Risks of Permethrin Use to Federally Threatened

Valley Elderberry Longhorn Beetle
(*Desmocerus californicus dimorphus*)

Pesticide Effects Determinations
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List of Commonly Used Abbreviations and Nomenclature

µg/kg	Symbol for "micrograms per kilogram"
µg/L	Symbol for "micrograms per liter"
ºC	Symbol for "degrees Celsius"
AAPCO	Association of American Pesticide Control Officials
a.i.	Active Ingredient
AIMS	Avian Monitoring Information System
Acc#	Accession Number
amu	Atomic Mass Unit
BCB	Bay Checkerspot Butterfly
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
CAW	California Alameda Whipsnake
CBD	Center for Biological Diversity
CCR	California Clapper Rail
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CFWS	California Freshwater Shrimp
CI	Confidence Interval
CL	Confidence Limit
CTS	California Tiger Salamander
CTS-CC	California Tiger Salamander Central California Distinct Population Segment
CTS-SB	California Tiger Salamander Santa Barbara County Distinct Population Segment
CTS-SC	California Tiger Salamander Sonoma County Distinct Population Segment
DS	Delta Smelt
EC	Emulsifiable Concentrate
EC_{05}	5% Effect Concentration
EC_{25}	25% Effect Concentration
EC_{50}	50% (or Median) Effect Concentration

ECOTOX	EPA managed database of Ecotoxicology data
EEC	Estimated Environmental Concentration
EFED	Environmental Fate and Effects Division
e.g.	Latin *exempli gratia* ("for example")
EIM	Environmental Information Management System
EPI	Estimation Programs Interface
ESU	Evolutionarily significant unit
et al.	Latin *et alii* ("and others")
etc.	Latin *et cetera* ("and the rest" or "and so forth")
EXAMS	Exposure Analysis Modeling System
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FQPA	Food Quality Protection Act
ft	Feet
GENEEC	Generic Estimated Exposure Concentration model
HPLC	High Pressure Liquid Chromatography
IC_{05}	5% Inhibition Concentration
IC_{50}	50% (or median) Inhibition Concentration
i.e.	Latin for *id est* ("that is")
IECV1.1	Individual Effect Chance Model Version 1.1
KABAM	K_{OW} (based) Aquatic BioAccumulation Model
kg	Kilogram(s)
kJ/mole	Kilojoules per mole
km	Kilometer(s)
K_{AW}	Air-water Partition Coefficient
Kd	Solid-water Distribution Coefficient
K_F	Freundlich Solid-Water Distribution Coefficient
K_{OC}	Organic-carbon Partition Coefficient
K_{OW}	Octanol–water Partition Coefficient
LAA	Likely to Adversely Affect
lb a.i./A	Pound(s) of active ingredient per acre
LC_{50}	50% (or Median) Lethal Concentration
LD_{50}	50% (or Median) Lethal Dose
LOAEC	Lowest Observable Adverse Effect Concentration
LOAEL	Lowest Observable Adverse Effect Level
LOC	Level of Concern
LOD	Level of Detection

LOEC	Lowest Observable Effect Concentration
LOQ	Level of Quantitation
m	Meter(s)
MA	May Affect
MATC	Maximum Acceptable Toxicant Concentration
m^2/day	Square Meters per Days
ME	Microencapsulated
mg	Milligram(s)
mg/kg	Milligrams per kilogram (equivalent to ppm)
mg/L	Milligrams per liter (equivalent to ppm)
mi	Mile(s)
mmHg	Millimeter of mercury
MRID	Master Record Identification Number
MW	Molecular Weight
n/a	Not applicable
NASS	National Agricultural Statistics Service
NAWQA	National Water Quality Assessment
NCOD	National Contaminant Occurrence Database
NE	No Effect
NLAA	Not Likely to Adversely Affect
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observable Adverse Effect Concentration
NOAEL	No Observable Adverse Effect Level
NOEC	No Observable Effect Concentration
NRCS	Natural Resources Conservation Service
OPP	Office of Pesticide Programs
OPPTS	Office of Prevention, Pesticides and Toxic Substances
ORD	Office of Research and Development
PCE	Primary Constituent Element
pH	Symbol for the negative logarithm of the hydrogen ion activity in an aqueous solution, dimensionless
pKa	Symbol for the negative logarithm of the acid dissociation constant, dimensionless
ppb	Parts per Billion (equivalent to µg/L or µg/kg)

ppm	Parts per Million (equivalent to mg/L or mg/kg)
PRD	Pesticide Re-Evaluation Division
PRZM	Pesticide Root Zone Model
ROW	Right of Way
RQ	Risk Quotient
SFGS	San Francisco Garter Snake
SJKF	San Joaquin Kit Fox
SLN	Special Local Need
SMHM	Salt Marsh Harvest Mouse
TG	Tidewater Goby
T-HERPS	Terrestrial Herpetofaunal Exposure Residue Program Simulation
T-REX	Terrestrial Residue Exposure Model
UCL	Upper Confidence Limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VELB	Valley Elderberry Longhorn Beetle
WP	Wettable Powder
wt	Weight

1. Executive Summary

1.1. Purpose of Assessment

The purpose of this assessment is to evaluate potential direct and indirect effects on the Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*) (VELB) 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 VELB. 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), procedures outlined in the Agency's Overview Document (USEPA, 2004), and consistent with a suit in which permethrin was alleged to be of concern to the VELB (*Center for Biological Diversity (CBD) vs. EPA et al*., Case No. 07-2794-JCS).

The VELB was listed as threatened in 1980 by the USFWS. The species is found in areas with elderberry shrubs throughout California's Central Valley and associated foothills on the east and the watershed of the Central Valley on the west.

1.2. Scope of Assessment

1.2.1. Uses Assessed

Permethrin 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. Type I pyrethroids do not have a cyano group substitution in the *alpha* position of the alcohol moiety of the ester structure; in contrast, Type II pyrethroids have the cyano group. Permethrin 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 neurotoxic insecticide with contact and stomach action, having a slight repellent effect. The primary biological effects of permethrin 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. Effects are observed on both the peripheral and central nervous system.

Formulation types registered for permethrin include wettable powders, dispersible granules, emulsifiable concentrates, liquids, ready to use products, granulars, seed treatments, and dusts. Application methods include: 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. 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. For agriculture uses, maximum seasonal rates usually range from 0.1 to 0.4 lb a.i./A, and depending on the crop, the maximum number of permethrin applications per season usually range from 1 to 8. However, for certain crops, the maximum number of applications is not specified. Permethrin may be applied year-round. Non-agricultural use exceeds that of use on agricultural crops.

In California, the greatest average annual usage from 1999-2008 was the use in structural pest control (Kaul and Jones, 2010). 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. There are no areas within the state of California where permethrin use is prohibited; therefore, potential exposure to insects 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. Currently, labeled uses of permethrin include a variety of crops such as alfalfa, nut trees, avocado, cole crops, corn, leafy vegetables, cucurbit vegetables, garlic, onions, potatoes and fruit trees, as well as uses on forests and nurseries, and non-crop uses such as turf, residential and mosquito control.

The following general uses are considered as part of the federal action evaluated in this assessment: alfalfa, avocado, cole crops, corn, eggplant, fruit trees, garlic and potatoes, turnip root, leafy vegetables, cucurbit vegetables, nut trees, onion, row crops, tomato, tomatillo, ant mound control in crop sites, and mosquito adulticide use in crop sites. In addition, the following general non-food and non-agricultural uses are considered: forestry, nursery, turf, ant mound control in non-agricultural sites, mosquito adulticide use in non-agricultural sites, soil barrier treatment, and perimeter treatment.

Refer to Tables 2-4 to 2-6, and Table 3-1 for details about the use information and assessed uses. See also Section 2.7.2 for a more detailed list of uses considered in this assessment. Certain uses of permethrin were not assessed. The uses not included are: permethrin applications as granular or dust product, and uses to treat seeds (refer to Tables E-2 to E-4 of the Appendix E for details on the uses of permethrin not assessed, and Section 6.1.1 for uncertainties regarding those uses).

1.2.2. Environmental Fate Properties of Permethrin

Permethrin consists of four stereoisomers with the configurations arising from the two stereocenters in the cyclopropane ring; it is a racemic mixture of the *cis*- and *trans*- isomers (currently registered technical active product has a content of *cis*- isomer ranging from 35%-55%). The [1R, *cis*] isomer is the most insecticidally active, followed by the [1R, *trans*] isomer. Although there is some evidence that the *trans* isomers are less persistent than the *cis* isomers, there is not sufficient fate data to distinguish each individual isomer. Thus, this assessment considered parent permethrin (both *cis* and *trans* isomers) as the stressor of concern.

Permethrin is a 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 2,2-dichloroethenyl group attached to the cyclopropane moiety. Permethrin has a low solubility in water (5.5 ppb, Laskowski, 2002) and has a hydrophobic nature ($K_{OW} = 1.26 \times 10^6$, Laskowski, 2002), which indicates that the chemical strongly adsorbs to soils and partitions with sediments in aquatic systems. This is confirmed by the high $K_{FOC} \geq 28{,}200$ L/kg. The 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 ($K_{FOC} \geq$ 28,000 L/kg). Permethrin is relatively persistent to hydrolysis, aqueous and soil photolysis (80 days and 106 days, respectively). Permethrin is also persistent in anaerobic environments (anaerobic soil and anaerobic aquatic metabolism half-lives of 204 and 113-175 days, respectively). One major mechanism of pesticide transport for permethrin is spray drift. For additional environmental fate and transport information about permethrin, refer to Section 2.4.

1.2.3. Evaluation of Degradates and Stressors of Concern

Cis- and *trans*-DCVA, 3-PB-alcohol and 3-PBA (acid) are major degradation products of permethrin that occur as a result of the ester bond breakage, at up to 44% of the applied radioactivity in laboratory studies (for structures and nomenclature of these chemicals, refer to **Table 2-1**). Little data on the toxicity of these degradates to nontarget animals or plants were available for this review. However, evaluation of the chemical structure of the degradates suggests little similarity to the active parent compound, and the cleavage of the ester linkage during degradation of the parent structure is expected to result in a significantly decreased toxicity of those degradates relative to the parent. Limited data are available for the acute effects of DCVA on aquatic invertebrates. Acute 48-hour studies examining effects of DCVA on *Daphnia magna* resulted in an EC_{50} = 25 mg a.i./L (MRID 00158556), which shows much lower toxicity to aquatic invertebrates than the parent compound permethrin (*Daphnia magna* 48-hour EC_{50}s range from 0.04 to 9.9 µg a.i./L; MRIDs 00043736, 00110662, 00043736, 40098001, 00110663, 00110662, 00042139, 43740602 and 42584002). Based on these lines of evidence, this assessment focuses only on the parent, *cis*- and *trans*-permethrin.

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, 6th revision dated April 1st 2009; DP Barcode D357566, see Appendix I).

1.3. Assessment Procedures

A description of routine procedures for evaluating risk to the San Francisco Bay Species is provided in Attachment I.

1.3.1. Terrestrial Exposure Assessment

The T-REX model is used to estimate exposure to terrestrial invertebrates resulting from uses involving permethrin spray applications. The AGDISP model is also used to estimate deposition of permethrin on terrestrial habitats from spray drift due to the use of the chemical for mosquito abatement (*i.e.*, the application efficiency on the treated field). Direct effects of permethrin use to the VELB will be examined by comparing predicted exposure concentrations from the T-REX model to the available terrestrial invertebrate toxicity data.

If terrestrial plant toxicity data are available, the TerrPlant model is used to estimate exposures to terrestrial-phase habitat, including plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar permethrin applications. The TerrPlant model will not be used in this assessment due to the lack of quantitative terrestrial plant toxicity data for permethrin. However, the potential indirect effects of permethrin use to the VELB and modification of critical habitat will be discussed qualitatively in this assessment based on the best available information for phytotoxic effects of permethrin.

1.3.2. Toxicity Assessment

The assessment endpoints include direct toxic effects on survival, reproduction, and growth of individuals, as well as indirect effects, such as reduction of the food source and/or modification of habitat. Federally-designated critical habitat has been established for the VELB. Primary constituent elements (PCEs) were used to evaluate whether permethrin has the potential to modify designated critical habitat. The Agency evaluated registrant-submitted studies and data from the open literature to characterize permethrin toxicity. The most sensitive toxicity value available from acceptable or supplemental studies for each taxon relevant for estimating potential risks to the assessed species and/or their designated critical habitat was used.

Section 4 summarizes the ecotoxicity data available on permethrin relevant to the VELB. Permethrin is classified as highly toxic to honey bees on an acute contact exposure basis. Although effects to terrestrial plants cannot be quantified due to the lack of data, several incidents involving permethrin have been reported to the Agency. Therefore, permethrin toxicity to terrestrial plants, including potential effects to the elderberry (obligate host of VELB), cannot be discounted.

1.3.3. Measures of Risk

Acute and chronic risk quotients (RQs) are compared to the Agency's Levels of Concern (LOCs) to identify instances where permethrin use has the potential to adversely affect the assessed species or adversely modify their designated critical habitat. When RQs for a particular type of effect are below LOCs, the pesticide is considered to have "no effect" on the species and its designated critical habitat. Where RQs exceed LOCs, a potential to cause adverse effects or habitat modification is identified, leading to a conclusion of "may affect". If permethrin use "may affect" the assessed species, and/or may cause effects to designated critical habitat, the best available additional information is considered to refine the potential for exposure and effects, and distinguish actions that are Not Likely to Adversely Affect (NLAA) from those that are Likely to Adversely Affect (LAA).

1.4. Summary of Conclusions

Based on the best available information, the Agency makes a Likely to Adversely Affect determination from the use of permethrin based on direct effects to the VELB. Indirect effects to terrestrial prey items and habitat modification were also identified. Additionally, the Agency has determined that there is the potential for modification of designated critical habitat and makes a habitat modification effects determination from the use of the chemical based on the PCEs of critical habitat. A summary of the risk conclusions and effects determinations for the assessed VELB and its designated critical habitat is presented in **Table 1-1** and **Table 1-2**.

Table 1-3. 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 VELB, a description of the baseline status and cumulative effects for the VELB is provided in Attachment II.

Table 1-1. Effects Determination Summary for Effects of Permethrin on the VELB

Species	Effects Determination	Basis for Determination
Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*)	Likely to Adversely Affect (LAA)	**Potential for Direct Effects** 1. Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of insects. 2. RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 33 modeled spray application scenarios. 3. The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. 4. Four reported incidents involve insects; 1 involved a registered use that was linked as highly probable to the observed effects on hundreds to thousands of butterflies. 5. 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 VELB.
		Potential for Indirect Effects ***Terrestrial prey items, riparian habitat*** The elderberry plant serves as an obligate host for the VELB. While no acceptable data were available to quantify the effects of permethrin on terrestrial plant, the following lines of evidence suggest that indirect effects to VELB via risks to terrestrial plants may occur: 1. Because permethrin use is likely to result in adverse effects to nontarget terrestrial invertebrates, native pollinators of the elderberry are also likely to be negatively impacted by permethrin use and result in impaired plant reproduction. 2. Three incidents have been reported to the Agency that suggest permethrin use (alone or with the synergist piperonyl butoxide) may have caused adverse effects to terrestrial plants. The total number of incidents that actually occur in the environment are believed to be much higher than those reported. However, none of the incidents have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, and permethrin is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Since no acceptable submitted data were available to quantify the effects of permethrin on terrestrial plants, these incidents serve as the best available information, and much uncertainty exists regarding the phytotoxic effects of permethrin.

Table 1-2. Effects Determination Summary for the Critical Habitat Impact Analysis

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*)	Habitat modification	1. Based on information provided in the VELB Status and Life History document prepared by the Fish & Wildlife Services, any human disturbance that adversely affects the beetle results in modification of critical habitat (1980 Federal Register Vol. 45, No. 155) . Permethrin use is likely to result in direct adverse effects to the VELB (see Table 1-1). 2. Because permethrin use is likely to result in adverse effects to nontarget terrestrial invertebrates, native pollinators of the elderberry are also likely to be negatively impacted by permethrin use and result in impaired plant reproduction. 3. Three incidents have been reported to the Agency that suggest permethrin use (alone or with the synergist piperonyl butoxide) may have caused adverse effects to terrestrial plants. The total number of incidents that actually occur in the environment are believed to be much higher than those reported. However, none of the incidents have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, and permethrin is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Since no acceptable submitted data were available to quantify the effects of permethrin on terrestrial plants, these incidents serve as the best available information, and much uncertainty exists regarding the phytotoxic effects of permethrin.

Table 1-3. Use Specific Summary of the Potential for Adverse Effects to Relevant Terrestrial Taxa

Use	Terrestrial Invertebrates (Acute)[1]	Terrestrial Plants[2]
Avocado	Yes	Yes
Cole Crops (Broccoli)	Yes	Yes
Corn (Pop corn)	Yes	Yes
Corn (Sweet corn)	Yes	Yes
Forestry (Cottonwood)	Yes	Yes
Fruit Trees (Pear)	Yes	Yes
Fruit Trees (Peach)	Yes	Yes
Garlic & Potatoes	Yes	Yes
Major Leafy Vegetables (Lettuce)	Yes	Yes
Minor Leafy Vegetables	Yes	Yes
Major Cucurbits (Cucumber)	Yes	Yes
Minor Cucurbits (Melons)	Yes	Yes
Nursery (Pine Seed Orchard- Reduced)	Yes	Yes
Nursery (Pine Seed Orchard- Maximum)	Yes	Yes
Onions (Onion)	Yes	Yes
Onions (Fennel)	Yes	Yes
Row Crops (Celery)	Yes	Yes
Row Crops (Rhubarb)	Yes	Yes
Tomato (Tomato)	Yes	Yes
Tomato (Tomatillos)	Yes	Yes

Use	Terrestrial Invertebrates (Acute)[1]	Terrestrial Plants[2]
Turf (Golf course and Recreational Areas)	Yes	Yes
Ant Mound Treatments (Non-agricultural, Turf, Recreational and Ag. Fruit Trees)	Yes	Yes
Adulticide (Mosquito Control)	Yes	Yes
Soil Barrier Treatment (Fencerows & Hedgerows)	Yes	Yes
Soil Barrier Treatment (Range Land)	Yes	Yes
Residential Turf and Ornamentals (Home and Garden)	Yes	Yes
Perimeter Treatment (Urban and Rural Structures)	Yes	Yes
Termite Treatment (Urban and Rural Structures)	Yes	Yes
Garden Vegetables (Home and Garden)	Yes	Yes
Garden Nuts and Fruits (Home and Garden)	Yes	Yes
Soil Barrier Treatment (Urban and Rural Structures)	Yes	Yes

[1] A yes in this column indicates a potential for direct effect to VELB.
[2] A yes in this column indicates a potential for indirect effects to VELB and potential modification to critical habitat.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated.

When evaluating the significance of this risk assessment's direct/indirect and adverse 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, pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Information and methodology required for this type of analysis would include enhanced information on the density and distribution of VELB 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.

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* (USEPA, 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA, 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS/NOAA, 2004).

2.1. Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened VELB 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. This ecological risk assessment has been prepared consistent with a settlement agreement in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

In this assessment, direct and indirect effects to the VELB and potential modification to designated critical habitat for the VELB are evaluated in accordance with the methods described in the Agency's Overview Document (USEPA, 2004).

The VELB was listed as threatened in 1980 by the USFWS. The species is found in areas with elderberry shrubs throughout California's Central Valley and associated foothills on the east and the watershed of the Central Valley on the west.

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 VELB and its designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached for the assessed species in the lawsuit 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".

Additionally, for habitat and PCEs, a "No Effect" or a "Habitat Modification" determination is made.

A description of routine procedures for evaluating risk to the San Francisco Bay Species is provided in Attachment I.

2.2. Scope

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

Permethrin consists of four stereoisomers with the configurations 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% and the minimum *trans* isomers is 45% in the product. Although there is some evidence that the *trans* isomers are less persistent than the *cis* isomers, there is no sufficient fate data to distinguish each individual isomer. Thus, this assessment considered parent permethrin (both *cis* and *trans* isomers) as the stressor of concern.

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: 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. Potential permethrin uses are year-round and include agricultural; 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 (refer to **Section 2.4.3** for further details). There are no areas within the state of California where permethrin use is prohibited; therefore, potential exposure to insects, other invertebrates, plants 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.

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 VELB and its designated critical habitat. Further discussion of the action area for the VELB and its critical habitat is provided in Section 2.7.

2.2.1. Evaluation of Degradates

Major degradation products of permethrin include *cis*- and *trans*-DCVA, 3-PB alcohol and 3-PBA at up to 44% of the applied radioactivity in laboratory studies (for structure and nomenclature of these chemicals, refer to **Table 2-1**). These degradates result from the ester bond breakage, and only limited data on the toxicity of these degradates was available for this review. However, evaluation of the chemical structure of the degradates suggest little similarity to the active parent compound, and the cleavage of the ester linkage during degradation of the parent structure is expected to result in a significantly decreased toxicity of those degradates relative to the parent.

Limited data are available for the acute effects of DCVA on aquatic invertebrates. Acute 48-hour studies examining effects of DCVA on *Daphnia magna* resulted in an EC_{50} = 25 mg DCVA/L (MRID 00158556, unreviewed), which shows much lower toxicity to aquatic invertebrates than the parent compound permethrin (*Daphnia magna* 48-hour EC_{50}s range from 0.04 to 9.9 µg a.i. permethrin/L; MRIDs 00043736, 00110662, 00043736, 40098001, 00110663, 00110662, 00042139, 43740602 and 42584002).

Based on these lines of evidence, this assessment focuses only on the parent, *cis*- and *trans*-permethrin. 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, 6th revision; dated April 1st 2009; DP Barcode D357566, refer to Appendix I).

2.2.2. Evaluation of Mixtures

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

Permethrin has registered products that contain multiple active ingredients. No product data have been submitted to EFED to evaluate the potential for differences in toxicity between technical grade permethrin and the chemical formulated with multiple active ingredients. 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. The results of this analysis show that an assessment based on the toxicity of the single active ingredient of permethrin is appropriate. A qualitative examination of the trends in LD_{50} values, with the associated confidence intervals, across the range of percent active ingredient, shows no discernable trends in potency that would suggest synergistic or antagonistic interactions. A majority of formulated products had oral LD_{50} values >5000 mg/kg. Thirteen of the 22 products with definitive LD_{50} values had associated 95% confidence intervals which overlapped with the confidence interval for permethrin. The remaining nine products (containing permethrin and piperonyl butoxide) had LD_{50} values below the confidence interval for permethrin. However, given the variability of the available oral acute toxicity data, the relative few products that fell near (but outside) the confidence intervals are not considered toxicologically significant. Furthermore, other products with similar or higher concentrations of permethrin and piperonyl butoxide showed no evidence of interactive effects. Given that permethrin shows low overall toxicity to mammals and extremely high toxicity to terrestrial invertebrates (target organism), a substantial amount of uncertainty exists when extrapolating permethrin toxicity data between the two taxa.

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 receptors. 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 that 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. For this assessment, no data that quantitatively addressed the effects to terrestrial invertebrates from the use of the synergist piperonyl butoxide in combination with permethrin were available. 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, 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 terrestrial invertebrates, it is expected that further analysis of any available data with multiple active ingredients or synergists is not likely to result in radical alterations of this risk assessment's conclusions.

2.3. Previous Assessments

In October 2008 (USEPA 2008b)[1], the Agency conducted a listed species risk assessment to assess the potential risks of permethrin to the federally listed 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). In addition, the 2008 assessment evaluated whether these actions can be expected to result in modification of designated critical habitat for the CRLF and BCB. Based on the best available information, the Agency made 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 determined that there was the potential for modification of CRLF designated critical habitat from the use of the chemical, but that there was not the potential for modification of BCB designated critical habitat.

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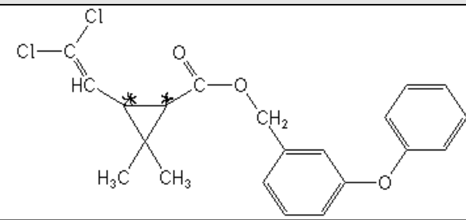
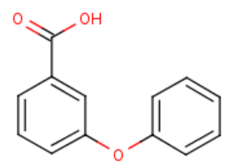
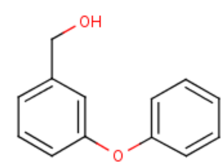
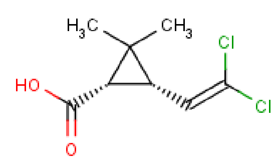
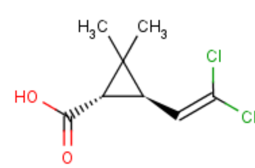
[1] Available at http://www.epa.gov/oppfead1/endanger/litstatus/effects/redleg-frog/index.html .

The national-level scope of the EFED chapter of the Reregistration Eligibility Decision Document (RED) for permethrin (Dated April 5th 2006; DP Barcode D326784, USEPA 2006b) and the subsequent Addendum to the Revised EFED RED Chapter for Permethrin (Dated April 5th 2006; DP Barcode D328142, USEPA 2006c) found that permethrin exposure in aquatic media (water column and sediment/ porewater), can potentially occur at levels that exceed the Agency's levels of concern (LOCs). Risks were identified for listed and non-listed aquatic organisms (fish and water-column and sediment-dwelling invertebrates) with acute and chronic LOC exceedances. 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 were not available for terrestrial plants and the potential for risk remains an uncertainty.

In addition to the assessment associating risks with mosquito abatement uses and agricultural uses, the same EFED chapter of the Reregistration Eligibility Decision 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 that are toxic to aquatic organisms have been found in aquatic areas that receive runoff from suburban developments.

2.4. Environmental Fate Properties

This assessment considered parent permethrin as the stressor. Permethrin is a type I synthetic pyrethroid; it is not substituted in the *alpha* position of the alcohol moiety of the ester structure. Type II pyrethroids, in contrast, are substituted in the *alpha* position. Permethrin 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% and the minimum *trans* isomers is 45% in the product (based upon the sample label of Pounce WSB Insecticide, EPA Reg. No. 279-3083). **Table 2-1** provides the structure of permethrin and related compounds, as well as chemical names and CAS numbers.

Table 2-1: Permethrin and its Major Breakdown Products		
Common Name	**Chemical Name/ CAS #**	**Structure**
Permethrin	(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate CAS # 52645-53-1 (unspecified stereochemistry, chiral centers are marked with asterisks)	
m-PBA	*m*-phenoxybenzoic acid CAS # 3739-38-6	
m-PB-alc or *m*-PB-alcohol	*m*-phenoxybenzyl alcohol CAS # 13826-35-2	
cis-DCVA	*cis*-permethric acid or *cis*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid CAS # 59042-49-8	
trans-DCVA	*trans*-permethric acid or *trans*-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid CAS # 59042-50-1	

Permethrin is a persistent synthetic pyrethroid in the environment as it is slow to hydrolyze and biodegrade. Pyrethroids such as permethrin, that have the 2,2-dichloroethenyl 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 L/kg). The reported value of log octanol/ water partition coefficient of 6.1 (K_{OW} = 1.3 x 10^6) suggests that permethrin has the potential to bioaccumulate in aquatic organisms, assuming that chemical metabolism is negligible. However, the measured bioconcentration factor in fish (**Table 2-3**) is much lower than that expected based on K_{OW}, which suggests that permethrin metabolism by fish is substantial. Permethrin has a high molecular weight of 391.30 g/mol. With a vapor pressure of 1.48 x 10^{-8} mmHg, and due to its very low solubility, its calculated Henry's Law Constant is moderately low (1.4 x 10^{-6} atm-m^3/mol). Permethrin's air/water partition coefficient (K_{AW}) is 5.7 x 10^{-5}, which classifies it as 'slightly volatile from a water surface' (USEPA 2008a), and the $C_{water+soil}/C_{air}$ = 4.4 x 10^6, which classifies the chemical as 'non-volatile from moist soil' (USEPA 2008a). Based on these properties, permethrin would have a slight potential to volatilize from wet surfaces, but not from moist soil. The slight potential to volatilize of permethrin is attenuated by its tendency to bind to organic matter (*e.g.*, soils, sediments, or organic matter and particulate in natural water). Table 2-2 lists various important physicochemical characteristics of the chemical. Table 2-3 lists the other environmental fate properties of permethrin, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

Table 2-2. Physicochemical Properties of Permethrin

Property	Permethrin	
	Value[1]	**MRID or Source**
Molecular Weight	391.30 g/mole	EXTOXNET data base [3]
Chemical Formula	$C_{21}H_{20}Cl_2O_3$	Permethrin data sheet [2]
Density/ Specific Gravity	1.19 – 1.27 g/cm^3	Tomlin, C.D.S. (ed.). The Pesticide Manual – 11th ed., British Crop Protection Council, Surrey, England 1997, p. 944 [4]
Vapor Pressure (mmHg)	**1.48x10^{-8}** (Average of two values) (at 25°C)	MRID No. 42109801 & Laskowski 2002[5]
	2.18x10^{-8} (at 25°C)	USDA, Agric. Res. Service [4]
	1.9x10^{-8} (*cis*), and 1.1x10^{-8} (*trans*)	Wells *et al*., 1986
Henry's Law Constant (atm-m^3/mole at 20-25°C)	**1.4x10^{-6}**	Calculated using solubility of 0.0055 mg/L and VP of 1.5x10^{-8} mmHg
	1.6x10^{-7}	Calculated using solubility of 0.0055 mg/L and VP of 2.15x10^{-8} mmHg
Water Solubility (mg/L)	0.175 (Average of 0.22, and 0.13)	MRID No. 42109801
	0.0055 at 20°C	Wollerton, 1987 [5]
Octanol – water partition coefficient (log K_{OW})	6.1 at 20°C	Wollerton, 1987 [5]
Dissociation Constant (pK_a and/or pK_b)	Not available	PPDB [6]
Air-water partition coefficient (K_{AW})	$K_{AW} = C_{air}/C_{water}$ = HLC/RT = 5.7 x 10^{-5} 'Slightly volatile from a water surface'	Calculated Value, USEPA, 2008a
Octanol-air partition coefficient (K_{OA})	$K_{OA} = \frac{K_{OW}}{K_{AW}} = \frac{K_{OW}RT}{\text{Henry's Law Constant}}$ = 2.2 x 10^{10}	Calculated Value
UV/visible light absorption	Peaks at approximately 200 and 275 nm, with some tailing (in acetonitrile). λ_{max} at 207 and 273 nm at pH 7.	MRID 40242801 RD D274107[7]
Volatilisation Flux	Not available	Not available
$C_{water+soil}/C_{air}$	$C_{water+soil}/C_{air} = (1/K_{AW})(1/r + K_d)$ = 4.4 x 10^6 'Non-volatile from moist soil'	Calculated Value USEPA, 2008a

Table 2-2. Physicochemical Properties of Permethrin		
Property	**Permethrin**	
	Value[1]	**MRID or Source**

[1] If more than one value is given, the best value is **bolded**.
[2] http://www.alanwood.net/pesticides/permethrin.html (Accessed 08/20/10)
[3] http://extoxnet.orst.edu/pips/permethr.htm (Accessed 08/20/10)
[4] Information taken from the Hazardous Substances Data Bank (HSDB) at http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB (accessed 08/20/10)
[5] As cited in Laskowski, 2002.
[6] http://sitem.herts.ac.uk/aeru/iupac/Reports/515.htm (accessed 08/25/10)
[7] As cited by HED in its RED document D357566, 4/1/09 (refer to Appendix I).

Table 2-3. Summary of Permethrin Environmental Fate Properties

Study	**Value and unit**	**Major Degradate** ***Minor Degradates***	**MRID # or Citation**	**Study Classification**
Abiotic Hydrolysis	Half-life[1] = Stable, pH 3 Stable, pH 6 125-350 days, pH 9	**Major:** *m*-PB-alcohol (15.5%), **Minor:** *cis-/trans*-DCVA (6.5%)	00102043	Acceptable
Air Photolysis	Not available	N/A	N/A	N/A
Atmospheric Degradation	Half-life[1] = 0.467 days, estimated for hydroxyl radical	N/A	EPISuite v.4.0	N/A
Direct Aqueous Photolysis	Half-life[1] = 80 days, pH = 5	**Major:** None	40242801	Supplemental
Soil Photolysis	Half-life[1] = 106 days, loam soil	**Major:** None, **Minor:** *m*-PBA, and *m*-PBA	40190101	Acceptable
Aerobic Soil Metabolism	Half-life[1] = 37 days, 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	Acceptable
Anaerobic Soil Metabolism	Half-life[1] = 204 days, sandy loam soil	**Major:** *trans*-DCVA (13%) and *m*-PBA (12%); maxima observed at 60 days	41970601	Acceptable
Aerobic Aquatic Metabolism	Half-life[1] = Pond water test system from Wilson, NC: 38.2 days (Acid label) total system 42.9 days (Alcohol label) total system	**Major:** *trans*-DCVA (20% at 21 DAT) **Minor:** *cis*-DCVA and *m*-PBA (≤5.7%)	43938201	Acceptable
Anaerobic Aquatic Metabolism	Half-life[1] = 175 days (acid label) total system 113 days (alcohol label) in total system	**Major:** *cis*- and *trans*-DCVA, *m*-PBA, CO_2 (33.8-43.6% by 367 DAT)	43982001	Acceptable

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Solid-water distribution coefficient (K_d)	K_d, soil texture 140 L/kg, sand 217 L/kg, sandy loam 236 L/kg, silty loam 246 L/kg, clay loam 401 L/kg, sandy loam sediment	N/A	41868001	Acceptable
Freundlich solid-water distribution coefficient (K_F)	K_F, 1/n, soil texture 446 L/kg, 1.32, sand 355 L/kg, 1.12, sandy loam 344 L/kg, 1.09, silty loam 378 L/kg, 1.10, clay loam 1,517 L/kg, 1.29, sandy loam sediment	N/A	41868001	Acceptable
Organic-carbon normalized distribution coefficient (K_{OC})	K_{OC}, soil texture 60,900 L/kg, sand 20,900 L/kg, sandy loam 19,300 L/kg, silty loam 20,500 L/kg, clay loam 25,500 L/kg, sandy loam sediment	N/A	41868001	Acceptable
Freundlich organic-carbon normalized distribution coefficient (K_{FOC})	K_{FOC}, 1/n, soil texture 194,000 L/kg, 1.32, sand 34,100 L/kg, 1.12, sandy loam 28,200 L/kg, 1.09, silty loam 31,500 L/kg, 1.10, clay loam 96,600 L/kg, 1.29, sandy loam sediment	N/A	41868001	Acceptable
***m*-PBA**, Freundlich solid-water distribution coefficient and organic carbon normalized distribution coefficient (K_F and K_{FOC})	K_F = 0.98 to 3.11 L/kg K_{FOC} = 118 to 215 L/kg In sand, silt clay, clay, sandy loam, and another sandy loam soils	N/A	43424901	Acceptable
***trans*-DCVA**, Freundlich solid-water distribution coefficient and organic carbon normalized distribution coefficient (K_F and K_{FOC})	K_F = 0.16 to 0.54 L/kg K_{FOC} = 18 to 48 L/kg In sand, silt clay, clay, sandy loam, and another sandy loam soils	N/A	43424901	Acceptable
Volatility from Soil (Laboratory)	Study was waived	N/A	N/A	Waived
Volatility from Soil (Field)	Study was waived	N/A	N/A	Waived
Terrestrial Field Dissipation	Dissipation Half-life[1,2] = Bareground plots 17 days, NC silt loam soil, and 43 days IL silty clay soil	**Observed:** *trans*-DCVA and *m*-PBA at both NC and IL sites	42359109	Acceptable

Study	Value and unit	Major Degradate *Minor Degradates*	MRID # or Citation	Study Classification
Aquatic Field Dissipation	Dissipation Half-life[1,2] = Pond water, California 1.8/ 1.4 days from the pond water for *cis*-/ *trans*-permethrin; 118/ 18 days from the sediment top 2" for *cis*-/ *trans*-permethrin	**Observed:** *cis*-DCVA, *trans*-DCVA and *m*-PBA dissipated from the water with half-lives of 28, 22 & 7.5 days, respectively. Not detected in sediment.	44030501	Acceptable
	Dissipation Half-life[1,2] = Pond water, North Carolina 3.1/ 1.4 days from the pond water for *cis*-/ *trans*-permethrin; 156/ 62 days from the sediment top 2" for *cis*-/ *trans*-permethrin	**Observed:** *cis*-DCVA, *trans*-DCVA and *m*-PBA dissipated from the water with half-lives of 33, 23 & 14 days, respectively. Not detected in sediment.	44034101	Acceptable
Bioconcentration Factor (BCF) – Bluegill Sunfish (*Lepomis macrochirus*)	Steady State BCF= 570-610 L/kg wet wt whole fish 180-230 L/kg wet wt edible tissue 950-1,100 L/kg wet wt nonedible tissue Depuration: 4.7 days for 50% depuration	Only *trans*-DCVA was identified, at 4-10% of the total radioactivity	41300401, 41300402, 41300403	Acceptable

Abbreviations: wt=weight
[1]Half-lives were calculated using the single-first order equation and nonlinear regression, unless otherwise specified.
[2]The value may reflect both dissipation and degradation processes.

As shown in **Table 2-3**, permethrin is stable to hydrolysis at pHs 3-6, and it degrades at a slow rate ($t_{½}$ = 125-350 days) in alkaline solutions (pH 9) at 25°C in the dark. The hydrolysis products were *m*-PB-alcohol and *cis*-DCVA/*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. The half-life in the anaerobic soil metabolism study was 204 days (in a study that lasted 30 aerobic and 60 anaerobic days) and major degradates were *trans*-DCVA and *m*-PBA. 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 L/kg). K_{FOC} values in the range of 28,000 to 194,000 L/kg 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 L/kg (moderately mobile) and for *trans*-DCVA = 18 to 48 L/kg (mobile)]. 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. 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.

Acceptable fish bioconcentration studies, conducted in bluegill sunfish, showed that permethrin bioconcentrated with factors of 950 – 1100x in viscera, 570 – 610x in the whole fish, and 180 – 230x in the fillet. Depuration occurred at a moderate rate, with 73-83% depuration occurring after 14 days.

2.4.1. Environmental Transport Mechanisms

Potential transport mechanisms for a pesticide include surface water runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. Surface water runoff and spray drift are expected to be the major routes of exposure for permethrin to non-target organisms.

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 are considered in evaluating the potential for atmospheric transport of permethrin to locations the VELB may be exposed.

Limited atmospheric monitoring in California[2] was conducted in Butte, Monterey and Santa Barbara Counties. Application air monitoring was conducted in Butte County and ambient air monitoring was conducted in Monterey County (both in 1997). Of 24 application samples in Butte County, three were above the LOQ (LOQ = 0.33 µg/sample, equivalent to 0.015 µg/m^3 for 24 hour sampling at 15 L/min). The highest concentration was 0.57 µg/m^3. Ambient samples were taken in populated areas of Monterey County that coincided with the use of permethrin on lettuce and celery. Of the 115 samples collected, six were reported as "detected" and 109

[2] http://www.cdpr.ca.gov/docs/emon/pubs/tac/permthrn.htm (accessed 08/27/10).

samples were below the LOD (LOD = 0.10 μg/sample). Monitoring samples were taken in Lompoc, an agricultural city in Santa Barbara County in 2000, for a total of 31 pesticides. Permethrin was detected at trace levels to 4.3 ng/m^3 (highest 1-day air concentration).

Potential transport mechanisms for permethrin includes, among others, spray drift. Soil bound permethrin may undergo secondary drift with dust storms, that may cause its deposit on nearby or distant ecosystems. Spray drift is expected to be the major route of exposure for permethrin to non-target insects and other terrestrial organisms. Permethrin has a low vapor pressure (1.48×10^{-8} mmHg) 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. Permethrin's estimated atmospheric half-life is short (~0.5 days for the hydroxyl radical reaction), indicating a low potential for transport via volatilized active substance (as opposed to present in suspended solids).

2.4.2. Mechanism of Action

Permethrin is a neurotoxic insecticide with contact and stomach action, having a slight repellent effect. The primary biological effects of permethrin 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 (calcium ion 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 (*gamma*-aminobutyric acid) and glutamate receptor-channel complexes and voltage-activated Ca^{2+} channels, but the toxicological significance of these actions is uncertain.

Pyrethroids, including permethrin, stimulate repetitive action in the nervous system by binding to voltage-gated Na^+ channels, prolonging the Na^+ ion permeability during the excitatory phase of the action potential. This action leads to spontaneous depolarizations, augmented neurotransmitter secretion rate and neuromuscular block, which ultimately results in paralysis of the insect. The toxicity of permethrin is dependent on the ratio of the isomers present; the *cis*-isomer being more toxic.

Relative to physiological responses, researchers have designated two types of pyrethroids, Type I (*e.g.*, S-bioallethrin, resmethrin and permethrin) and Type II (*e.g.*, cypermethrin, deltamethrin and fenvalerate). Structurally, Type I pyrethroids lack the cyano group that characterizes Type II pyrethroids. Physiologically, Type I pyrethroids have shorter periods of sodium channel disruption (shorter inactivation time) than that of Type II pyrethroids.

2.4.3. Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for permethrin represent 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.

This assessment considered all of the mitigation measures included in the labels issued after the 2006 Amended Reregistration Eligibility Decision (RED) document for permethrin (USEPA 2006a). These mitigation measures were effective May 30, 2008 and are described in detail in the permethrin 2006 RED document. In summary, the mitigation measures included reductions in application rates and number of applications, and changes in the minimum retreatment intervals for almost all major uses of the chemical. In addition label language on buffers, maintained vegetative buffers, and spray drift requirements were implemented. A summary of important mitigation measures that affect exposure, from the 2006 Amended RED, is included in the Appendix E.

This assessment also considered PR Notice 2005-1, which imposes droplet size specifications to ground and aerial Ultra-Low Volume (ULV) applications of permethrin use as a mosquito adulticide. These specifications are already implemented in all labels for permethrin.

In May 2009, a revised RED for permethrin was issued (USEPA 2009b). Certain additional measures are being imposed to mitigate ecological risks; however, these measures were not included in this assessment because they have not been implemented as of the issuance of the Verification Memorandum (dated 09/08/10).[3] According to the Verification Memorandum, they are expected to be implemented in the product labels in the year 2011. Refer to the Appendix B for a copy of the Verification Memorandum.

According to the revised 2009 RED (USEPA 2009b), further droplet size specifications will be included in the mosquito adulticide labels (these specifications are more restrictive than those imposed by PR Notice 2005-1). These new specifications could result in lower exposure potential for the VELB due to the uses of permethrin as a mosquito adulticide.

Furthermore, for non-crop outdoor uses, various restrictions will take place. For example, for products labeled for use on and around buildings and other structures, all outdoor applications will be limited to spot or crack-and-crevice treatments, with certain exceptions. Other than applications to building foundations, all outdoor applications to impervious surfaces such as sidewalks, driveways, patios, porches and structural surfaces (such as windows, doors, and eaves) are limited to spot and crack-and-crevice applications, only Other restrictions are related to the prevention of runoff or contamination of surface waters.

[3] The verification memorandum is issued by the Pesticide Re-evaluation Division (PRD) and serves to provide additional information on the use pattern of permethrin that is not captured in the LUIS process.

Currently, permethrin is labeled for use in numerous agricultural and non-agricultural sites. Currently, there are around 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. This method to extract the labels is intended to provide information about the maximum use rates and the use patterns for the chemical.

Tables 2-4 to **2-6** present the uses and corresponding application rates and methods of application for permethrin considered in this assessment. **Table 2-4** presents agricultural crop uses and corresponding application rates and methods of label application for liquid sprays.

Table 2-4 Labeled Permethrin Crop Use Patterns (liquid sprays)♠

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)			
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**
	Almond, hazelnut, pistachio, and walnut [6]	1, 6	**0.40**	**4-5**	**1.6-2.0**	**NS**
Avocado	Avocado	1-5 Foliar	**0.20**	**4**	**0.80**	**7**
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**
Other 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**
	Sweet [6]		**0.25**	**6**	**1.5**	**3**
Forestry	Cottonwood Hybrid (Poplar)	2 Foliar	**0.20**	**N/S**	**N/S**	**N/S**

Table 2-4 Labeled Permethrin Crop Use Patterns (liquid sprays)♠

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)			
	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**
Leafy Vegetables	Brussels Sprouts	1-5 Foliar	**0.10**	**4**	**0.40**	**5**
	Lettuce (Head/Leafy)		**0.20**	**4**	**0.80**	**7**
	Spinach, Orach (Mountain Spinach), and New Zealand		**0.20**	**3**	**0.60**	**3**
Other Leafy Vegetables	Amaranth (Chinese), Celtuce, Chard (Swiss), Chervil, Chicory, Chrysanthemum (Leafy), Corn Salad, Cress (Garden & Upland), Dandelion, Dock (Sorrel), Cardoon, Parsley, Purslane (Garden/Winter, Roquette (Arugula)	1-5 or not specified Foliar	**0.20**	**10**	**2**	**3**
Cucurbits [4]	Cantaloupe	1-5 Foliar	**0.20**	**4**	**0.80**	**7**
	Cucumber, Pumpkin, Squash 1, and Watermelon		**0.20**	**6**	**1,2**	**7**
Other 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**

Table 2-4 Labeled Permethrin Crop Use Patterns (liquid sprays)♠

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)			
	Nursery Stock	Aerial Foliar	0.75	6	N/S	28
		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
	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 per the 2006 RED, 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, Musk, and winter "Casaba/Crenshaw/Honeydew/Persian, and summer); and Squash 2= Butternut, Zucchini

[6] Only for home and garden use.

Home and garden labelled uses are included in **Table 2-5**. These uses were not covered by the mitigation measures issued after the 2006 RED. The labels cover use on home turf and ornamentals in addition to outdoor residential perimeter, barrier, and termite treatments.

Table 2-5 Labelled 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)			
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		**0.87**	**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**

[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

Labelled use patterns in **Tables 2.4** and **2-5** 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.

Finally, the most relevant non-agricultural use patterns for permethrin considered in this assessment are included **Table 2-6**; these patterns are summarized from a much larger non-agricultural use pattern table included in **Appendix E** (refer to **Table E-5** of the appendix). **Table 2-6** includes only important uses that could potentially cause significant permethrin ecological exposures.

Table 2-6. Labelled Permethrin Use Patterns Assessed for California (non-crop uses)

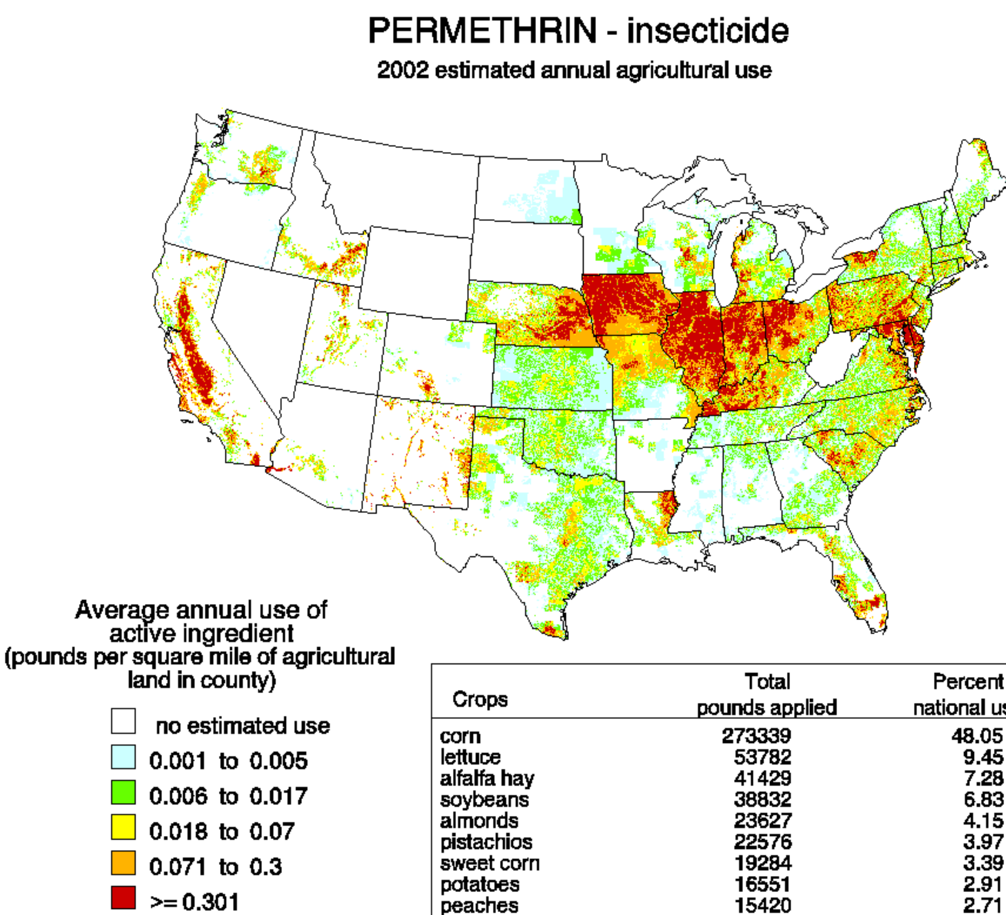
Treatment Type	*Spray Type*	*Application Method*	*Use Pattern*	*Application Rate (lb a.i./A And Other Parameters*
Soil Barrier Treatment	Liquid, Mist and ULV sprays	Ground	Fencerows and Hedgerows	0.01 lb a.i/A with no other information
			Range Land	0.1 lb a.i/A with no other information

Table 2-6. Labelled Permethrin Use Patterns Assessed for California (non-crop uses)				
Treatment Type	*Spray Type*	*Application Method*	*Use Pattern*	*Application Rate (lb a.i./A And Other Parameters*
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

Permethrin uses include granular and dust applications, and seed treatment; however, these uses are not assessed for the VELB in this document. Label information related to the granular formulation use in agricultural crops is summarized in **Table E-2** of the **Appendix E**, while the label information related to dust use in home and garden vegetables is included in **Table E-3** of the same appendix. Finally, permethrin is used for dip and seed treatment. **Table E-4** of the **Appendix E** summarizes labeled used information for the dip and seed treatment uses. For the granular uses, the application rates are generally of the same order of magnitude as for liquid applications. For dust applications, the application rate was not specified for most of the crops. According to the labels for dust applications, the applicator should arrive at a complete coverage of foliage. For the treatment of seeds (dipping or using slurry or mist seed treatment equipment), the application rates were low, compared to the liquid formulations. At this time, the Division does not have models or methods to assess these uses. It is recognized that the uses due to granular and dust applications do not encompass risks beyond the treatment area because there is no drift. Furthermore, because permethrin is not systemic, it appears that exposure to terrestrial invertebrates due to seed treatment applications is low. However, it is reasonable to presume risk due to these uses, especially given that all the liquid applications resulted in exceedances of the LOCs.

Several of the agricultural crops for permethrin may be planted or cultivated more than once a year. For example, broccoli, cabbage, cauliflower, collards, lettuce, celery, spinach and artichoke may have multiple crops in a year in California. For modeling purposes, the EFED generally assumes one crop cycle per year.

According to the United States Geological Survey's (USGS) national pesticide usage data (based on information from 1999 to 2004), an average of over 560,000 lbs of permethrin is applied nationally to agricultural use sites in the U.S. (Figure 2-1) (non-agricultural uses are not included in this figure). By far, the highest agricultural use for permethrin at the time was corn, with 48.05% of the pounds applied; this use was followed by lettuce, alfalfa hay and soybeans with 6.8-9.4% of the pounds applied. Use sites included the majority of the continental USA, with highest use in California, the Delmarva peninsula, and the cornbelt (http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m6048, accessed 08/20/10)[4].



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 2-1. Permethrin Use in Total Pounds per County

[4] The pesticide use maps available from this site show the average annual pesticide use intensity expressed as average weight (in pounds) of a pesticide applied to each square mile of agricultural land in a county. The area of each map is based on state-level estimates of pesticide use rates for individual crops that were compiled by the CropLife Foundation, Crop Protection Research Institute based on information collected during 1999 through 2004 and on 2002 Census of Agriculture county crop acreage. The maps do not represent a specific year, but rather show typical use patterns over the five year period 1999 through 2004.

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2010) using state-level usage data obtained from USDA-NASS[5], Doane (www.doane.com); the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[6]. 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 was generated using CDPR PUR data. Ten years (1999-2008) 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.[7] 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 ten years. The units of area treated are also provided where available.

Table 2-7 provides the average application rate, 95 percentile application rate, 99 percentile application rate and maximum application rate for agricultural uses of permethrin, for records available for the ten years 1999-2008. These data were provided by BEAD (Kaul and Jones, 2010). It is noted that crops like chervil, Chinese greens, gai ion, grape, herb (spice), mustard and sunflower had average application rates at or above 0.5 lb a.i./A. It was also noted that rice, which is not known to be among the labeled crops appears in the list.

Table 2-7. Permethrin Agricultural Usage in California (average data 1999-2008)[1]

SITE NAME	AVE APP RATE	95TH PERC APP RATE	99TH PERC APP RATE	MAXIMUM APP RATE
ALFALFA	0.1	0.2	0.2	1.3
ALMOND	0.2	0.4	0.5	3.5
APPLE	0.1	0.2	0.8	0.8
APRICOT	0.3	0.5	0.5	0.5
ARRUGULA	0.2	0.7	1.4	3.2
ARTICHOKE, GLOBE	0.2	0.3	0.3	2.8
ASPARAGUS	0.2	2.0	2.0	2.0
AVOCADO	0.2	0.2	0.2	0.2
BARLEY	0.2	0.2	0.2	0.2
BASIL, SWEET	0.1	0.1	0.1	0.1
BEAN, DRIED	0.1	0.2	0.2	0.2

[5] United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.pestmanagement.info/nass/app_usage.cfm.

[6] 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 .

[7] Most pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, and along roadside and railroad rights of way, and postharvest treatments of agricultural commodities are reported in the database. The primary exceptions to the reporting requirement are home-and-garden use and most industrial and institutional uses (http://www.cdpr.ca.gov/docs/pur/purmain.htm).

Table 2-7. Permethrin Agricultural Usage in California (average data 1999-2008)[1]				
SITE NAME	AVE APP RATE	95TH PERC APP RATE	99TH PERC APP RATE	MAXIMUM APP RATE
BEAN, SUCCULENT	0.2	0.2	0.2	0.2
BEAN, UNSPECIFIED	0.1	0.1	0.1	0.1
BEET	0.1	0.1	0.1	0.1
BOK CHOY	0.3	0.7	3.0	4.0
BROCCOLI	0.1	0.1	0.2	1.6
BRUSSELS SPROUT	0.1	0.1	0.2	0.8
CABBAGE	0.2	0.2	0.2	2.5
CANTALOUPE	0.1	0.2	0.2	0.4
CARDOON	0.1	0.2	0.2	0.2
CARROT	0.1	0.1	0.1	0.1
CAULIFLOWER	0.1	0.1	0.2	1.0
CELERY	0.2	0.2	0.2	2.0
CHERRY	0.2	0.2	0.7	2.9
CHERVIL	0.7	0.7	0.7	0.7
CHICORY	0.2	0.2	0.2	3.0
CHINESE CABBAGE (NAPPA)	0.2	0.2	0.5	6.4
CHINESE GREENS	0.5	1.6	2.7	2.7
CHRISTMAS TREE	0.1	0.2	0.2	0.2
CILANTRO	0.2	0.2	0.2	0.2
COLE CROP	0.2	0.2	0.2	0.2
COLLARD	0.2	0.2	0.2	0.2
CORN (FORAGE - FODDER)	0.2	0.2	0.5	6.1
CORN, HUMAN CONSUMPTION	0.2	0.2	0.3	20.0
COTTON	0.1	0.3	0.5	0.5
CUCUMBER	0.2	0.2	0.2	0.6
DAIKON	0.1	0.1	0.1	0.1
DANDELION GREEN	0.1	0.2	0.2	0.2
EGGPLANT	0.2	0.2	0.3	0.3
ENDIVE (ESCAROLE)	0.2	0.2	0.2	2.0
FENNEL	0.1	0.2	0.2	0.2
FOREST, TIMBERLAND	0.0	0.0	0.0	0.0
GAI LON	0.5	4.0	4.0	4.0
GARLIC	0.2	0.3	0.3	0.3
GRAPE	0.5	0.9	0.9	0.9
GRAPE, WINE	0.2	0.2	0.2	0.2
GREENHOUSE FUMIGATION	0.1	0.5	0.5	0.5
HERB, SPICE	1.3	1.3	1.3	1.3
KALE	0.1	0.3	0.3	0.3
KOHLRABI	0.1	0.1	0.1	0.1
LEMON	0.2	0.2	0.2	0.2
LETTUCE, HEAD	0.1	0.2	0.2	2.5
LETTUCE, LEAF	0.1	0.2	0.2	2.0
MELON	0.2	0.2	0.3	1.6
MUSHROOM	0.3	0.4	0.6	1.2
MUSHROOM HOUSE	0.3	0.3	0.3	0.3
MUSTARD	18.9	187.5	187.5	187.5

Table 2-7. Permethrin Agricultural Usage in California (average data 1999-2008)[1]				
SITE NAME	AVE APP RATE	95TH PERC APP RATE	99TH PERC APP RATE	MAXIMUM APP RATE
N-GRNHS FLOWER	0.4	0.8	1.3	7.2
N-GRNHS PLANTS IN CONTAINERS	0.4	1.0	2.5	5.6
N-GRNHS TRANSPLANTS	0.1	0.3	1.6	4.9
N-OUTDR FLOWER	0.2	0.4	0.8	6.4
N-OUTDR PLANTS IN CONTAINERS	0.4	1.2	2.6	7.1
N-OUTDR TRANSPLANTS	0.2	0.9	1.8	3.3
NECTARINE	0.2	0.3	0.3	0.3
OAT	0.2	0.4	0.4	0.4
OAT (FORAGE - FODDER)	0.2	0.3	0.3	0.3
ONION, DRY	0.2	0.3	0.4	3.2
ONION, GREEN	0.2	0.2	0.2	0.2
ORANGE	0.3	0.3	0.3	0.3
PARSLEY	0.2	0.2	0.3	2.1
PEACH	0.2	0.3	0.4	3.2
PEAR	0.2	0.8	0.8	0.9
PEPPER, FRUITING	0.2	0.2	0.5	3.2
PEPPER, SPICE	6.9	32.0	62.9	62.9
PISTACHIO	0.3	0.4	0.4	4.8
PLUM	0.1	0.2	0.2	0.2
POTATO	0.2	0.2	0.3	3.2
PRUNE	0.2	0.3	0.3	0.3
PUMPKIN	0.2	0.2	0.4	0.9
RADISH	0.2	0.2	0.2	0.2
RAPPINI	0.1	0.2	0.2	0.2
RICE	0.1	0.1	0.1	0.1
RYEGRASS	0.1	0.1	0.1	0.1
SOIL FUMIGATION/PREPLANT	0.2	0.2	0.2	0.2
SOYBEAN	0.2	0.2	0.2	0.2
SPINACH	0.2	0.2	0.2	17.5
SQUASH	0.2	0.2	0.8	6.0
SQUASH, SUMMER	0.2	0.2	0.2	0.5
SQUASH, WINTER	0.2	0.2	0.2	0.2
SQUASH, ZUCCHINI	0.2	0.2	0.2	0.2
STRAWBERRY	0.2	0.2	0.2	0.2
SUGARBEET	0.2	0.2	0.2	0.2
SUNFLOWER	0.8	2.2	2.2	2.2
SWISS CHARD	0.2	0.2	0.3	2.3
TOMATILLO	0.2	0.2	0.8	0.8
TOMATO	0.2	0.2	0.3	3.0
TOMATO, PROCESSING	0.2	0.2	0.2	2.8
TURNIP	0.1	0.1	0.1	0.1
UNCULTIVATED AG	0.2	0.2	0.2	0.2
VEGETABLE	0.3	1.0	1.0	1.0
VEGETABLES, LEAFY	0.2	0.2	0.8	1.9

Table 2-7. Permethrin Agricultural Usage in California (average data 1999-2008)[1]				
SITE NAME	AVE APP RATE	95TH PERC APP RATE	99TH PERC APP RATE	MAXIMUM APP RATE
WALNUT	0.2	0.4	0.5	3.2
WATERMELON	0.2	0.2	1.3	3.8
WHEAT	0.1	0.2	0.2	0.2
WHEAT (FORAGE - FODDER)	0.2	0.2	0.2	0.2

[1]. Only agricultural crops were included. Only records in units of lb a.i./A were included. Records for which units were in lb/square feet or other miscellaneous units were excluded. Furthermore, records for "permethrin, other related" were excluded, since they were only a few records and only one was in units of lb/A, but it represented a non-crop use.

Table 2-8 provides the average annual pounds of permethrin applied to all counties in California. An average of 430,693 lbs of permethrin were applied in all of California, for the period 1999-2008 (shaded row of the table). From the table, it is observed that the counties with the highest usage of permethrin, exceeding 10% of the total use are Los Angeles (17.42% of the total) and Riverside (11.65%). Furthermore, counties at or above ~5% of the total use are Fresno (5.84% of the total), Kern (4.96%), Monterey (5.67%), Orange (8.72%), San Bernardino (4.81%) and San Diego (5.72%).

Table 2-8. Average Annual Pounds of Permethrin Applied to California Counties (average data 1999-2008)[1]		
COUNTY	AVE ANNUAL POUNDS APPLIED	PERCENT OF TOTAL (%)
TOTAL ALL COUNTIES	**430,693**	**100.00**
ALAMEDA	2,514	0.58
ALPINE	16	<0.01
AMADOR	183	0.04
BUTTE	3,036	0.70
CALAVERAS	2,857	0.66
COLUSA	1,885	0.44
CONTRA COSTA	2,887	0.67
DEL NORTE	33	0.01
EL DORADO	2,203	0.51
FRESNO	25,144	5.84
GLENN	2,182	0.51
HUMBOLDT	47	0.01
IMPERIAL	11,161	2.59
INYO	9	<0.01
KERN	21,360	4.96
KINGS	5,676	1.32
LAKE	213	0.05
LASSEN	144	0.03
LOS ANGELES	75,030	17.42
MADERA	13,257	3.08
MARIN	1,009	0.23
MARIPOSA	90	0.02
MENDOCINO	194	0.05
MERCED	10,605	2.46

Table 2-8. Average Annual Pounds of Permethrin Applied to California Counties (average data 1999-2008)[1]		
COUNTY	AVE ANNUAL POUNDS APPLIED	PERCENT OF TOTAL (%)
TOTAL ALL COUNTIES	**430,693**	**100.00**
MODOC	212	0.05
MONO	1	<0.01
MONTEREY	24,367	5.67
NAPA	338	0.08
NEVADA	511	0.12
ORANGE	37,567	8.72
PLACER	1,087	0.25
PLUMAS	61	0.01
RIVERSIDE	50,183	11.65
SACRAMENTO	3,840	0.89
SAN BENITO	1,692	0.39
SAN BERNARDINO	20,723	4.81
SAN DIEGO	24,640	5.72
SAN FRANCISCO	1,210	0.28
SAN JOAQUIN	8,780	2.04
SAN LUIS OBISPO	3,234	0.75
SAN MATEO	1,461	0.34
SANTA BARBARA	5,679	1.32
SANTA CLARA	12,252	2.84
SANTA CRUZ	1,042	0.24
SHASTA	1,312	0.30
SIERRA	13	<0.01
SISKIYOU	219	0.05
SOLANO	1,030	0.24
SONOMA	1,118	0.26
STANISLAUS	18,809	4.37
SUTTER	3,164	0.73
TEHAMA	480	0.11
TRINITY	13	<0.01
TULARE	11,598	2.69
TUOLUMNE	1,674	0.39
VENTURA	6,687	1.55
YOLO	2,780	0.65
YUBA	1,176	0.27
[1]. The shaded row represents the total of all counties in California.		

The non-agricultural uses of permethrin in California exceed the agricultural uses. For example, for structural pest control, the average pounds applied for the 10 year period of 1999-2008 is 277,657 lb, which represents 64.46% of the total pounds of permethrin applied in California. This non-agricultural use alone exceeds all other uses for the chemical in California (Kaul and Jones, 2010).

2.5. Assessed Species

Table 2-9 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 Attachment III. See Figure 2-2 for a map of the current range and designated critical habitat, of the VELB.

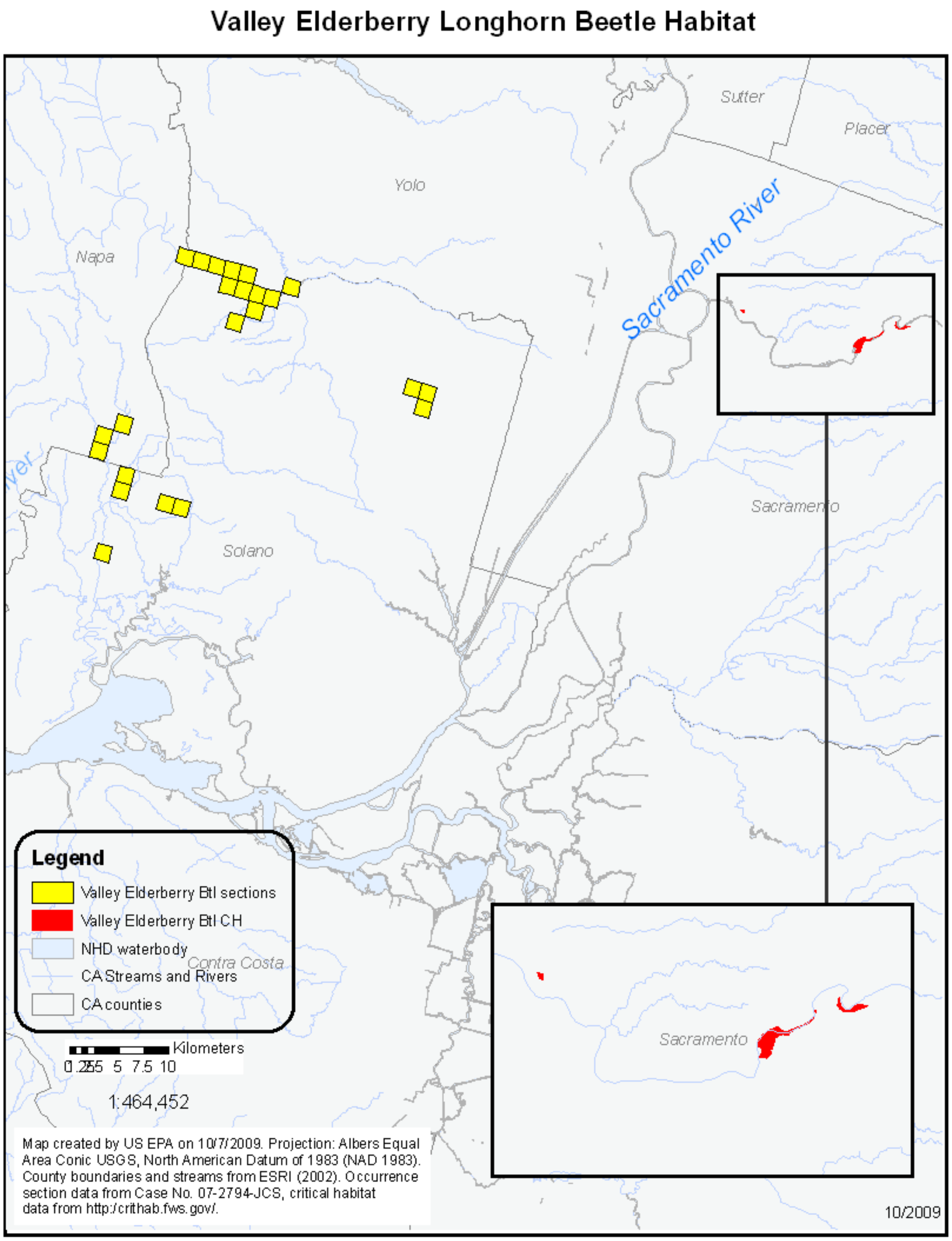
The VELB was listed as threatened in 1980 by the USFWS. The species is found in areas with elderberry shrubs throughout California's Central Valley and associated foothills on the east and the watershed of the Central Valley on the west.

Table 2-9. 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
Valley Elderberry Longhorn Beetle (VELB) (*Desmocerus californicus dimorphus*)	Males: 1.25–2.5 cm length Females: 1.9–2.5 cm length	Central Valley of California (from Shasta County to Fresno County in the San Joaquin Valley)	Completely dependent on its host plant, elderberry (*Sambucus species*), which is a common component of the remaining riparian forests and adjacent upland habitats of California's Central Valley	Yes	The larval stage may last 2 years living within the stems of an elderberry plant. Female VELB lay their eggs "singly or in small groups" on live elderberry leaves, in crevices in the bark, at the stem/trunk junctions, or at the stem/petiole junctions of the elderberry. Then larvae enter the pupal stage and transform into adults. Adults emerge and are active from March to June feeding and mating, when the elderberry produces flowers.	Obligates with elderberry trees (*Sambucus* sp). Adults eat the elderberry foliage until about June when they mate. Upon hatching the larvae tunnel into the tree where they will spend 1-2 years eating the interior wood which is their sole food source.

[1] For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see Attachment II.

Figure 2-2. Valley Elderberry Longhorn Beetle Critical Habitat and Occurrence Sections identified in Case No. 07-2794-JCS.



2.6. Designated Critical Habitat

Critical habitat has been designated for the VELB. Risk to critical habitat is evaluated separately from risk to direct and indirect effects on the species. ‘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 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)). Table 2-10 describes the PCEs for the critical habitats designated for the VELB.

Table 2-10. Designated Critical Habitat PCEs for the VELB[1].

Species	PCEs	Reference
Valley Elderberry Longhorn Beetle	Areas that contain the host plant of this species (*i.e.*, elderberry plants, *Sambucus* sp.)	43 FR 35636 35643, 1978

[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. PCEs that are abiotic, including, physical-chemical water quality parameters such as salinity, pH, and hardness are not evaluated.

More detail on the designated critical habitat applicable to this assessment can be found in **Attachment II**. 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 VELB form the basis of the critical habitat impact analysis. According to the VELB Status & Life History document provided by the U.S. Fish & Wildlife Services, *"The threats that may adversely modify the critical habitat and require special management include: 1) modification of riparian habitats by river channelization; 2) construction of buildings, roads, bridges, or parking lots, directly eliminating the beetle's host plant, elderberry (Sambucus sp.).; and 3) human disturbance, such as vandalism or fire, resulting from increased recreational use, which adversely affects the beetle" (USFWS, 1980).*

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 and LAA Effects Determination Area

2.7.1. Action Area

The action area is the geographic area that could be affected by the Federal action. The Federal action is the authorization or registration of pesticide use or uses as described on the label(s) of pesticide products containing a particular active ingredient. The action area is defined by the

Endangered Species Act as, “all areas to be affected directly or indirectly by the Federal action and not merely the immediate are involved in the action” (50 CFR §402.2). Based on an analysis of the Federal action, the action area is defined by the actual and potential use of the pesticide and areas where that use could result in effects. 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 sublethal effects available in the effects literature. 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 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 VELB and their designated critical habitat within the state of California. For this assessment, the entire state of California is considered the action area. The purpose of defining the action area as the entire state of California is to ensure that the initial area of consideration encompasses all areas where the pesticide may be used now and in the future, including the potential for off-site transport via spray drift that could influence the VELB. Additionally, the concept of a state-wide action area takes into account the potential for direct and indirect effects and any potential modification to critical habitat based on ecological effect measures associated with reduction in survival, growth, and reproduction, as well as the full suite of sublethal effects available in the effects literature.

It is important to note that the state-wide action area does not imply that direct and/or indirect effects and/or critical habitat modification are expected to or are likely to occur over the full extent of the action area, but rather to identify all areas that may potentially be affected by the action. The Agency uses more rigorous analysis including consideration of available land cover data, toxicity data, and exposure information to determine areas where VELB and designated critical habitat may be affected or modified via endpoints associated with reduced survival, growth, or reproduction.

2.7.2. LAA Effects Determination Area

A stepwise approach is used to define the Likely to Adversely Affect (LAA) Effects Determination Area. An LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the species and/ or modify its designated critical habitat using EFED's standard assessment procedures (see **Attachment I**) and effects endpoints related to survival, growth, and reproduction. This is the area where the "Potential Area of LAA Effects" (initial area of concern + drift distance) overlaps with the range and/or designated critical habitat for the species being assessed. If there is no overlap between the potential area of LAA effects and the habitat or occurrence areas, a no effect determination is made. The first step in defining the LAA Effects Determination Area is to understand 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. In addition, a distinction has been made between food use crops and those that are non-food/ non-agricultural uses.

The following general agricultural uses of permethrin are relevant to the VELB and are considered part of the federal action evaluated in this assessment:

-alfalfa (alfalfa hay and seed crops)
-avocado
-cole crops (broccoli, cabbage, cauliflower, collards, horseradish, kohlrabi)
-corn (pop, sweet)
-corn (field)
-eggplant
-fruit trees (pear)
-fruit trees (peach, papaya, cherry, apple)
-garlic and potatoes, turnip root
-leafy vegetables (lettuce, Brussel sprouts, orach, spinach, New Zealand spinach)
-leafy vegetables [Chinese amaranth, cardoon, celtuce, Swiss chard, chervil chicory, leafy chrysanthemum, corn salad, garden and upland cress, dandelion, dock (scorrel), parsley, purslane (winter and garden), roquette (arugula)]
-cucurbit vegetables (cucumber, cantaloupe, eggplant, pumpkin, squash, watermelon)
-cucurbit vegetables [melons, melons (bitter, balsam pear), citron melon, melons (honeydew, musk and winter "Casaba/ Crenshaw/ Honeydew/ Persian"), guerkin, gourd (Chinese wax), luffa, momordica, zucchini, spaguetti squash]
-nut trees (pistachio, almond, filbert-hazelnut, walnut)
-onion (onion and fennel)
-row crops (celery, artichoke, asparagus, pepper)
-row crops (rhubarb, field grown roses)
-tomato
-tomatillo
-ant mound control in crop sites (see also below, use in non agricultural sites), and
-mosquito adulticide use in crop sites (see also below use in non-agricultural sites).

In addition, the following general non-food and non-agricultural uses are considered part of the federal action being assessed:

-forestry (softwood – conifer, hybrid cottonwood/ poplar)

-nursery (nursery stock, pine – seed orchard, Christmas trees)
-turf (golf course, recreational/ industrial areas)
-ant mound control in non-agricultural sites (see also above, use in crop sites)
-mosquito adulticide use in non-agricultural sites (see also above, use in crop sites)
-soil barrier treatment (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), and
-perimeter treatment [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)].

Refer to **Tables 2-4** to **2-6** for use information details and **Table 3-1** for a summary of specific uses assessed.

Following a determination of the assessed uses, an evaluation of the potential “footprint” of permethrin use patterns (*i.e*., the area where pesticide application may occur) is determined. This “footprint” represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. For permethrin, these land cover types include pasture/ hay, orchards/ vineyards, cultivated crops, forest, developed (low, medium and high intensity, open space) and other (*e.g.*, non-agricultural uncultivated areas/soils). Note that these include several of the land cover types. Land cover types not included are wetlands, open water, barren land, shrubs and grassland.

A “Footprint” of potential use is assumed to cover a wide area and will not have a spatially defined area for the following uses or combinations of uses:

- mosquito adulticide,
- right-of-way,
- fire ant control,
- large number of uses covering a high number of land cover types such as a residential use along with an agricultural use

Therefore, 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. For characterization, a map showing the potential use of permethrin based on land cover classes in the state of California is included in Appendix J. Maps concentrating on potential permethrin use in the areas of VELB occurrence and critical habitat are also included in Appendix J. These maps show a more limited scope of the area in which permethrin may be potentially used, as mosquito adulticide, right-of-way, fire ant and many residential uses are not spatially defined. In this case, an initial area of concern map is not necessary as 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 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 sublethal effects available in the effects literature. Therefore, the action area extends to a point where environmental exposures are below any measured lethal or sublethal effect threshold for any biological entity at the whole organism, organ, tissue, and cellular level of organization. In situations where it is not possible to determine the threshold for an observed effect, the action area is not spatially limited and is assumed to be the entire state of California.

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 VELB and its 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 most 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

For more information on the assessment endpoints, measures of ecological effect, see Attachment I.

2.8.1. Assessment Endpoints

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. **Table 2-11** identifies the taxa used to assess the potential for direct and indirect effects from the uses of permethrin for each listed species assessed here. The specific assessment endpoints used to assess the potential for direct and indirect effects to each listed species are provided in **Table 2-12.**

Table 2-11. Taxa Used in the Analyses of Direct and Indirect Effects for the Assessed Listed Species.

Listed Species	Birds	Mammals	Terr. Plants	Terr. Inverts.	FW Fish	FW Inverts.	Estuarine /Marine Fish	Estuarine /Marine Inverts.	Aquatic Plants
Valley elderberry longhorn beetle	n/a	n/a	Indirect (food/ habitat) *	Direct	n/a	n/a	n/a	n/a	n/a

Abbreviations: n/a = Not applicable; Terr. = Terrestrial; Invert. = Invertebrate; FW = Freshwater
* obligate relationship

Table 2-12. Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Permethrin to Result in Direct and Indirect Effects to the VELB and Modification of Critical Habitat.

Taxa Used to Assess Direct and Indirect Effects to Assessed Species and/or Modification to Critical Habitat or Habitat	Direct/Indirect Effect	Assessment Endpoints	Measures of Ecological Effects
1. Terrestrial Invertebrates	Direct Effect	Survival, growth, and reproduction of individuals via direct effects	Most sensitive terrestrial invertebrate acute EC_{50} or LC_{50} (guideline or ECOTOX)
2. Terrestrial Plants	Indirect Effect	Modification of critical habitat/habitat via indirect effects on food and habitat (*i.e.*, riparian and upland vegetation)	No data available for quantitative use.

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.

Assessment endpoints used to evaluate potential for direct and indirect effects are equivalent to the assessment endpoints used to evaluate potential effects to designated critical habitat. If a potential for direct or indirect effects is found, then there is also a potential for effects to critical habitat. 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.

2.9. Conceptual Model

2.9.1. Risk Hypotheses

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

The labeled use of permethrin within the action area may:

- directly affect VELB by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect VELB and/or modify its designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect VELB and/or modify its designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range

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 VELB and the conceptual models for the PCE components of critical habitat are shown in **Figure 2-3**. 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 VELB and modification to designated critical habitat is expected to be negligible.

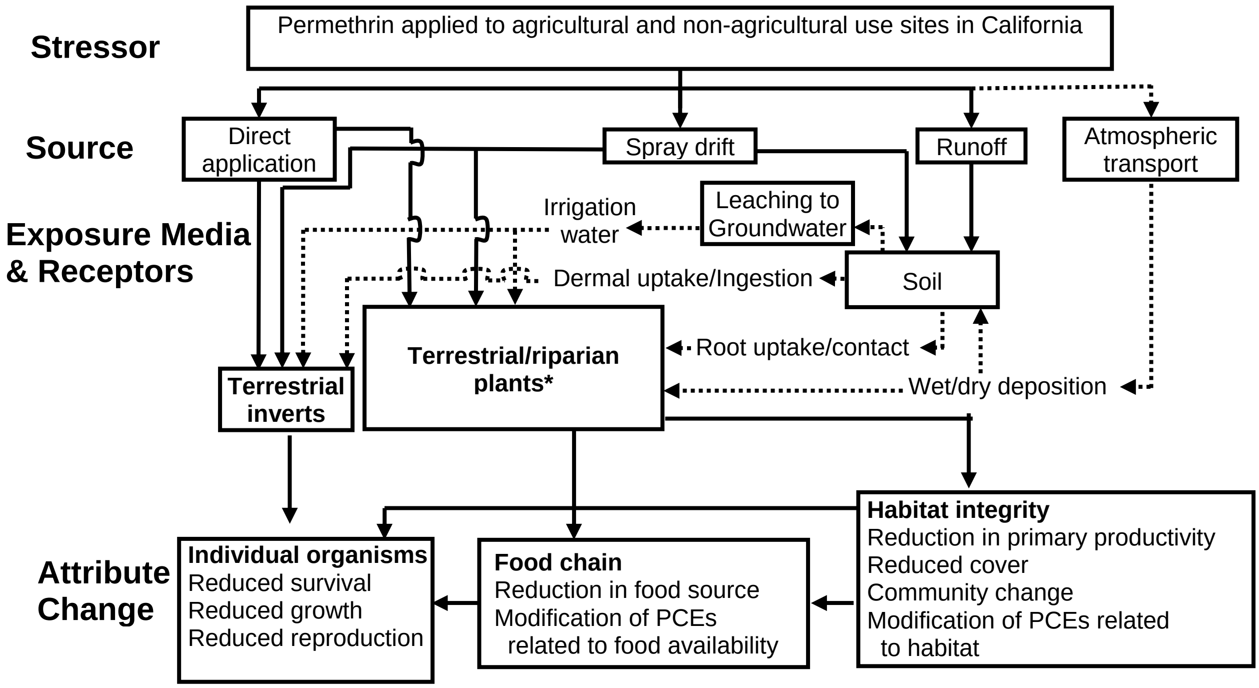


Figure 2-3. Conceptual model depicting stressors, exposure pathways, and potential effects to terrestrial organisms from the use of permethrin.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.
PCEs=primary constituent elements
* The VELB has an obligate relationship with the elderberry plant.

2.10. Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the assessed species, 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 (USEPA, 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.

Descriptions of routine procedures for evaluating risk to the San Francisco Bay Species are provided in **Attachment I**.

2.10.1. Measures of Exposure

The environmental fate properties of permethrin indicate that runoff, runoff of eroded particles containing the pesticide and spray drift are the principle potential transport mechanisms of permethrin to the terrestrial habitats of the VELB. In this assessment, only transport of permethrin through spray drift is considered in deriving quantitative estimates of permethrin exposure to the VELB, its prey, and its habitat. Runoff and runoff of eroded particles are not examined quantitatively in this assessment because exposure to terrestrial invertebrates through those routes is unlikely. Furthermore, no permethrin plant toxicity studies were available for quantitative evaluation of phytotoxic effects; thus, exposure to plants via runoff was not measured.

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 µg/ sample. In addition, permethrin was detected at trace levels to 4.3 ng/m^3 in Lompoc, Santa Barbara County in 2000. Permethrin has a low vapor pressure ($1.48x10^{-8}$ mmHg) and a relatively low Henry's Law Constant ($1.4x10^{-6}$ atm-m^3/mole); furthermore, its atmospheric degradation half-life is only ~0.5 days (EPISuite v.4.0 estimate for hydroxyl radical reaction). It appears, based on permethrin's physicochemical and fate characteristics, that long range atmospheric transport is not likely for the chemical.

Measures of exposure are based on terrestrial models that predict estimated environmental concentrations (EECs) of permethrin using maximum labeled application rates and methods of application. The model used to predict terrestrial EECs on food items is Terrestrial Residue EXposure (T-REX) model. The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant, however no plant toxicity data was available to compare to relevant exposure concentrations for this assessment. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. More information on these models is available in Attachment I.

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. To determine the deposition of the pesticide for the use of permethrin as a mosquito adulticide, the spray drift model AGDISP (version 8.13) was used. The output of interest from AGDISP in this case is the application efficiency (fraction of the material that deposits in the target area under the aircraft). Estimates of application efficiency were used to adjust application rates input into T-REX for exposure estimates for terrestrial wildlife resulting from mosquito adulticide uses (See the "Terrestrial Animal Exposure Assessment" section of the assessment for more detail; **Section 3.3**).

2.10.2. Measures of Effect

Data identified in Section 2.8 are used as measures of effect for direct and indirect effects. Data were obtained from registrant submitted studies or from literature studies identified by

ECOTOX. More information on the ECOTOXicology (ECOTOX) database and how toxicological data is used in assessments is available in **Attachment I**.

2.10.2.a. 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 VELB in terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. The risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see **Appendix C**). More information on standard assessment procedures is available in **Attachment I**.

2.10.3. Data Gaps

2.10.3.1 Fate and Transport Data

The environmental fate database is substantially complete and suitable for a screening level assessment. At this time, there are no listed environmental fate data gaps.

2.10.3.2 Ecotoxicity Data

No acceptable terrestrial plant toxicity data or terrestrial invertebrate studies on the synergistic effects of permethrin used in conjunction with PBO are available for quantitative use for permethrin. (refer to the "Uncertainties" section of the document for additional detail; **Section 6.2**).

3. Exposure Assessment

Permethrin is formulated in various ways (*e.g.* liquid, water dispersible granules, wettable powder, emulsifiable concentrate, 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 formulated 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 insect pests. The formulated product labels legally limit permethrin's potential use to only those sites that are specified on the labels.

During the Reregistration Eligibility Decision process, the matter of most concern, at the time when the EFED Risk Assessment (D324198, 2/2006) was issued, was the risk to aquatic organisms. Many of the restrictions imposed by the 2006 amended RED were related to the protection of aquatic habitats (*e.g.*, imposing a buffer zone and a vegetative filter strip from certain bodies of water). Other restrictions were related to applications (*e.g.* reduction in application rates, number of applications, or increasing the interval between applications). These measures were effective May 30, 2008 and were included in this assessment.

After issuing a Revised HED Risk Assessment, and in May of 2009, a revised RED document for permethrin was issued (USEPA 2009b). Certain new measures are being imposed to mitigate human and ecological risks. These measures are not included in this assessment because they have not been implemented as of the issuance of the Verification Memorandum from the Pesticide Re-evaluation Division (dated 09/08/10). It is expected that they will be implemented in 2011 (information derived from the Verification Memo, see **Appendix B**). Among the restrictions, new restrictive droplet size specifications will be included in the mosquito control specifications for ULV applications, which were not included in this assessment. For non-crop outdoor uses, various restrictions will take place. For example, for products labeled for use on and around buildings and other structures, all outdoor applications will be limited to spot or crack-and-crevice treatments, with certain exceptions. Other restrictions are related to the prevention of runoff or contamination of surface waters.

The new more restrictive language and droplet size specifications that will be included in the mosquito control labels, have the potential to change the risk picture for the VELB due to that use. It is likely that the exposure to the terrestrial habitats will be reduced.

Currently registered agricultural and non-agricultural uses of permethrin within California include alfalfa, nut trees, avocado, cole crops, corn, forestry, fruit trees, garlic, potatoes, leafy vegetables, cucurbit vegetables, nursery, onion, row crops, tomato, tomatillo, turf, ant mound treatment, adulticide use, soil barrier treatment and perimeter treatment. The uses being assessed are summarized in **Table 3-1**.

Table 3-1. Permethrin Uses, Scenarios, and Application Information

CATEGORY	USES	MAX APP RATE (lbs a.i./A)	# APPS/ CROP	MINIMUM INTERVAL
Agricultural Use Patterns				
Alfalfa	Alfalfa hay and seed crops	0.20	5	30
Nut Trees	Pistachio	0.3	3	10
Avocado	Avocado	0.20	4	7
Cole crop	Broccoli	0.20	4	5
Corn	Corn (pop)	0.2	3	5

CATEGORY	USES	MAX APP RATE (lbs a.i./A)	# APPS/ CROP	MINIMUM INTERVAL
Corn	Corn (sweet)	0.2	4	3
Forestry	Softwood (conifer), hybrid cottonwood/ poplar	0.20	N/S, Assumed to be 10	N/S, Assumed to be 5
Fruit tree	Pear	1@0.4 and 1@0.25	2	10
Fruit tree	Peach	0.25	3	10
Garlic and Potatoes	Garlic and potatoes	0.20	4	10
Leafy vegetables	Leafy vegetables[2]	0.2	4	7
Leafy vegetables	Other leafy vegetables[3]	0.2	10	3
Cucurbit vegetables	Cucurbit vegetables[4]	0.2	6	7
Cucurbit vegetables	Other cucurbit vegetables[5]	0.24	8	N/S, assumed to be 7
Nursery	Christmas trees, Nursery stock and Pine seed orchard[6]	0.4	6	28
Nursery	Pine seed orchard (current label high rate) [6]	1.6	6	28
Onion	Onion	1@0.1 and 3@0.3	4	7
Onion	Fennel	0.2	10	3
Row Crops	Celery, artichoke, asparagus, pepper	0.2	5	7
Row Crops	Rhubarb, field grown roses	0.2	10	5
Tomato	Tomato	0.2	3	7
Tomatillo	Tomatillo	0.2	6	N/S, assumed to be 7
Ant mound treatment [7]	Agricultural fruit trees	0.84	4	7
Non-agricultural Use Patterns				
Turf	Golf course, recreational areas	0.87	6	N/S, Assume 7
Mosquito control[8]	Recreational and agricultural areas	0.007	26	1
Ant mound Treatment [7]	Non-agricultural areas, turf, recreational areas	0.84 (same rate as for use on fruit trees, see above)	4	7
Soil Barrier Treatment	Fencerows and Hedgerows	0.01	10	N/S, assumed to be 7
Soil Barrier Treatment	Range Land	0.1	10	N/S, assumed to be 7
Residential Turf and Ornamentals	Home & Garden	4.23	N/S, assumed to be 3	5

CATEGORY	USES	MAX APP RATE (lbs a.i./A)	# APPS/ CROP	MINIMUM INTERVAL
Perimeter Treatment	Urban & Rural Structures	1.43	N/S, assumed to be 4	N/S, assumed to be 90
Termite Treatment	Urban & Rural Structures	0.77	1	None
Garden Vegetables	Home & Garden	0.25	6	3
Garden Nuts and Fruits	Home & Garden	0.4	5	N/S, assumed to be 10
Barrier Treatment	Urban & Rural Structures	1@0.08 and 3@0.10	2	N/S, assumed to be 7

Uses assessed based on memorandum from Pesticide Re-evaluation Division (PRD) dated September 8, 2010 and EFED Label Data report and associated Label Use Information Reports prepared on September 17, 2010. Reasonable conservative assumptions were made in the absence of specific use information. Except for the use for mosquito control, a maximum of 10 applications was assumed because the prolonged use of permethrin can result in development of resistance to the chemical.

[1]Application assumed in the summer.

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

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

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

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

[6] The first run covers Christmas 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 highest rate in the current label (1.6 lb a.i. /A).

[7] Assuming mound application for 80 mounds per acre, reference http://edis.ifas.ufl.edu/UW242 (accessed 08/26/10).

[8] CFR 2005-1 imposes various restrictions in the adulticide labels (additional details below).

3.2. Terrestrial Invertebrate Exposure Assessment

Terrestrial Animal Exposure Modeling-Adulticide Use

The purpose of the modeling of the mosquito adulticide use of permethrin is to determine the application efficiency, which is expected to be much lower than the default values for typical agricultural applications.

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 non-target organisms. 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. 8.13). This model estimates the deposition of the pesticide to the treated area. In other words, AGDISP estimates the application efficiency over the treated area. AGDISP provides a better prediction of spray drift under circumstances where a mosquito adulticide is used. The modeling using AGDISP was included in the previous endangered species assessment for other SFB species (USEPA 2008b) and is also provided in this document.

For the adulticide use, the labels available for permethrin have specifications on various parameters that may affect the exposure to the field. These parameters were specified after the 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 labels. Furthermore, the altitude of aerial applications is also specified. New additional restrictions imposed after the 2009 RED for permethrin are expected to be effective in 2011 (USEPA 2009b); however, they were not modeled for this assessment because they have not been imposed as of the issuance of the verification memorandum (09/08/10, **Appendix B**). The sample label selected for modeling was BIOMIST® 4+4 ULV (EPA Reg. No. 8329-35). It contains 4.00% permethrin and 4.00% piperonyl butoxide (PBO). Only aerial applications were modeled because they result in higher exposure than ground applications. 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 at the maximum application rate). BIOMIST® 4+4 ULV is a ready to use mosquito 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, meaning that 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 been shown (in previous permethrin assessments) that exposure 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, which is the most conservative assumption. 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 (refer to **Table 3-2**).

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). In the model, a low evaporation rate was assumed and the volatile fraction was kept at a minimum (conservative assumptions). 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, and considered a conservative assumption). Generally, the remaining input parameters in AGDISP were kept at their default value (unless otherwise specified). **Table 3-2** shows the input parameters utilized in AGDISP.

Table 3-2. Input Parameters for AGDISP for Permethrin Mosquitocide Use

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

Table 3-2. Input Parameters for AGDISP for Permethrin Mosquitocide Use	
Parameter	**Value**
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

Table 3-3 shows the output from AGDISP used for the adulticide modeling. The application efficiency is relevant for this assessment and used in T-REX.

Table 3-3. AGDISP Output Results, Permethrin Use as Mosquitocide		
Parameter	**Value & Units**	**Source**
Application efficiency	0.020	AGDISP

The application efficiency derived from AGDISP represents the efficiency on the field. For the purposes of appropriately estimating risk to terrestrial animals resulting from permethrin use for mosquito control, the deposition of permethrin in the treated area or the application efficiency (expressed as a fraction of applied = 0.020) was used to adjust the maximum labeled application rate for mosquito adulticide 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 to terrestrial invertebrates (see also the next section).

Terrestrial Animal Exposure Modeling-Spray Applications

T-REX is used to calculate EECs for terrestrial invertebrates exposed to permethrin. For this assessment, the "dietary"-based EECs (non-body-weight-adjusted) are used to predict residue concentrations that will deposit on a nontarget terrestrial invertebrate following a spray application of permethrin. The small insect category represents the larvae of the VELB, while the large insect category represents the adult VELB. 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. Dietary-based EECs calculated by T-REX for small insects (units of a.i./g) are used to estimate exposure to terrestrial invertebrates. The EECs are later compared to the adjusted acute contact toxicity data for bees in order to derive RQs.

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 insects. A review of the existing agricultural labels for permethrin has revealed that maximum rates of application for other methods are the same or lower. 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.

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 (please, also refer to the previous section). 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 previous section of this document to estimate deposition of permethrin in the treated area. In particular, AGDISP estimated the application efficiency (fraction of applied; 0.020) 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 to terrestrial invertebrates 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 3-4**. 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). Please refer to **Table 3-1** for details regarding which uses are covered under each "Use Category." An example output from T-REX v. 1.4.1 is available in **Appendix D**.

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 $K_{OW} = 1.26\text{x}10^6$; 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. 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.

Table 3-4. Summary EECs Used for Estimating Risk to Terrestrial Invertebrates and Derived Using T-REX ver. 1.4.1. for Permethrin (Liquid Formulations)

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Exposure Category	Dietary-based EECs (mg/kg-diet)
Alfalfa (Alfalfa)	0.2, 30, 5	Small Insects	36.4
		Lg Insects	4.0
Nut Trees (Pistachio)	0.3, 10, 3	Small Insects	82.8
		Lg Insects	9.2
Avocado (Avocado)	0.2, 7, 4	Small Insects	71.6
		Lg Insects	8.0
Cole Crops (Broccoli)	0.2, 5, 4	Small Insects	79.5
		Lg Insects	8.8
Corn (Pop corn)	0.2, 5, 3	Small Insects	65.8
		Lg Insects	7.3
Corn	0.2, 3, 4	Small Insects	89.2

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Exposure Category	Dietary-based EECs (mg/kg-diet)
(Sweet corn)		Lg Insects	9.9
Forestry (Cottonwood)	0.2, 5, 10	Small Insects	119.9
		Lg Insects	13.3
Fruit Trees (Pear)	0.4, 10, 2	Small Insects	88.4
		Lg Insects	9.8
Fruit Trees (Peach)	0.25, 10, 3	Small Insects	69.0
		Lg Insects	7.7
Garlic & Potatoes (Garlic & Potatoes)	0.2, 10, 4	Small Insects	62.2
		Lg Insects	6.9
Major Leafy Vegetables (Lettuce)	0.2, 7, 4	Small Insects	71.6
		Lg Insects	8.0
Minor Leafy Vegetables	0.2, 3, 10	Small Insects	158.4
		Lg Insects	17.6
Major Cucurbits (Cucumber)	0.2, 7, 6	Small Insects	84.8
		Lg Insects	9.4
Minor Cucurbits (Melons)	0.24, 7, 8	Small Insects	110.2
		Lg Insects	12.3
Nursery (Pine Seed Orchard-Reduced)	0.4, 28, 6	Small Insects	75.3
		Lg Insects	8.4
Nursery (Pine Seed Orchard-Maximum)	1.6, 28, 6	Small Insects	301.3
		Lg Insects	33.5
Onions (Onion)	0.3, 7, 4	Small Insects	107.4
		Lg Insects	11.9
Onions (Fennel)	0.2, 3, 10	Small Insects	158.4
		Lg Insects	17.6
Row Crops (Celery)	0.2, 7, 5	Small Insects	79.2
		Lg Insects	8.8
Row Crops (Rhubarb)	0.2, 5, 10	Small Insects	119.9
		Lg Insects	13.3
Tomato (Tomato)	0.2, 7, 3	Small Insects	61.1
		Lg Insects	6.8
Tomato (Tomatillos)	0.2, 7, 6	Small Insects	84.8
		Lg Insects	9.4
Turf (Golf Course and Recreational Areas)	0.87, 7, 6	Small Insects	369.0
		Lg Insects	41.0
Ant Mound	0.84, 7, 4	Small Insects	300.6

Use Category[1]	App Rate (lbs a.i./A), Interval (Days), # of Apps[2]	Exposure Category	Dietary-based EECs (mg/kg-diet)
Treatments (Non-ag, Turf, Recreational, &Ag. Fruit Trees)		**Lg Insects**	33.4
Adulticide (Mosquito Control) [3]	**0.00014** [4]**, 1, 26**	**Small Insects**	0.3
		Lg Insects	0.03
Soil Barrier Treatment (Fencerows & Hedgerows)	**0.01, 7, 10**	**Small Insects**	4.8
		Lg Insects	0.5
Soil Barrier Treatment (Range Land)	**0.1, 7, 10**	**Small Insects**	47.8
		Lg Insects	5.3
Residential Turf & Ornamentals (Home and Garden)	**4.23, 5, 3**	**Small Insects**	1391
		Lg Insects	155
Perimeter Treatment (Urban and Rural Structures)	**1.43, 90, 4**	**Small Insects**	196.5
		Lg Insects	21.8
Termite Treatment (Urban and Rural Structures)	**0.77, N/A, 1**	**Small Insects**	104.0
		Lg Insects	11.6
Garden Vegetables (Home and Garden)	**0.25, 3, 6**	**Small Insects**	148.4
		Lg Insects	16.5
Garden Nuts and Fruits (Home and Garden)	**0.4, 10, 5**	**Small Insects**	133.3
		Lg Insects	14.8
Soil Barrier Treatment (Urban and Rural Structures)	**0.1, 7, 2**	**Small Insects**	23.4
		Lg Insects	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] Based on mitigation measures per the 2006 Amended Permethrin RED.
[4] 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; 0.020) in order to determine the application rate representative of the applied amount to foliage and other various wildlife food items.

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Atmospheric Monitoring Data

There is limited atmospheric monitoring in California.[8] Application air monitoring was conducted in Butte County and ambient air monitoring was conducted in Monterey County 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 µg/sample (equivalent to 0.015 $\mu g/m^3$ (0.96 pptv) for sampling performed for 24 hours at 15 L/min). The LOD was 0.10 µg/sample. Of 24 application samples in Butte County, three were above the LOQ. The highest concentration was 0.57 $\mu g/m^3$ (35 pptv, west sampling site, first sampling period). 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 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 VELB or modify their designated critical habitat. 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.

As described in the Agency's Overview Document (USEPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment for the VELB, evaluated taxa include terrestrial invertebrates (direct effects) and terrestrial plants (indirect effects/critical habitat). Toxicity information is characterized based on registrant-submitted studies and a review of the open literature on permethrin via ECOTOX.

[8] http://www.cdpr.ca.gov/docs/emon/pubs/tac/permthrn.htm (accessed 08/27/10).

4.1. Ecotoxicity Study Data Sources

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (USEPA, 2004). Open literature data presented in this assessment were obtained from ECOTOX information obtained in January 2010. 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.

Open literature toxicity data for other 'target' insect species (not including bees, butterflies, beetles, and non-insect invertebrates including soil arthropods and worms), which include efficacy studies, are not currently considered in deriving the most sensitive endpoint for terrestrial insects. Efficacy studies do not typically provide endpoint values that are useful for risk assessment (*e.g.*, NOAEC, EC50, *etc.*), but rather are intended to identify a dose that maximizes a particular effect (*e.g.*, EC100). Therefore, efficacy data and non-efficacy toxicological target insect data are not included in the ECOTOX open literature summary table provided in Appendix H. For the purposes of this assessment, 'target' insect species are defined as all terrestrial insects with the exception of bees, butterflies, beetles, and non-insect invertebrates (*i.e.*, soil arthropods, worms, *etc*.) which are included in the ECOTOX data presented in Appendix H. The list of citations including toxicological and/or efficacy data on target insect species not considered in this assessment is provided in Appendix G.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, survival, reproduction, and growth) identified in Section 2.8. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because quantitative relationships between modifications and reduction in species survival, reproduction, and/or growth are not available. Although the effects determination relies on endpoints that are relevant to the assessment endpoints of survival, growth, or reproduction, it is important to note that the full suite of sublethal endpoints potentially available in the effects literature (regardless of their significance to the assessment endpoints) are considered, as they are relevant to the understanding of the area with potential effects, as defined for the action area.

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 G**.** Appendix G also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment.

A detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sublethal endpoints is presented in Appendix H. Appendix I includes a summary of the human health effects data for permethrin.

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 ecological incident data, are considered to further refine the characterization of potential ecological effects associated with exposure to permethrin. A summary of the available terrestrial ecotoxicity information and the incident information for permethrin are provided in Sections 4.2 through 4.4.

4.2. Toxicity of Permethrin to Terrestrial Organisms

Table 4-1 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. Additional information is provided in Appendix F (Summary of Ecotoxicity Data).

Table 4-1. Terrestrial Toxicity Profile for Permethrin

Endpoint	Acute/ Chronic	Species	Toxicity Value Used in Risk Assessment	Citation MRID/ ECOTOX reference No.	Comment
Terrestrial invertebrates	Acute Contact	Honeybee (*Apis mellifera*)	48-hour LD_{50} = 0.024 µg a.i./bee	MRID 42674501	Acceptable Endpoint based on mortality
Terrestrial plants	Not applicable	No acceptable data identified			

Acute toxicity to terrestrial animals is categorized using the classification system shown in Table 4-2 (USEPA, 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4-2. Categories of Acute Toxicity for Terrestrial Invertebrates

Toxicity Category	Acute LD_{50}
Highly toxic	< 2 µg ai/bee
Moderately toxic	2 – 10.99 µg ai/bee
Practically non-toxic	≥ 11 µg ai/bee

4.2.1. Toxicity to Terrestrial Invertebrates

A summary of acute terrestrial invertebrate data, including data published in the open literature, is provided below in Sections 4.2.1.a. through 4.2.1.b. These data show a high degree of toxicity to terrestrial invertebrates.

4.2.1.a. Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

The only Agency guideline terrestrial invertebrate tests are for honey bees (*Apis mellifera*). A total of six studies that 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 (MRIDs 42674501, 00045044, 00045046, 42674501, 42009301) have been submitted for permethrin. 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. The probit slope of 2.9 (95% CI = 2.2 – 3.6) in the most sensitive study will be used to calculate the individual chance of effects (MRID 42674501).

Table 4.3. Honey Bee Acute Toxicity.

Species	Type of study	% a.i.	48-hour LD_{50} (µg a.i./bee)	Category	Identification number, date	Study classification[a]
Honey bee (*Apis mellifera*)	Acute Contact	93.1	0.024	Highly toxic	MRID 42674501 1993	Acceptable
Honey bee (*Apis mellifera*)	Acute Contact	Tech	0.05	Highly toxic	MRID 00045044 1975	Supplemental
Honey bee (*Apis mellifera*)	Acute Contact	NR	0.16	Highly toxic	MRID 00045046 1975	Supplemental
Honey bee (*Apis mellifera*)	Acute Oral	Tech	0.19	Highly toxic	MRID 00045044 1975	Supplemental
Honey bee (*Apis mellifera*)	Acute Oral	93.1	0.13	Highly toxic	MRID 42674501 1993	Acceptable
Honey bee (*Apis mellifera*)	Foliar Residue	25WP	<0.2 lb a.i./acre (97-100% mortality at this application rate)	Highly toxic	MRID 42009301 1991	Acceptable

[a]Acceptable: study satisfies guideline; Supplemental: study is scientifically sound, but does not satisfy guideline.

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. Many of the studies have little information reported and the results are presented below 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 US1975). 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.

Table 4.4. Non-target Insect Toxicity.

Species	% a.i.	Test type	Test result	Identification number, date	Study classification[a]
Parasitic wasp (*Apanteles sp.*)	3.2EC	Acute, 5 day contact	100% mortality at 0.2 lb a.i./A 17% mortality at 0.1 lb a.i./A	MRID 05009995 1975	Supplemental
Parasitic wasp (*Opius bruneipus*)	3.2EC	Acute, 5 day contact	43% mortality at 0.2 lb a.i./A 0% mortality at 0.1 lb a.i./A	MRID 05009995 1975	Supplemental
Parasitic wasp (*Telenomus remus*)	3.2EC	Acute, 5 day contact	90% mortality at 0.2 lb a.i./A 13% mortality at 0.1 lb a.i./A	MRID 05009995 1975	Supplemental
Parasitic wasp (*Copidosoma truncatellum*)	3.2EC	Acute, 2 day contact	100% mortality at 0.2 lb a.i./A 85% mortality at 0.1 lb a.i./A	MRID 05009995 1975	Supplemental
Parasitic wasp (*Diglyphus intermedius*)	3.2EC	Acute, 5 day contact	40% mortality at 0.2 lb a.i./A 55% mortality at 0.1 lb a.i./A	MRID 05009995 1975	Supplemental

Table 4.4. Non-target Insect Toxicity.					
Species	**% a.i.**	**Test type**	**Test result**	**Identification number, date**	**Study classification[a]**
Mite (*Amblyseium fallacis*)	25EC	Acute	100% mortality at 0.5 ppm	MRID 00045048 1975	Supplemental
Mite (*Amblyseium fallacis*)	Ambush	Acute	LC_{50} <1 ppm	ICI US 1976	Supplemental
Mite (*Amblyseium fallacis*)	Form.	Acute, dip test	LC_{50} <0.5 ppm	ICI US NR	Supplemental
Convergent ladybeetle (*Hippodamia convergens*)	Form.	Contact	LD_{50} <3.9 ppm	MRID 05009995 1975	Supplemental
Convergent ladybeetle (*Hippodamia convergens*)	Form.	Treated foliage	LD_{50} = 15.5 ppm	MRID 05009995 1975	Supplemental
Alfalfa leafcutter bee (*Megachile rotundata pacifica*)	NR	Caged with treated foliage	48-hour LD_{50} = 0.16 µg a.i./bee	ICI US 1975	Supplemental
Predatory mite (*Metaseiulus occidentalis*)	Ambush	Acute	LD_{50} <2.0 ppm	ICI US Aug/Sep 1976	Supplemental
Predatory mite (*Metaseiulus occidentalis*)	25 EC	Acute, contact	LD_{90} = 1–5 ppm	MRID 00045048 1975	Supplemental
Predatory mite (*Metaseiulus occidentalis*)	Form.	Acute, dip test	LD_{50} = <1 ppm	ICI US NR	Supplemental
Alkali bee (*Nomia melanderi*)	NR	Caged with treated foliage	48-hour LD_{50} = 0.16 µg a.i./bee	NR 1975	Supplemental

[a]Acceptable: study satisfies guideline; Supplemental: study is scientifically sound, but does not satisfy guideline.

4.2.1.b. Open Literature Data on Acute Exposure (Mortality) Studies

Open literature studies on permethrin acute contact toxicity to terrestrial insects were obtained via the USEPA ECOTOX database and screened for acute toxicity endpoints that were more sensitive than the acute LD_{50} endpoint obtained from submitted data on the honeybee (i.e., 0.024 ug a.i./organism or 0.1875 ug a.i./g-organism; MRID 42674501). The ECOTOX database contained laboratory-based, acute contact LD_{50} results for species in four Orders in the Class Insecta: Hymenoptera, Coleoptera, Lepidoptera, and Diptera (a complete listing of ECOTOX data is found in Appendix H). Acute contact studies with LD_{50} values expressed as ug a.i./ organism were screened for LD_{50} values of 0.24 ug a.i./organism and lower, which is 10X greater than the honeybee LD_{50} (0.024 ug a.i./organism). Toxicity studies reporting LD_{50} values up to 0.24 ug a.i./organism were considered because the test organisms may have been significantly larger than the honeybee and may have resulted in LD_{50} values lower than 0.1875 ug a.i./g-organism obtained for the honeybee once converted to an ug a.i./g organism basis. The latter expression of the LD_{50} (ug a.i./g-organism) is the one actually used as the basis of the terrestrial invertebrate risk assessment. Acute contact LD_{50} studies with results already expressed as ug a.i./g-organism were reviewed further if LD_{50} values were less than 0.1875 ug a.i./g-organism.

A total of 13 studies were initially identified using the aforementioned screening criteria. Upon further review, seven of the 13 studies were considered unacceptable for quantitative or qualitative use in this risk assessment (ECOTOX reference #62672, #113323, #96523, #112748, #74126, #108379, #100430). Reasons for rejecting these studies include: the use of field collected organisms that were likely pre-exposed to one or more pesticides; a lack of control mortality data; or control mortality that exceeded 10%. Findings from the remaining six studies are shown in **Table 4.5**. All of these studies were considered acceptable for qualitative use (i.e., scientifically defensible) but not acceptable for quantitative use (i.e., for RQ calculation) for various reasons including: use of target pests (all studies); lack of information on chemical purity (#95765, #74115); and questionable acclimation procedures between testing and rearing temperatures (#92552). Nonetheless, the only test in the same Order as the VELB (i.e., Coleoptera) produced an LD_{50} value of 0.185 ug a.i./g-organism (#74115 for the two-spotted lady beetle). This LD_{50} is practically identical to that for honeybee (0.1875 ug a.i./g-organism), which suggests that honeybee is a reasonable surrogate for the VELB. Furthermore, the lowest LD_{50} value reported (0.048 ug a.i./g-organism for mosquito; #116328) is only a factor of four lower than the LD_{50} value for honeybee. The mosquito would be expected to be highly sensitive to permethrin given its development and use as a mosquito adulticide. Therefore, it appears that honeybee represents reasonably the sensitivity of the more sensitive terrestrial invertebrates in the context of acute, contact permethrin toxicity and will be used to quantify risks to the VELB in this assessment.

Table 4.5. Selected Open Literature Studies on Acute Contact Mortality to Terrestrial Invertebrates

Species (Order)	**Formulation (% a.i.)**	**Duration, Life Stage**	**LD50** (ug ai/org)	**LD50** (ug ai/g-org or ppm)	**ECOTOX ID (Study Classification)**
Mosquito, Aedes aegypti (Diptera)	Tech (98%)	1 day (adult)	NR	0.048	116328 (qualitative)
Egyptian cotton leafworm Spodoptera littoralis (Leptidoptera)	Tech (> 95%)	1 day (larvae);	NR	0.087 (20 C) 0.61 (35 C)	92552 (qualitative)
Two Spotted Lady Beetle Adalia bipuncata (Coleoptera)	Tech (NR)	3 day (25 mg larvae)	NR	0.185	74115 (qualitative)
Common house fly, *Musca dommestica* (Diptera)	Tech (NR)	1 day (adult; ~20 mg)	0.009	0.45	95765 (qualitative)
Old world bollworm, Helicoverpa armigera (Leptidoptera)	Tech (96%)	2 day (3rd instar larvae, ~35 mg)	0.03	0.86	108057 (qualtitative)

Pink bollworm, *Pectinophora gossypiella* (Lepidoptera)	Tech (82%-100%)	2 day (adult)	0.0118-0.0323	NR	113462 (qualitative)

4.2.1.c. Chronic Exposure Studies

In addition to the above laboratory studies, a number of field studies examining the toxicity of permethrin to ladybird beetles (*Coccinella undecimpunctata* and *C. 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 nontarget invertebrates and impact invertebrate pollinators.

Table 4.6. Terrestrial Invertebrate Field Toxicity Testing.

Species	**% a.i.**	**Test type**	**Test result**	**Identification number, date**	**Study classification[a]**
Seven spot ladybird (*Coccinella septempunctata*) and Eleven spot ladybird (*C. undecimpunctata*)	NR	Field application to oil seed rape	Significant reduction in numbers at rates of 15 ppm and higher, 24 h post-treatment.	ICI US NR	Supplemental
Hover flies (Syrphidae)	NR	Field, spray application	All rates of 31.2 ppm and above ceased a reduction in the numbers of larvae and no larvae observed at 125 ppm.	ICI US NR	Supplemental
Six-spotted thrips (*Scolothrips sexmaculatus*)	25	Field, 8-spray program on a 10-day interval with PP557 25% EC and PP383 25% EC applied to cotton.	No significant reduction in numbers at 8 days post-treatment at 3.2 oz a.i./A.	ICI US 1976	Supplemental

Hemipteran predators (*Geocoris pallens*) (*Orius tristicolor*) (*Nabis americoferris*)	25	Field, 8-spray program on a 10-day interval with PP557 25% EC and PP383 25% EC applied to cotton.	Significant reduction in numbers at all rates tested (0.8/1.6 and 3.2 oz); populations temporarily eliminated.	NR 1976	Supplemental
Earthworms (Lumbricus and Allolobophora spp.) and unnamed spiders, mites and collembola	NR	Spray application	Slight decrease (non-statistically significant) in earthworm populations at 5 kg a.i./A, no effect at 0.5 kg a.i./A.	ICI US 1975	Supplemental
[a]Acceptable: study satisfies guideline; Supplemental: study is scientifically sound, but does not satisfy guideline.					

A total of four studies examining sublethal effects of permethrin to arthropods were accepted for the ECOTOX database. Two studies examined insect feeding behavior, with permethrin exposure resulting in a LOAEL of 0.11 lbs a.i./acre for the soybean looper (*Pseudoplusia includens*) and a NOAEL of 0.098 lbs a.i./acre for the corn earworm (*Heliothis zea*) (ECOTOX #89285 and #89059). One study looked at permethrin developmental effects on the potato tuberworm (*Phthorimaea operculella*), with a NOAEL = 8 ppm a.i. for emergence (ECOTOX #99807). In a study examining the changes in growth (weight) of the fall armyworm (*Spodoptera frugiperda*), the LOAEL was determined to be 5 ppm a.i. (ECOTOX #90474). These studies show that sublethal effects have been observed for terrestrial invertebrates at registered application rates or levels predicted by terrestrial exposure modeling for multiple permethrin uses.

These chronic and sublethal data are provided for characterization purposes only. For the purposes of risk estimation, the Agency currently uses only acute terrestrial invertebrate mortality data for calculating RQs to compare to the interim terrestrial invertebrate LOC developed for litigation assessments.

4.2.2. 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. Plant toxicity testing is now required for a larger set of pesticides, including insecticides such as permethrin (40 CFR Part 158). 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 that are acceptable for quantitative use. 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. These studies were deemed unacceptable because they were efficacy studies in which observed effects were confounded by the presence of an insect pest complex (spreadsheet of the available ECOTOX open literature data that can be found in **Appendix H)**. Therefore, reported incident are the best available information that examines adverse effects of permethrin on terrestrial plants, and the Agency relies on these reports to inform the risk conclusions for terrestrial plants in this assessment.

4.3. Toxicity of Chemical Mixtures

As previously discussed in Section 2.2.2, the results of available toxicity data for mixtures of permethrin with other pesticides are presented in Appendix A. 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 EFED to evaluate the potential for differences in toxicity between technical grade permethrin, and permethrin formulated with multiple active ingredients. 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 G**. 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**; however, there is a high degree of uncertainty when extrapolating effects of permethrin on mammals to terrestrial invertebrates.

4.4. Incident Database Review

A review of the Ecological Incident Information System (EIIS, version 2.1), the 'Aggregate Incident Reports' (v. 1.0) database for ecological incidents involving permethrin was completed on August 24, 2010. Only incidents involving terrestrial invertebrates or terrestrial plants are included in this assessment and are discussed below in Sections 4.4.1 through 4.4.2. A complete list of the incidents involving permethrin including associated uncertainties is included in Appendix K.

4.4.1. Terrestrial Invertebrate Incidents

Four permethrin incidents involving terrestrial invertebrates exist in the EIIS database. Two incidents were listed as highly probable, one as probable and one 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, and other unknown butterflies. Two other incidents with unknown legality of use were reported. In the first incident, adverse effects to butterflies from permethrin use were classified as "probable". Following permethrin application for municipal mosquito control, 1-2 dozen commercially-raised butterflies were killed in a local colony maintained by a hobbyist (I016728-007). In another incident with unknown legality, "possible" apiary damage was reported to the Agency following permethrin treatment with the synergist PBO for mosquito control (I012515-004).

A full list of all incidents involving permethrin and terrestrial invertebrates is shown in **Table 4-3**.

Table 4-6. Permethrin Incident Reports Involving Terrestrial Invertebrate 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 Ambush 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 – 4.3 ppm. 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.
I016728-007	Unknown butterfly (Lepidoptera)	Probable	Unknown	Pinellas County Mosquito Control received a report of 1-2 dozen commercially-raised butterflies following community-wide spraying with Biomist 31+66 ULV with active ingredients permethrin and piperonyl butoxide. Adult and caterpillar mortality occurred in a colony maintained by a local butterfly hobbyist. Florida, 4/1/2005.
I012515-004	Bee (Apidae)	Possible	Unknown	Apiary damage possibly caused by permethrin and piperonyl butoxide after spraying for municipal mosquito control. No information available on suspected misuse. Mississippi, 5/9/2001.

[a] Certainty index rating describing likelihood that permethrin was the actual cause of incident. In order of increasing certainty, the incident is classified as either unrelated, unlikely, possible, probably or highly probable.

4.4.2. Terrestrial Plant Incidents

Eight 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 chlorpyrifos (another insecticide), and the plant damage could not be solely attributed to either chemical (I010927-003). In the second registered-use incident, many pesticides were involved and imazethapyr (an herbicide) was suspected to be the cause of any plant injuries, not permethrin (I016138-001).

In five of the incident reports, the legality of use was unknown. In the first reported incident with unknown legality, little information was provided except that damage occurred to an edible crop following permethrin application (I007340-620). In another incident with unknown legality, a farmer reported that the permethrin and carboxin in the soil inoculate he added at the time of planting caused nitrogen deficiency in his soybeans due to reductions in the number of rhizobium bacteria. The damage could not solely be attributed to either chemical (I009544-001). A third incident report, residential tropical plants exhibited phytotoxic damage after a municipal mosquito control treatment with permethrin and the synergist pipernyl butoxide. The report states that the plants may have already been experiencing nutrient deficiency, but the damage could be a result of exposure to the permethrin/PBO application (I012515-002). Another permethrin incident with unknown legality involved drift from a nearby field (300 yards away) that was treated with permethrin, glyphosate, atrazine and S-metolachlor. Tree damage in a nearby nursery occurred, but could not be attributed solely to any chemical (I015105-005). The last permethrin incident with unknown legality was a report of lawn browning following permethrin application. The incident was classified as “unlikely” based on the assertion in the report that permethrin is not a known phytotoxicant (I000340-007).

Although the legality of use is an uncertainty based on the limited information presented in the incident reports, three of the terrestrial plant incident reports involved permethrin alone or permethrin with PBO, a commonly used pyrethroid synergist. This information creates uncertainty regarding the potential effects on terrestrial plants from use of products containing permethrin.

All permethrin-related plant incidents in the EIIS database are listed in **Table 4-4**.

Table 4-7. Permethrin Incident Reports Involving Terrestrial Plant Species

Incident #	Organism(s) Affected	Certainty [a]	Legality of Use	Description
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.
I007340-620	Unknown edible crop	Possible	Unknown	Damage occurred to an edible crop as a result of permethrin use. Florida, 4/22/1998.
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.
I012515-002	Unknown tropical plants	Possible	Unknown	Tropical plants were exposed to permethrin and piperonyl butoxide during a mosquito control treatment. Plants exhibited burn spots, yellowing leaves and defoliation. The report states that the 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.
I015105-005	Unknown nursery trees,	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

Table 4-7. Permethrin Incident Reports Involving Terrestrial Plant Species				
Incident #	**Organism(s) Affected**	**Certainty [a]**	**Legality of Use**	**Description**
	ornamentals and birds			active ingredient may have caused the damage. Tennessee, 4/27/2004.
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.
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. California, 10/11/2004.
I000340-007	Unknown lawn plants	Unlikely	Unknown	Permethrin was applied near a residence, and browning of lawn plants was reported. Florida, 10/7/1992.

[a] Certainty index rating describing likelihood that permethrin was the actual cause of incident. In order of increasing certainty, the incident is classified as either unrelated, unlikely, possible, probably or highly probable.

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

The Agency uses the probit dose response relationship as a tool for providing additional information on the potential for acute direct effects to individual listed species and aquatic animals that may indirectly affect the listed species of concern (USEPA, 2004). As part of the risk characterization, an interpretation of acute 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.

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 VELB 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”). In the risk estimation section, risk quotients are calculated using standard EFED procedures and models. In the risk description section, additional analyses may be conducted to help characterize the potential for risk.

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 C). For acute exposures to terrestrial invertebrates, the LOC is 0.05. The LOC for acute exposures to plants is 1.0.

Acute risks to terrestrial invertebrates are estimated based on exposures resulting from applications of permethrin Error! Reference source not found. through **2-6**, and
Table 3-1, predicted EECs from **Table 3-4** and the appropriate toxicity endpoint from **Table 4-1**. Exposures are not derived for terrestrial plants, as discussed in Section 3.3, because no quantitative toxicity data was available for terrestrial plants.

5.1.1. Exposures in the Terrestrial Habitat

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5.1.1.a. Terrestrial Invertebrates

In order to assess the risks of permethrin to terrestrial invertebrates, the honey bee is used as a surrogate for terrestrial invertebrates. The toxicity value for terrestrial invertebrates is 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 (µg a.i./g of bee) calculated by T-REX for small insects are divided by the calculated toxicity value for terrestrial invertebrates, which is 0.1875 µg a.i./g of bee, to derive RQs. Larvae for the VELB are considered ‘small insects’ in this assessment, while the adults of these species are considered ‘large insects’. Risk quotients are shown for small insects and large insects in Table 5-1. EECs were calculated based on uses summarized in **Table** 3-1.

Table 5-1. Summary of acute RQs for terrestrial invertebrates, estimated based on the maximum permethrin foliar spray application scenarios using T-REX v.1.4.1.

Use Category[1]	Terrestrial Invertebrates	
	Small Insects[2]	Large Insects[2]
Alfalfa (Alfalfa)	**190**	**21**
Nut Trees (Pistachio)	**440**	**49**
Avocado (Avocado)	**380**	**43**
Cole Crops (Broccoli)	**420**	**47**
Corn (Pop corn)	**350**	**39**
Corn (Sweet corn)	**480**	**53**
Forestry (Cottonwood)	**640**	**71**
Fruit Trees (Pear)	**470**	**52**
Fruit Trees (Peach)	**370**	**41**
Garlic & Potatoes (Garlic & Potatoes)	**330**	**37**
Major Leafy Vegetables (Lettuce)	**380**	**43**
Minor Leafy Vegetables	**840**	**94**
Major Cucurbits (Cucumber)	**450**	**50**
Minor Cucurbits (Melons)	**590**	**66**
Nursery (Pine Seed Orchard- Reduced)	**400**	**45**
Nursery (Pine Seed Orchard- Maximum)	**1600**	**180**
Onions (Onion)	**570**	**63**
Onions (Fennel)	**840**	**94**

Use Category[1]	Terrestrial Invertebrates	
	Small Insects[2]	Large Insects[2]
Row Crops (Celery)	**420**	
		47
Row Crops (Rhubarb)	**640**	
		71
Tomato (Tomato)	**330**	
		36
Tomato (Tomatillos)	**450**	
		50
Turf (Golf course and Recreational Areas)	**2000**	
		220
Ant Mound Treatments (Non-ag, Turf, Recreational, &Ag. Fruit Trees)	**1600**	
		180
Adulticide (Mosquito Control)	**1.6**	
		0.16
Soil Barrier Treatment (Fencerows & Hedgerows)	**26**	
		2.7
Soil Barrier Treatment (Range Land)	**255**	
		28
Residential Turf and Ornamentals (Home and Garden)	**7400**	
		830
Perimeter Treatment (Urban and Rural Structures)	**1050**	
		120
Termite Treatment (Urban and Rural Structures)	**550**	
		62
Garden Vegetables (Home and Garden)	**790**	
		88
Garden Nuts and Fruits (Home and Garden)	**710**	
		79
Soil Barrier Treatment (Urban and Rural Structures)	**120**	
		14

*** = LOC exceedances (RQ $\geq$ 0.05) are bolded.**

[1] Please refer to Table 3-4 for EECs calculated by T-REX that are used to determine RQs.

[2] 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)].

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 VELB (**Table 5-1**). 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 (see **Table 5-1**; RQs based on EECs for small insects range from 1.60 to 7400 and RQs based on EECs for large insects range from 0.16 to 830).

Chance of Individual Effects
As stated earlier, the chance of an individual event (*i.e.*, mortality) is estimated for situations when exposure at the EEC occurs for a species with sensitivity to permethrin on par with the most sensitive 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.

The individual chance of effects 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 probit slope of 2.9 (95% CI = 2.2 – 3.6) in the most sensitive study will be used to calculate the individual chance of effects (MRID 42674501).

Based on this analysis, the individual chance of mortality for terrestrial invertebrates with each use scenario is 1 in 1, with the exception of adulticide and soil barrier treatment (fencerows & hedgerows) uses. For the adulticide use, the individual chance of effects for small invertebrates is 1 in 1.38 (95% confidence interval = 1 in 1.48, 1 in 1.30) and for large invertebrates is 1 in 97.3 (95% confidence interval = 1 in 25.9, 1 in 480). For the soil barrier treatment (fencerows & hedgerows) use, the individual chance of effects is 1 in 1 for small invertebrates and 1 in 1.12 for large invertebrates (95% confidence interval = 1 in 1.21, 1 in 1.07). This indicates a high probability of adverse effects to terrestrial invertebrates at labeled use rates.

5.1.1.b. 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 4.2.2**) as a result of permethrin use. Therefore, RQs cannot be calculated at this time for this taxonomic group. Discussion regarding lines of evidence for the potential for indirect effects to the VELB, which has an obligate relationship with a specific terrestrial plant, can be found in the "Risk Description" portion of the chapter (**Section 5.2**).

5.1.2. 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 a preliminary 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 based on analysis of risk quotients and a comparison to the Level of Concern. The final No Effect/May Affect determination is made after the spatial analysis is completed at the end of the risk description, **Section 5.2.3**. In **Section 5.2.3**, a discussion of any potential overlap between areas where potential usage may result in LAA effects and areas where species are expected to occur (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

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 preliminary "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 has been identified and the Agency concludes a preliminary "may affect" determination for the VELB for the currently labeled uses of permethrin. Based on the potential for direct effects to the VELB, high risks to terrestrial invertebrate pollinators and the uncertainty surrounding permethrin phytotoxic effects, the Agency concludes a preliminary "habitat modification" determination to designated VELB critical habitat for currently labeled uses of permethrin. A summary of the risk estimation results are provided in Table 5-2 for direct and indirect effects to the listed species assessed here and in Table 5-3 for the PCEs of their designated critical habitat.

Table 5-2. Risk Estimation Summary for Permethrin - Direct and Indirect Effects to the VELB

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Potential Direct/Indirect Effects to the VELB
Terrestrial Invertebrates	Listed Species (Yes)	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).	Direct Effects
Terrestrial Plants	Sufficient quantitative terrestrial plant data are not available.		Indirect Effects

Table 5-3. Risk Estimation Summary for Permethrin – Effects to Designated Critical Habitat (PCEs) of the VELB.

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation
Terrestrial Plants	Sufficient quantitative terrestrial plant data are not available.	

Following a preliminary "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.
- <u>Likelihood of the Effect Occurring</u>: Discountable effects are those that are extremely unlikely to occur.
- <u>Adverse Nature of Effect</u>: 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.a** through **5.2.1.b**. 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. These discussions do not consider the spatial analysis. 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. Finally, in **Section 5.2.3**, a discussion of any potential overlap between areas of concern and the species (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

5.2.1. Valley Elderberry Longhorn Beetle

5.2.1.a. Direct Effects

As previously discussed, 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. Therefore, there is the potential for permethrin use in any given area across the state to spatially and temporally coincide with the VELB.

For the purposes of evaluating direct exposure and effects to the VELB, larvae for the VELB 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 VELB 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 VELB resulting from seed treatments was not quantitatively evaluated.

RQ values representing exposures of permethrin to terrestrial invertebrates are used to represent direct exposures of permethrin to the VELB. There are exceedances of the Agency’s interim LOC (0.05) for listed terrestrial invertebrates for all of the modeled spray application scenarios assessed (for both large (adult VELB) and small (VELB larvae) insects) with RQs ranging from 0.16 to 7400, and the high probability of an individual mortality occurrence based on the highest acute RQ for terrestrial invertebrates (~1 in 1). Additionally, permethrin is a highly efficacious broad spectrum insecticide and there is spatial overlapping of patterns of permethrin use throughout the entire state of California with VELB habitat. Furthermore, multiple terrestrial incidents involving terrestrial invertebrates and registered uses of permethrin have been reported to the Agency. Based on these lines of evidence, the Agency concludes that there is a potential for direct effects to the VELB as result of labeled permethrin use in California.

5.2.1.b. Indirect Effects

i. Potential Loss of Prey

The primary diet for the VELB larvae and adult are elderberry plants (*Sambucus*) and perhaps up to three elderberry species (*S. glauca*, *S. caerulea*, and *S. Mexicana*). VELB adults consume elderberry foliage and possibly also the flowers whereas the larvae are borers and feed on the soft pith in stems and roots of the elderberry (USFWS, 1984 and 2007; and LSA, 2004). In addition to serving as the primary dietary item of the VELB, terrestrial plants serve several important habitat-related functions that are described below in **Section 5.2.2** in detail with regards to critical habitat. Therefore, the potential for indirect effects to the VELB 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 VELB 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 4.2.2,** there were no data to reliably quantitatively evaluate the effects and the potential risks of permethrin to terrestrial plants. However, indirect effects to the VELB via impacts on its prey items (terrestrial plants) may be expected when considering the available incident information reported to the Agency. Elderberry plants reproduce through both self-pollination and cross-pollination, and elderberry pollen is transferred by wind and honeybees (USDA, 2003; Way, 1981). Therefore, any adverse impacts to insects will likely have an adverse impact on elderberry reproduction. Additionally, three terrestrial plant incidents reported to the Agency involved permethrin alone or permethrin with piperonyl butoxide, a commonly used pyrethroid synergist. Based on the best available information, the Agency determines that there is the potential for indirect effects to the VELB.

5.2.2. Modification of Designated Critical Habitat

For the purposes of this assessment, the potential for indirect effects to the VELB 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 5.2.1** above (in which the potential for indirect effects to the VELB via loss of terrestrial plant food items and impacts to habitat and/or primary production was assessed), effects to terrestrial plants cannot be quantified due to the lack of data. However, the Agency concludes that the weight-of-evidence suggests that effects to the obligate host species, the elderberry plant, will occur as a result of labeled permethrin use in California to the extent that there will be modification of VELB designated critical habitat. This decision is based on the potential for direct effects to the VELB, adverse effects on terrestrial invertebrate pollinators of the elderberry and reported incidents of phytotoxicity following permethrin use.

5.2.3. Spatial Extent of Potential Effects

Given the broad use pattern of permethrin across the state of California, including both agricultural and non-agricultural uses, there is the potential for permethrin use in any given area to spatially and temporally coincide with the VELB.

5.3. Effects Determinations

5.3.1. Valley Elderberry Longhorn Beetle

Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of insects. The 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. 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 VELB, and disrupt its life-cycle at various points. Therefore, based on the best available information, the Agency makes a Likely to Adversely Affect determination for VELB from the use of permethrin. Additionally, the Agency has determined that there is the potential for modification of designated critical habitat and makes a habitat modification determination from the use of the chemical based on the potential for direct and indirect effects and effects to the PCEs of critical habitat.

5.3.2. Addressing the Risk Hypotheses

Based on the conclusions of this assessment, the stated hypotheses defined in Section 2.9.1 are addressed to represent concerns in terms of direct and indirect effects of permethrin on the VELB and its designated critical habitat.

The labeled uses of permethrin may:

- … directly affect terrestrial-phase VELB by causing acute mortality or by adversely affecting chronic growth or fecundity.

And may:

- … indirectly affect the VELB and/or affect their designated critical habitat by reducing or changing the composition of the food supply or
- … indirectly affect the VELB and affect their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range

6. Uncertainties

Uncertainties that apply to most assessments completed for the San Francisco Bay Species Litigation are discussed in **Attachment I**. This section describes additional uncertainties specific to this assessment.

6.1. Exposure Assessment Uncertainties

6.1.1. Use Scenarios Not Assessed

In this assessment, certain types of application were not assessed. These include the granular, dust and seed treatments. For the seed treatments, the equivalent application rates appear to be much lower than for liquid applications related to the same crops.[9] For the granular applications, rates are of the same order of magnitude to those for liquid applications to the same crops. However, for the dust applications, the rate of application is frequently not specified. Rather, the labels instruct the user to arrive at complete coverage of the foliage. It is recognized that for the dust and granular applications, the value of drift is negligible. Thus exposure would be limited to the area of application. Because the equivalent application rate for seed treatments are low, compared to the liquid applications, and permethrin is not systemic, it also appears that the exposure to non-target terrestrial invertebrates from these uses is low, compared to liquid applications.

At this time, the EFED does not have a model to assess the exposure to terrestrial invertebrates due to these types of applications; however, it appears reasonable to assume risk, based upon the results of the liquid or spray applications, which resulted in risk quotients that exceeded the levels of concern for all the scenarios tested. This issue remains an uncertainty of this assessment.

6.1.2. 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 of mammals and birds in the T-REX model. These residue assumptions are based on plant residue data, and extrapolated to small and large insects based on surface:mass ratios.

6.2. Effects Assessment Uncertainties

6.2.1. Data Gaps

Estimates of risk to terrestrial plants are important for an assessment of potential adverse effects to the VELB, as it has an obligate relationship with the elderberry 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 that are considered acceptable for quantitative use.

[9] The equivalent application rate is the rate assuming uniform exposure of permethrin to the treated field.

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. These studies were deemed unacceptable because they were efficacy studies in which observed effects were confounded by the presence of an insect pest complex.

In addition, no studies have been submitted to the Agency to quantitatively evaluate the synergistic effects of piperonyl butoxide and permethrin on terrestrial invertebrates or plant species.

6.2.2. Sublethal Effects

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

A total of four studies examining sublethal effects of permethrin to arthropods were accepted for the ECOTOX database. Two studies examined insect feeding behavior, with permethrin exposure resulting in a LOAEL of 0.11 lbs a.i./acre for the soybean looper (*Pseudoplusia includens*) and a NOAEL of 0.098 lbs a.i./acre for the corn earworm (*Heliothis zea*) (ECOTOX #89285 and #89059). One study looked at permethrin developmental effects on the potato tuberworm (*Phthorimaea operculella*), with a NOAEL = 8 ppm a.i. for emergence (ECOTOX #99807). In a study examining the changes in growth (weight) of the fall armyworm (*Spodoptera frugiperda*), the LOAEL was determined to be 5 ppm a.i. (ECOTOX #90474). These studies show that sublethal effects have been observed for terrestrial invertebrates at registered application rates or levels predicted by terrestrial exposure modeling for multiple permethrin uses.

6.2.3. Products with Multiple Active Ingredients

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 and the already very highly toxic nature of permethrin alone to non-target terrestrial invertebrates, it is expected that further analysis of any available data on permethrin products with multiple active ingredients or synergists is not likely to result in radical alterations of this risk assessment's conclusions.

7. Risk Conclusions

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

Based on the best available information, the Agency makes a Likely to Adversely Affect determination from the use of permethrin based on direct effects to the VELB. Indirect effects to terrestrial prey items and habitat modification were identified. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the VELB from the use of the chemical. Given the LAA determination for VELB, a description of the baseline status and cumulative effects is provided in **Attachment III**.

A summary of the risk conclusions and effects determinations for the VELB and its critical habitat, given the uncertainties discussed in Section 6 and Attachment I, is presented in **Table 7-1** and **Table 7-2**. Use specific effects determinations are provided in **Table 7-3**.

Table 7-1. Effects Determination Summary for Effects of Permethrin on the VELB

Species	Effects Determination	Basis for Determination
		Potential for Direct Effects
Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*)	Likely to Adversely Affect (LAA)	1. Permethrin is a broad spectrum insecticide that is very highly toxic to adults and larvae of many diverse species of insects. 2. RQs for terrestrial invertebrates exceed the Agency's interim listed species acute LOC for all 33 modeled spray application scenarios. 3. The chance of individual effects (*i.e.*, mortality) for terrestrial invertebrates is as high as ~1 in 1. 4. Four reported incidents involve insects; 1 involved a registered use that was linked as highly probable to the observed effects on hundreds to thousands of butterflies. 5. 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 VELB.
		Potential for Indirect Effects
		Terrestrial prey items, riparian habitat The elderberry plant serves as an obligate host for the VELB. While no acceptable data were available to quantify the effects of permethrin on terrestrial plant, the following lines of evidence suggest that indirect effects to VELB via risks to terrestrial plants may occur: 1. Because permethrin use is likely to result in adverse effects to nontarget terrestrial invertebrates, native pollinators of the elderberry are also likely to be negatively impacted by permethrin use and result in impaired plant reproduction. 2. Three incidents have been reported to the Agency that suggest permethrin use (alone or with the synergist piperonyl butoxide) may have caused adverse effects to terrestrial plants. The total number of incidents that actually occur in the environment are believed to be much higher than those reported. However, none of the incidents have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, and permethrin is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Since no acceptable submitted data were available to quantify the effects of permethrin on terrestrial plants, these incidents serve as the best available information, and much uncertainty exists regarding the phytotoxic effects of permethrin.

Table 7-2. Effects Determination Summary for the Critical Habitat Impact Analysis

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*)	Habitat modification	1. Based on information provided in the VELB Status and Life History document prepared by the Fish & Wildlife Services, any human disturbance that adversely affects the beetle results in modification of critical habitat (1980 Federal Register Vol. 45, No. 155) . Permethrin use is likely to result in direct adverse effects to the VELB (see Table 1-1).

		2. Because permethrin use is likely to result in adverse effects to nontarget terrestrial invertebrates, native pollinators of the elderberry are also likely to be negatively impacted by permethrin use and result in impaired plant reproduction. 3. Three incidents have been reported to the Agency that suggest permethrin use (alone or with the synergist piperonyl butoxide) may have caused adverse effects to terrestrial plants. The total number of incidents that actually occur in the environment are believed to be much higher than those reported. However, none of the incidents have reliably linked permethrin to the observed effects with a certainty index of "probable" or higher, and permethrin is regularly directly applied on or near a very wide variety of agricultural and home garden plants. Since no acceptable submitted data were available to quantify the effects of permethrin on terrestrial plants, these incidents serve as the best available information, and much uncertainty exists regarding the phytotoxic effects of permethrin.

Table 7-3. Use Specific Summary of the Potential for Adverse Effects to Terrestrial Taxa

Use	Terrestrial Invertebrates (Acute)[1]	Terrestrial Plants[2]
Avocado	Yes	Yes
Cole Crops (Broccoli)	Yes	Yes
Corn (Pop corn)	Yes	Yes
Corn (Sweet corn)	Yes	Yes
Forestry (Cottonwood)	Yes	Yes
Fruit Trees (Pear)	Yes	Yes
Fruit Trees (Peach)	Yes	Yes
Garlic & Potatoes	Yes	Yes
Major Leafy Vegetables (Lettuce)	Yes	Yes
Minor Leafy Vegetables	Yes	Yes
Major Cucurbits (Cucumber)	Yes	Yes
Minor Cucurbits (Melons)	Yes	Yes
Nursery (Pine Seed Orchard- Reduced)	Yes	Yes
Nursery (Pine Seed Orchard- Maximum)	Yes	Yes
Onions (Onion)	Yes	Yes
Onions (Fennel)	Yes	Yes
Row Crops (Celery)	Yes	Yes
Row Crops (Rhubarb)	Yes	Yes
Tomato (Tomato)	Yes	Yes
Tomato (Tomatillos)	Yes	Yes
Turf (Golf course and Recreational Areas)	Yes	Yes
Ant Mound Treatments (Non-agricultural, Turf, Recreational and Ag. Fruit Trees)	Yes	Yes
Adulticide (Mosquito Control)	Yes	Yes
Soil Barrier Treatment (Fencerows & Hedgerows)	Yes	Yes
Soil Barrier Treatment (Range Land)	Yes	Yes
Residential Turf and Ornamentals (Home and Garden)	Yes	Yes
Perimeter Treatment (Urban and Rural Structures)	Yes	Yes
Termite Treatment (Urban and Rural Structures)	Yes	Yes
Garden Vegetables (Home and Garden)	Yes	Yes

Use	Terrestrial Invertebrates (Acute)[1]	Terrestrial Plants[2]
Garden Nuts and Fruits (Home and Garden)	Yes	Yes
Soil Barrier Treatment (Urban and Rural Structures)	Yes	Yes

[1] A yes in this column indicates a potential for direct effect to VELB.
[2] A yes in this column indicates a potential for indirect effects to VELB and potential modification to critical habitat.

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.

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