartment, PRZM/EXAMS has been employed in this assessment to generate estimates of exposure for this compartment. The basis for this estimation using PRZM/EXAMS is grounded in the Agency's Equilibrium Partitioning Sediment Guidelines (ESG) under the Clean Water Act [CWA Section 304(a)(2)] and the equilibrium partitioning theory (EqP). The EqP theory holds that a nonionic compound in the sediment partitions between sediment organic carbon, interstitial (pore) water and benthic organisms (Di Toro *et al.*, 1991, USEPA, 2003). At equilibrium, if the concentration in any phase is known, then the concentration in the other phases can be predicted through the organic/ carbon soil partition coefficient (k_{oc}).

Although both sediment and pore water concentrations of permethrin can be estimated using PRZM/EXAMS, EqP theory, and permethrin's k_{oc}, Di Toro et al. 1991 noted that "for nonionic organic chemicals, the concentration-response relationship for the biological effect of concern can most often be correlated with the interstitial water (pore water) concentration (µg chemical/ L interstitial water) ." Other studies have also indicated that given their strong hydrophobicity, the toxicity of pyrethroids in sediment will depend on their phase distribution, and the freely dissolved concentration in sediment pore water, in particular (Yang et al. 2006a, Yang et al. 2006b). Therefore, for this assessment, only concentrations of permethrin in pore water were generated (not in bulk sediment) in order to evaluate the potential for exposure to permethrin in the benthos relative to permethrin dissolved in the water column. Based on a comparison of estimated water concentrations, it was determined that peak, 21-day, and 60-day EECs ranged roughly from 3 to 29, 2 to 4, and 2 to 3 times higher in the water column than in the pore water, respectively.

Although risk estimates are a function of the magnitude of expected exposure as well as toxicity, no sediment toxicity studies with permethrin have been submitted to the Agency for quantitative evaluation of risk to benthic organisms. However, despite the lack of submitted sediment toxicity data, the ECOTOX database did identify a few studies in the open literature that evaluated the toxicity of aquatic organisms in the presence of sediment. Therefore, toxicity endpoints that were reported in these studies based on pore water concentrations were considered simultaneously alongside endpoints from studies based on water-only exposure for selection of the most sensitive toxicity value used in generating quantitative risk estimates for benthic and water column-dwelling invertebrates as a whole, regardless of the aquatic compartment they typically inhabit.

For these reasons, estimates of risk to aquatic invertebrates generated in this assessment based on the most sensitive toxicity data available for both benthic and water column-dwelling invertebrates along with water column EECs, are expected to be inclusive and sufficiently protective of all aquatic invertebrates for the purposes of this assessment; when risks were identified for freshwater and estuarine/marine invertebrates, it was assumed to apply to both benthic and water column-dwelling invertebrates. In addition, because risk estimates for both freshwater and estuarine/marine invertebrates already exceed the Agency's acute and chronic risk LOCs for all modeled scenarios, it is not expected that the availability of additional sediment toxicity data at this time would result in substantially different risk conclusions.

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, 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.

6.2.3 Use of Surrogate Species Effects Data

Acceptable guideline toxicity tests and open literature for aquatic-phase amphibians, terrestrial-phase amphibians, and reptiles, are not currently available for quantitative use in this risk assessment for permethrin. Therefore, toxicity data for surrogate species (*i.e.*, fish for aquatic-phase amphibians and birds for terrestrial-phase amphibians and reptiles) are used in some instances to assess risks from the use of permethrin in California. Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency's LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

Although no data are available for quantitative evaluation of risks to aquatic-phase amphibians resulting from permethrin use, the available open literature information on permethrin toxicity to aquatic-phase amphibians shows that the most sensitive acute ecotoxicity endpoint for aquatic-phase amphibians was at least 12 times less sensitive than the most sensitive acute endpoint available for freshwater fish (bluegill sunfish LC_{50} = 0.79 µg a.i./L; boreal toad LC_{50} >10 µg a.i./L). Therefore, endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase amphibians including the CRLF, and extrapolation of the risk conclusions from the most sensitive tested species to aquatic-phase amphibians is likely to overestimate the potential risks to those species. Further characterization of this uncertainty was provided in the "Risk Description" section of the document (**Section 5.2**). Data are not available for performing a similar comparison of surrogate avian toxicity data with terrestrial-phase amphibian or reptilian toxicity data.

Additionally, suitable toxicity data from chronic exposure to permethrin are not currently available for aquatic (both freshwater and estuarine/marine) invertebrates and fish as described in **Section 4**. Therefore, the chronic effects endpoints used in this assessment for these taxonomic groups are based on an acute-to-chronic ratio using toxicity data from fathead minnows as previously discussed. Characterization of the associated uncertainties and implications for risk conclusions were discussed in the "Risk Description" section of the document (**Section 5.2**). Additionally, permethrin is likely to adsorb readily to particulate and sediment, thus potentially increasing toxic exposure in the benthos; however, toxicity data for benthic organisms are not currently available. Instead, risk to benthic and water column-dwelling invertebrates as a whole were evaluated based on the most sensitive toxicity data available for freshwater and estuarine/marine invertebrates, regardless of the aquatic compartment they typically inhabit, and water column EECs. The assumptions and uncertainties regarding the lack of sediment toxicity data and the implications for risk conclusions were introduced in **Section 2.10**, and were discussed further in **Section 6.2.1**.

6.2.4 Sub-lethal Effects

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

Although the full suite of sub-lethal endpoints potentially available in the effects literature (regardless of their significance to the assessment endpoints) are often considered to define the action area for other chemicals, in the case of permethrin, LOC exceedances are expected to occur on all land cover types throughout the state of California as a result of this federal action and the final full extent of the action area is assumed to encompass the entire state. Therefore, for this assessment, sub-lethal toxicity data from the open literature were only considered for inclusion if: the effects were evaluated on the basis of relevant routes of exposure that could be reliably interpreted in the context of existing risk assessment exposure assumptions; the endpoints were clearly more sensitive than existing registrant-submitted measures of effect for a given taxonomic group; the data could fill critical data gaps (*e.g*, terrestrial plant data); the data could present a toxicity profile for under-represented taxa (*e.g.*,toxicity data for amphibians or reptiles); the data provided information on sub-lethal effects that could be clearly and reasonably linked to relevant assessment endpoints (*i.e.*, survival, reproduction, and growth) at concentrations lower than the most sensitive endpoints used to quantitatively evaluate risk for a given taxonomic group. Those studies that reported sub-lethal endpoints and met these criteria were discussed previously in **Section 4**, the "Effects Assessment" section of the document. To the extent to which sub-lethal effects are not considered in this assessment, the potential direct and indirect effects of permethrin on listed species may be underestimated.

For a comprehensive consideration of all potential sub-lethal effects resulting from exposure to permethrin please refer to the detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sub-lethal endpoints, that can be found in **APPENDIX H**. Citations of all open literature not considered as part of this assessment because they were either rejected by the ECOTOX screen or accepted by ECOTOX but not used (*e.g.*, the endpoint is less sensitive) are included in **APPENDIX B. APPENDIX B** 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 listed species risk assessment.

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

7. Risk Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this listed species risk assessment represents the best data currently available to assess the potential risks of permethrin to the CRLF, CCR, SFGS, SMHM, and BCB and their designated critical habitat (if applicable).

Based on the best available information, the Agency makes a May Affect and Likely to Adversely Affect (LAA) determination for the CRLF, CCR, SFGS, SMHM, and BCB from the use of permethrin. Additionally, the Agency has determined that there is the potential for modification of CRLF designated critical habitat from the use of the chemical, but that there is not the potential for modification of BCB designated critical habitat. Given the LAA determination for the CRLF, CCR, SFGS, SMHM, and BCB and potential modification of designated critical habitat for the CRLF, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment 2**, and the baseline status and cumulative effects for the CCR, SFGS, SMHM, and BCB is provided in **Attachment 4**.

A summary of the risk conclusions and effects determinations for the CRLF, CCR, SFGS, SMHM, and BCB, and their 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 effects of permethrin on the CRLF, CCR, SFGS, SMHM, and BCB.

Species	Effects Determination [1]	Basis for Determination
		Potential for Direct Effects
California red-legged frog (*Rana aurora draytonii*) (CRLF)	LAA[1]	***Aquatic-phase (Eggs, Larvae, and Adults)***: -Acute RQs for freshwater fish (used as a surrogate for aquatic-phase CRLFs) exceed the listed species acute risk LOC for all 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater fish (surrogate for aquatic-phase CRLFs) is as high as ~1 in 1. - Chronic RQs for freshwater fish (used as a surrogate for aquatic-phase CRLFs) exceed the chronic risk LOC for 40 of the 48 modeled scenarios. -24 of 26 aquatic ecological incidents reported to the Agency involve fish; the link to permethrin for 7 of these incidents is highly probable; 11 resulted from registered uses. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with each of the critical life-stages of the aquatic-phase CRLF.
		Terrestrial-phase (Juveniles and Adults): -Based on refined model estimates, chronic RQs for birds (used as a surrogate for terrestrial-phase CRLFs) exceed the chronic risk LOC for up to 13 of the 34 modeled spray application scenarios. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with each of the critical life-stages of the terrestrial-phase CRLF.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity <u>Freshwater invertebrates</u>: -Acute and chronic RQs for freshwater invertebrates exceed the non-listed species acute and chronic risk LOCs for all 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater invertebrates is as high as ~1 in 1. -Two of three incidents reported to the Agency involving aquatic invertebrates were a result of registered uses that were linked to the observed effects as highly probable. <u>*Freshwater fish and aquatic-phase amphibians*</u>: -Acute RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the non-listed species acute risk LOC for 39 of the 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for fish and aquatic-phase amphibians is as high as ~1 in 1. - Chronic RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the chronic risk LOC for 40 of the 48 modeled scenarios.
		Terrestrial prey items, riparian habitat <u>*Terrestrial-phase amphibians*</u>:

		-Based on refined model estimates, chronic RQs for birds (used as surrogate for terrestrial-phase amphibians) exceed the chronic risk LOC for 13 of the 34 modeled spray application scenarios. <u>Terrestrial invertebrates</u>: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e*., mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. <u>Small mammals</u>: -Acute RQs for small mammal prey items exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e*., mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammal prey items exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses.
California clapper rail (*Rallus longirostris obsoletus*) (CCR)	LAA[1]	**Potential for Direct Effects**
		- Risk of direct acute lethality to the CCR under the Residential Turf and Ornamentals exposure scenario cannot be precluded given the potential for very high exposure levels and non-definitive toxicity estimates. -Chronic RQs for birds exceed the chronic risk LOC for up to 24 of the 34 modeled spray application scenarios, as well as for all seed treatment uses. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with the CCR breeding season. -Two peaks in nesting activity in late April to early May and late June to early July coincide temporally with peak usage of permethrin (May through September).
		Potential for Indirect Effects
		Prey items, habitat, cover and/or primary productivity <u>Freshwater invertebrates</u>: -Acute and chronic RQs for freshwater invertebrates exceed the non-listed species acute and chronic risk LOCs for all 48 modeled scenarios. -The chance of individual effects (*i.e*., mortality) for freshwater invertebrates is as high as ~1 in 1. -Two of three incidents reported to the Agency involving aquatic invertebrates were a result of registered uses that were linked to the observed effects as highly probable. <u>Freshwater Fish</u>: -Acute RQs for freshwater fish exceed the non-listed species acute risk LOC for 39 of the 48 modeled scenarios. -The chance of individual effects (*i.e*., mortality) for freshwater fish is as high as ~1 in 1. - Chronic RQs for freshwater fish exceed the chronic risk LOC for 40 of the 48 modeled scenarios. <u>Estuarine/marine invertebrates</u>: -Acute and chronic RQs for estuarine/marine invertebrates exceed the non-listed species acute and chronic risk LOCs for all 45 modeled scenarios. -The chance of individual effects (*i.e*., mortality) for estuarine/marine invertebrates is as high as ~1 in 1. <u>Estuarine/marine Fish</u>: -Acute RQs for estuarine/marine fish exceed the non-listed species acute risk LOC

		for 10 of the 45 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for estuarine/marine fish is as high as ~1 in 1.04. - Chronic RQs for estuarine/marine fish exceed the chronic risk LOC for 18 of the 45 modeled scenarios. <u>Terrestrial invertebrates</u>: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. <u>Small mammals</u>: -Acute RQs for small mammal prey items exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e.*, mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammal prey items exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses. <u>Birds</u>: -Chronic RQs for birds exceed the chronic risk LOC for up to 24 of the 34 modeled spray application scenarios, as well as for all seed treatment uses.
San Francisco garter snake *Thamnophis sirtalis tetrataenia*) (SFGS)	LAA[1]	**Potential for Direct Effects**
		-Based on refined model estimates, chronic RQs for birds (used as a surrogate for reptiles) exceed the chronic risk LOC for up to 13 of the 34 modeled spray application scenarios. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with the SFGS breeding season in the spring and fall.
		Potential for Indirect Effects
		Prey items, habitat, cover and/or primary productivity <u>Freshwater invertebrates</u>: -Acute and chronic RQs for freshwater invertebrates exceed the non-listed species acute and chronic risk LOCs for all 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for freshwater invertebrates is as high as ~1 in 1. -Two of three incidents reported to the Agency involving aquatic invertebrates were a result of registered uses that were linked to the observed effects as highly probable. <u>Freshwater fish and aquatic-phase amphibians</u>: -Acute RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the non-listed species acute risk LOC for 39 of the 48 modeled scenarios. -The chance of individual effects (*i.e.*, mortality) for fish and aquatic-phase amphibians is as high as ~1 in 1. - Chronic RQs for freshwater fish (used as a surrogate for aquatic-phase amphibians) exceed the chronic risk LOC for 40 of the 48 modeled scenarios. <u>Terrestrial invertebrates</u>: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high

		as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. <u>*Terrestrial-phase amphibians and reptiles*</u>: -Based on refined model estimates, chronic RQs for birds (used as surrogate for terrestrial-phase amphibians) exceed the chronic risk LOC for 13 of the 34 modeled spray application scenarios. <u>*Small mammals*</u>: -Acute RQs for small mammal prey items exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e*., mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammal prey items exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses.
Salt marsh harvest mouse (*Reithrodontomys raviventris*) (SMHM)	LAA[1]	**Potential for Direct Effects**
		-Acute RQs for small mammals exceed the listed species acute risk LOC for up to 31 of the 34 modeled spray application scenarios, as well as for all granular and seed treatment uses. -The chance of individual effects (*i.e*., mortality) for mammals is as high as ~1 in 1. -Chronic RQs for mammals exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with the SMHM breeding season. - In addition, there is strong potential for periods of breeding activity to overlap temporally with peak usage of permethrin (May through September).
		Potential for Indirect Effects
		Prey items, habitat, cover and/or primary productivity <u>*Terrestrial invertebrates*</u>: - Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios, as well as for all granular uses. -The chance of individual effects (*i.e*., mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects as highly probable. <u>*Small mammals*</u>: -Acute RQs for small mammals that may help provide suitable habitat exceed the non-listed species acute risk LOC for up to 14 of the 34 modeled spray application scenarios, as well as for some granular uses. -The chance of individual effects (*i.e*., mortality) for mammals is as high as ~1 in 1 -Chronic RQs for small mammals that may help provide suitable habitat exceed the chronic LOC for up to 33 of the 34 modeled spray application scenarios, as well as for all granular uses and all seed treatment uses. <u>*Birds (nests)*</u>: -Chronic RQs for birds exceed the chronic risk LOC for up to 24 of the 34 modeled spray application scenarios, as well as for all seed treatment uses.
Bay	LAA[1]	**Potential for Direct Effects**

checkerspot butterfly (*Euphydryas editha bayensis*) (BCB)		- Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of biting, chewing, scaling, soil, and flying insects -RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 34 modeled spray application scenarios. -The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. -Three reported incidents involve insects; 1 involved a registered use that was linked to the observed effects on hundreds to thousands of butterflies as highly probable. - Given the number and diversity of registered uses (agricultural, industrial, commercial, public, and residential) spanning a large variety of use sites and geographical regions throughout the entire state of California, and the potential for year-round use, it is expected that permethrin use is likely to spatially and temporally coincide with all of the critical life-stages of the BCB, and disrupt its life-cycle at various points. -In addition, there may be a short overlap of peak usage with the occurrence of pre-diapause larvae in May, prior to larvae going into dormancy during the rest of months of peak usage of permethrin (May through September). -In order for there to be no exceedances of the Agency's LOCs for insects for any use, all uses would have to be limited to a single application at a rate of 0.000069 lb a.i./A or lower.
[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 the critical habitat impact analysis.		
Designated Critical Habitat for:	**Effects Determination [1]**	**Basis for Determination**
CRLF	HM[1]	-There is a potential for direct effects to the aquatic-phase CRLF and indirect effects via reduction of aquatic-phase prey items (aquatic invertebrates, fish, and aquatic-phase amphibians) as described in **Table 7.1** above. - There is a potential for direct effects to the terrestrial-phase CRLF and indirect effects via reduction of terrestrial-phase prey items (mammals, amphibians, and terrestrial invertebrates) as described in **Table 7.1** above.
BCB	NE[1]	-Although effects to terrestrial plants cannot be quantified due to the lack of data, aquatic non-vascular plants are not particularly sensitive to permethrin. -Permethrin has a neural toxic mode of action. -No studies demonstrating significant adverse effects of permethrin to any vascular aquatic or terrestrial plant have been identified in the open literature. -Since permethrin was registered for use in the U.S. in 1979, only seven ecological incidents have been reported to the Agency that involve any plants, and none have reliably linked permethrin to the observed effects with a certainty index of “probable” or higher, despite that it is regularly directly applied on or near a very wide variety of agricultural and home garden plants.

[1] Habitat Modification 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. However, given the broad scope of labeled uses, and since there are no areas within the state of California where permethrin use is restricted, and it is not unlikely that multiple uses for (and applications of) permethrin will occur simultaneously within the same areas, there are no areas where potential effects from permethrin use can be categorically discounted. Therefore, potentially mitigating effects such as ‘downstream dilution’ or ‘drift attenuation’ (to areas where permethrin is not used) were not considered in this assessment, as no region lies outside the bounds of potential permethrin use.

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, CCR, SFGS, SMHM, and BCB life stages within the action area and/or applicable designated critical habitat. 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 assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, 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 species and potential modification to critical habitat.

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