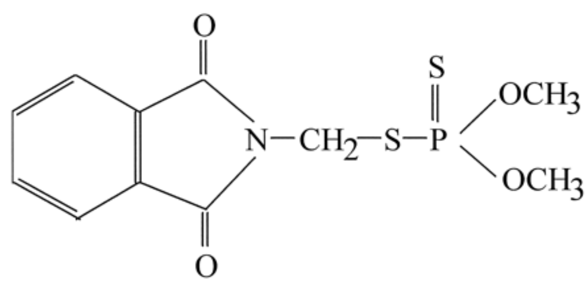
Risks of Phosmet Use to the Federally Threatened and Endangered California Tiger Salamander (*Ambystoma californiense*)



N-(Mercaptomethyl) phthalimide-S-(O,O-dimethyl phosphorodithioate)
CAS Registry Number: 732-11-6
PC Code: 059201

Pesticide Effects Determinations

Environmental Fate and Effects Division
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Table of Contents

Appendices

Attachments

List of Tables

List of Figures

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
DPS	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")

eg.	Latin *ergo* (“therefore”)
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
KF	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
PED	Pesticide Ecotoxicity Database
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
QSAR	Quantitative Structural-Activity Relationship
ROW	Right of Way
RQ	Risk Quotient
SFGS	San Francisco Garter Snake
SJKF	San Joaquine 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 Central California, Sonoma County, and Santa Barbara County Distinct Population Segments (DPSs) of the California tiger salamander (CTS; *Ambystoma californiense*) resulting from FIFRA regulatory actions regarding use of phosmet 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 CTS. 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 is consistent with a suit brought against EPA (*Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS) in which phosmet was alleged to be of concern to the CTS.

The CTS is found in grassland and oak savannah plant communities in central California, where it seasonally utilizes standing bodies of water (*e.g.*, fishless ponds) for breeding, egg-laying, and as larval habitat. In August 2004, the USFWS listed the CTS as threatened throughout its range. Specifically, the Central California CTS DPS was newly listed as threatened, and the Santa Barbara County and Sonoma County CTS DPSs were downlisted from endangered to threatened. However, the downlisting of the Santa Barbara County and Sonoma County DPSs was vacated by the U.S. District Court in August 2005. As a result, the Santa Barbara County and Sonoma County CTS DPSs are currently listed as endangered, while the Central California CTS DPS is listed as threatened.

Critical habitat has been designated by the USFWS for the Central California and Santa Barbara County DPSs and has been proposed for the Sonoma County DPS. This assessment evaluates the potential for modification to primary constituent elements (PCEs) of only the finalized designated critical habitat (*i.e.*, for the Central California and Santa Barbara County DPSs).

1.2. Scope of Assessment

1.2.1. Uses Assessed

Phosmet is a restricted–use, organophosphate insecticide. Formulation types registered include wettable powder (applied as a liquid) and emulsifiable concentrate. Currently, labeled uses of phosmet include alfalfa, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, citrus, grapes, ornamental trees (not for use in residential, park, or recreational areas) and non-bearing fruit trees, Christmas trees and conifers (tree farms), potatoes and peas. These current uses are evaluated as the federal action in this assessment.

1.2.2. Environmental Fate Properties of Phosmet

Phosmet has relatively low volatility and is soluble in water. Potential transport mechanisms considered in this assessment are limited to spray drift and runoff, as volatilization and atmospheric transport are not expected to occur. The compound is slightly mobile to moderately mobile in soils and is expected to dissipate rapidly in the environment. Phosmet is subject to rapid hydrolysis under alkaline and neutral conditions and to lesser extent under acidic conditions. Microbial-mediated degradation may also be a route of degradation.

1.2.3. Evaluation of Degradates and Stressors of Concern

Phosmet oxon, the only environmental degradate of phosmet identified as having toxicological concern, has been detected in six ambient water monitoring samples reported in the USGS NAWQA program with estimated concentrations ranging from 0.0069 to 0.0453 µg/L. Phosmet oxon was identified in only minor amounts (≤0.5%) in the environmental fate studies and its formation and decline in the environment are not characterized well enough to estimate environmental concentrations. There are currently no ecological toxicity data available for phosmet oxon; however, the oxon degradates of other organophosphate pesticides have been reported to be equally or more toxic than their parent compounds (USEPA, 2006a). This assessment quantitatively considered exposures to phosmet parent only; uncertainties regarding potential risk resulting from exposure to the oxon are discussed in the risk description.

1.3. Assessment Procedures

A description of routine procedures for evaluating risk to CTS is provided in Attachment 1.

1.3.1. Exposure Assessment

Tier-II aquatic exposure models are used to estimate high-end exposures of phosmet in aquatic habitats resulting from runoff and spray drift from different uses. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The AgDRIFT model is also used to estimate deposition of phosmet on aquatic habitats from spray drift. These estimates are supplemented with analysis of available California surface water monitoring data from U. S. Geological Survey's National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation.

Estimates of phosmet exposure in the terrestrial environment, as expected to result from registered uses of the chemical, are generated using the T-REX model for foliar uses, the AgDRIFT model for deposition of phosmet from spray drift, and the TerrPlant model for foliar applications that drift or run off to plants inhabiting semi-aquatic and dry areas. In addition, estimates of exposure from the T-HERPS model are compared to values from the T-REX model to further characterize dietary exposures of terrestrial-phase amphibians.

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 CTS in the Central California and Santa Barbara County DPSs but not in the Sonoma County DPS. Primary constituent elements (PCEs) were used to evaluate whether phosmet has the potential to modify designated critical habitat. The Agency evaluated registrant-submitted studies and data from the open literature to characterize phosmet 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. Toxicity data specific to phosmet are unavailable for terrestrial and aquatic plants. In the absence of data, the most sensitive toxicity endpoints from the organophosphate insecticides are discussed in the risk description for these taxonomic groups.

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 phosmet use has the potential to adversely affect the assessed species or 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 phosmet 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

1.4.1. Exposure to Phosmet

Peak model-estimated environmental concentrations in surface water resulting from different phosmet uses range from 2.08 to 245 µg/L. The maximum concentration of phosmet reported by NAWQA for California surface waters with agricultural watersheds is ≤ 0.21 µg/L. This value is approximately 1,000 times less than the maximum model-estimated environmental concentration. The maximum concentration of phosmet reported by the California Department of Pesticide Regulation surface water database (0.63 µg/L) is roughly 415 times lower than the highest peak model-estimated environmental concentration.

Direct exposure of the terrestrial-phase CTS to phosmet is assessed based upon estimated environmental concentrations (EECs) for a small bird (20 g) consuming short grass, as a surrogate for amphibians, with further refinements for the consumption of small (15 g) herbivorous mammals. Dietary and dose-based EECs for the small bird consuming short grass range from 181 to 2,277 mg a.i./kg diet and from 206 to 2,593 mg a.i./kg bw, respectively. Dietary and dose-based EECs for the consumption of small herbivorous mammals range from 182 to 2,285 mg a.i./kg diet and from 121 to 1,524 mg a.i./kg bw, respectively. Exposures of non-target amphibians, mammals, insects, and plants to phosmet are assessed to determine the potential for indirect effects to the CTS via effects on prey and habitat. Amphibian EECs are the same as those presented above for direct exposure of the CTS. Dietary and dose-based EECs for analysis of direct effects on small mammals range from 181 to 2,277 mg a.i./kg diet and from 173 to 2,171 mg a.i./kg bw, respectively. Small insect EECs range from 102 to 1,281 ppm. EECs for non-target terrestrial plants exposed to phosmet range from 0.003 to 4.70 lbs a.i./A in semi-aquatic areas and from 0.01 to 5.77 lbs a.i./A in dry areas; exposure as a result of spray drift is estimated to range from 0.003 to 4.58 lbs a.i./A.

1.4.2. Toxicity of Phosmet

Section 4 summarizes the ecotoxicity data available on phosmet. Phosmet is very highly toxic to freshwater fish and invertebrates on an acute exposure basis. Chronic effects in freshwater fish include reductions in fish length and survival. Phosmet is practically nontoxic to birds on an acute oral basis; it is moderately toxic to birds on a subacute dietary exposure basis and moderately toxic to mammals on an acute oral exposure basis. In addition, phosmet is highly toxic to honey bees on an acute contact exposure basis. Chronic effects to terrestrial vertebrates include reduced egg production in birds and reduced fertility, adult body weight, and pup body weight in mammals.

Phosmet is known to cause premature leaf drop in certain sweet cherry varieties, but the potential for adverse effects in other non-target terrestrial and aquatic plants has not been determined. A Quantitative Structural-Activity Relationship (QSAR) model for phosmet indicates that green algae may be sensitive to phosmet exposure. Limited data for other organophosphate insecticides show a potential for phytotoxic effects in both non-vascular and vascular aquatic plants and in specific terrestrial plants, particularly dicots. However, the nature and magnitude of these effects vary according to the chemical and species being tested, and it is unknown whether phosmet exposure would have similar effects on non-target plants.

1.4.3. Risks Associated with Phosmet Use

Based on the best available information, the Agency makes a “may affect” and “likely to adversely affect (LAA)” determination for the Central California, Santa Barbara County, and Sonoma County CTS DPSs as a result of the labeled use of phosmet. Additionally, the Agency has determined that there is the potential for modification of designated critical habitat of the CTS in the Central California and Santa Barbara County DPSs in association with use of phosmet. These conclusions are based upon exceedances of Levels of Concern (LOCs) and other lines of evidence (*e.g.,* incident reports) for taxonomic groups relevant to direct effects on CTS (*i.e.*, freshwater fish, birds, and amphibians), indirect effects on CTS via effects on the prey base (*i.e.*, freshwater fish, freshwater and terrestrial invertebrates, amphibians, birds, and mammals), and indirect effects on CTS via modification of habitat (*i.e.*, aquatic and terrestrial plants and mammals). Summaries of the risk conclusions and effects determinations for CTS and the designated critical habitat are presented in Table 1-1 and Table 1-2. Use-specific determinations are provided in 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 and potential modification of designated critical habitat for CTS, a description of the baseline status and cumulative effects for CTS is provided in Attachment 2.

Table 1-1. Effects Determination Summary for Effects of Phosmet on the CTS in the Central California, Santa Barbara County, and Sonoma County Distinct Population Segments

DPS	Effects Determination	Potential for Direct Effects
Central California Santa Barbara County Sonoma County	May affect/ LAA	***Aquatic-phase (Eggs, Larvae, and Adults):*** RQ values based on mortality and reduced number of offspring in freshwater fish (a surrogate for aquatic-phase amphibians) exceed the listed species and chronic LOCs, respectively.
		Terrestrial-phase (Juveniles and Adults): Acute and chronic dietary-based RQ values based on mortality and reduced reproduction (*i.e.*, number of eggs) in birds (a surrogate for terrestrial-phase amphibians) exceed the LOCs.
DPS	**Effects Determination**	**Potential for Indirect Effects**
Central California Santa Barbara County Sonoma County	May affect/ LAA	***Aquatic prey items, aquatic habitat, cover and/or primary productivity*** The LOCs are exceeded for aquatic prey items with respect to (1) acute effects (*i.e.*, mortality) in freshwater fish (*eg.*, amphibians) and invertebrates and (2) chronic effects in freshwater fish (*eg.*, amphibians) and freshwater invertebrates based on reduced numbers of offspring. Risk to aquatic and terrestrial plants is presumed in the absence of phytotoxicity data specific to phosmet; this indicates a potential for indirect effects via direct effects on prey (aquatic non-vascular plants), aquatic habitat (aquatic vascular plants and terrestrial/semi-aquatic plants), and primary productivity (aquatic vascular plants and terrestrial/semi-aquatic plants).
		Terrestrial prey items, riparian habitat In the absence of phytotoxicity data for phosmet, the potential for reductions in riparian habitat and primary productivity resulting from risk to terrestrial plants cannot be precluded. Additional reductions in habitat are expected based on exceedances of acute and chronic LOCs for small mammals. The small mammal exceedances, joined with acute and chronic exceedances for birds (*i.e.*, terrestrial-phase amphibians) and terrestrial invertebrates, also contribute to a potential reduction in the prey base.

[LAA] Likely to adversely affect.

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

DPS	Effects Determination	Basis for Determination
Central California Santa Barbara County	Habitat modification	PCEs are expected to be modified for aquatic habitat (PCE1), terrestrial habitat (PCE2), and corridors for migration and dispersal (PCE3) based upon LOC exceedances for small mammals and an asusmption of risk for to aquatic and terrestrial plants, in the absence of phytotoxicity data for phosmet. Phosmet use also may modify critical habitat by reducing the prey base as a result of direct effects on aquatic-nonvascular plants (presumed in the absence of phytotoxicity data), amphibians, mammals, and invertebrates.

Table 1-3. Phosmet Use-Specific Risk Summary for Aquatic- and Terrestrial-Phase CTS

Use(s)	Species Effects Determ.	Critical Habitat Mod.	**Potential for Effects** Taxon (Acute and/or Chronic Effects)			
			Aquatic Phase		***Terrestrial Phase***	
			Direct	**Indirect**	**Direct**	**Indirect**
Alfalfa	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (C) Mamm. (A, C) Invert. (A) Plants
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Apples, crabapples	LAA	Yes	Fish (A,C)	Fish (C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Apricots, cherries (tart), nectarines, peaches, plums, prunes	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Blueberries	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Christmas trees, pine trees, conifer and deciduous trees	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Citrus	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Grapes	LAA	Yes	N/A	Invert. (A) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Ornamentals	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants

Use(s)	Species Effects Determ.	Critical Habitat Mod.	Potential for Effects Taxon (Acute and/or Chronic Effects)			
			Aquatic Phase		*Terrestrial Phase*	
			Direct	**Indirect**	**Direct**	**Indirect**
Pears	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Peas	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Potatoes, sweet potatoes	LAA	Yes	N/A	Invert. (A) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants

Abbreviations: Determ. = Determination, Mod. = Modification, LAA = Likely to adversely affect, A = acute effects, C = chronic effects, Fish = freshwater fish (and aquatic-phase amphibians), Invert. = invertebrates, Birds = birds (*i.e.*, terrestrial-phase amphibians), Mamm. = mammals, N/A: not applicable.

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

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

- Enhanced information on the density and distribution of CTS life stages within the action area and/or applicable designated critical habitat. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.

- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual species and potential modification to critical habitat.

2. Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (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 Central California, Santa Barbara County, and Sonoma County Distinct Population Segments (DPSs) of the California tiger salamander (CTS) that may result from FIFRA regulatory actions regarding agricultural and non-agricultural use of phosmet. The ecological risk assessment has been prepared consistent with a suit brought against EPA (*Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS) in which phosmet was alleged to be of concern to the CTS. Direct and indirect effects to CTS and potential modification to designated critical habitat for CTS are evaluated in accordance with the methods described in the Agency's Overview Document (USEPA, 2004).

The CTS is found in grassland and oak savannah plant communities in central California, where it seasonally utilizes standing bodies of water (*e.g.*, fishless ponds) for breeding, egg-laying, and as larval habitat. Three DPS are recognized: the Central California DPS, the Santa Barbara County DPS, and the Sonoma County DPS. The Santa Barbara County and Sonoma County DPSs are currently listed as endangered, while the Central California DPS is listed as threatened.

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 phosmet 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). The action area for a national-level FIFRA regulatory decision associated with a use of phosmet may potentially involve numerous areas throughout the United States and its Territories.

For the purposes of this assessment, attention is focused on the relevant sections of the action area that include geographic areas associated with particular locations of the CTS and its designated critical habitat within the state of California. An "effects determination" is made for CTS in the Central California, Santa Barbara County, and Sonoma County DPSs and designated critical habitat associated with the Central California and Santa Barbara DPSs. An effects determination is not made with respect to designated critical habitat for the Sonoma County DPS because the designation has not been finalized; however, this should not be construed as the absence of risk.

As part of the effects determination, one of the following three conclusions will be reached separately for each DPS regarding the potential use of phosmet in accordance with current labels:

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

Additionally, a "No Effect" or a "Habitat Modification" determination is made for PCE's of designated critical habitat relevant to the Central California and Santa Barbara County DPSs. A description of routine procedures for evaluating risk to the CTS is provided in Attachment 1.

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

Phosmet is a restricted–use, organophosphate insecticide that is currently labeled for use on alfalfa, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, citrus, grapes, ornamental trees (not for use in residential, park, or recreational areas) and non-bearing fruit trees, Christmas trees and conifers (tree farms), potatoes, and peas. The current uses are the federal action evaluated in this assessment.

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

2.2.1. Evaluation of Degradates and Other Stressors of Concern

Phosmet oxon, which was identified only in minor amounts (<0.5%) in the environmental fate studies, is the only identified environmental degradate of toxicological concern. The only major degradates identified in the environmental fate studies were phthalamic acid (27%), n-hydroxymethyl phthalamic acid (19%), and phthalimide (43%). A number of other minor degradates were identified in the aerobic and anaerobic soil metabolism and hydrolysis studies. These degradates are various conjugates of the phthalimide, phthalamic acid, and phthalic acid moieties of the parent. With the exception of phosmet oxon, all the other identified degradates have lost the organophosphate moiety and are not expected to have acetylcholinesterase inhibition activity.

There are currently no ecotoxicity data for phosmet oxon; however, the oxon degradate of other organophosphate (OP) pesticides have been reported equally or more toxic than parent. For example, the OP Cumulative Risk Assessment (OP CRA) reported the toxicity of methyl paraoxon and chlorpyriphos-oxon to be within 10-fold of the parent OP (USEPA, 2006a). In cases where there were no data on the relative potency of the oxon to the parent OP, the OP CRA used a 10x – 100x bracketing approach to characterize potential risk from exposure to the oxon (USEPA, 2006a). The available data suggest that the relative toxicity of the organophosphate oxon degradate to amphibians and invertebrates may be even greater than the upper bound (100x) assumed for mammals in the CRA (USEPA, 2006a).

There have been six detections of phosmet oxon at three sites in Merced County, CA, all sampled in February 2004, but phosmet oxon was identified in only minor amounts in the environmental fate studies (≤0.5%) and its potential formation and decline in the environment is not characterized well enough to estimate environmental concentrations. Consequently, this assessment quantitatively considers effects resulting from exposures to phosmet parent only, with potential risk resulting from exposure to the oxon discussed in the risk description.

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 (USEPA, 2004; USFWS/NMFS/NOAA, 2004).

There are no registered products that contain phosmet along with other active ingredients. Therefore, this analysis is based on the toxicity of the single active ingredient, phosmet.

2.3. Previous Assessments

A Reregistration Eligibility Decision (RED) document was prepared for phosmet in 1998 (USEPA 1998). The RED identified potential acute and chronic risk to both aquatic and terrestrial animals from some use patterns. An Interim Reregistration Eligibility Decision (IRED) was issued in 2001. In 2006, an assessment comparing current application rates to those previously assessed in support of the RED was conducted (USEPA 2006b). The assessment concluded that although label modifications (rate reductions for some uses and proposed cancellation of some uses) may have changed estimated environmental concentrations to some extent, they did not result in substantial changes to the overall risks estimated in the RED.

In 2003, the Agency released an endangered species assessment for Pacific salmonids (http://www.epa.gov/oppfead1/endanger/litstatus/effects/phosmet-analysis.pdf), which determined that the use of phosmet in accordance with label conditions will have no effect on 13 salmon and steelhead Evolutionarily Significant Units (ESUs) and that phosmet may affect, but is not likely to adversely affect 13 ESUs. These determinations were based on the known or potential use of phosmet on various use sites in each county where there is habitat or a migration corridor for an ESU, the acute risk of phosmet, and the expected bioavailability of phosmet.

In June 2008, the Agency completed an endangered species pesticide effects determination for the California Red Legged Frog (CRLF) (http://www.epa.gov/espp/litstatus/effects/redleg-frog/#phosmet), which determined that the use of phosmet in accordance with the label is likely to adversely affect both the aquatic- and terrestrial-phase CRLF and modify its designated critical habitat. Potential risks included acute and chronic effects to fish and aquatic invertebrates, birds, and mammals, and risk to terrestrial invertebrates. Additionally, although detailed phytotoxicity data specific to phosmet are unavailable, phosmet is known to cause premature leaf drop in some sweet cherry varieties, and toxicity tests with other organophosphate insecticides indicate a potential risk to plants. Thus, indirect effects via habitat modification were considered possible. This determination was based on the known or potential use of phosmet relevant to the locations of the CRLF and its designated critical habitat within the State of California. While the estimated exposure was use-dependent, the LAA determination applied to all uses.

In April 2009, the Agency developed the Problem Formulation for the registration review of phosmet. After evaluating the application methods, mode of action, fate and transport, and the sensitivity of non-target aquatic and terrestrial species, the Agency hypothesized that phosmet had the potential to reduce survival, reproduction, and/or growth in non-target terrestrial and aquatic organisms when used in accordance with the current labels, via both acute and chronic exposures. These non-target organisms included Federally-listed threatened and endangered species as well as non-listed species. Additionally, because phosmet is an OP insecticide, the assessment indicated that the phosmet oxon could form under oxidative conditions. No data were available from the registrant-submitted studies or the ECOTOX open literature to evaluate the toxicity of the phosmet oxon. In the absence of toxicity data, the problem formulation indicated that the ecological risk assessment would assume that the oxon degradate was of toxicological concern.

2.4. Environmental Fate Properties

Phosmet (N-[mercaptomethyl] phthalimide-S-[O,O-dimethyl] phosphorodithioate) is a slightly mobile to moderately mobile chemical that is expected to dissipate quickly in the environment. Phosmet is subject to rapid hydrolysis under alkaline and neutral conditions and to a lesser degree under acidic conditions. Therefore, phosmet will not likely persist in surface water resources. In acidic soils, where microbial activity is considered minimal, leaching may be a route of dissipation for the chemical. Phosmet is soluble in water (20 mg/L, at 20^{o}C) and is not expected to volatilize significantly based on its low vapor pressure (4.9x10^{-7} torr). There are no data on the bioaccumulation potential of phosmet in fish. However, the octanol/water partition coefficient ranges from 602 to 1096, suggesting low potential for bioaccumulation. In neutral soils, microbial-mediated degradation may be a route of dissipation.

Table 2-1 lists the physical-chemical properties of phosmet and the phosmet oxon. Table 2-2 lists the other environmental fate properties of phosmet, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

Table 2-1. Physical-chemical Properties of Phosmet and Phosmet Oxon

Property	Parent Compound		Phosmet Oxon	
	Value and units	MRID or Source	Value and units	MRID or Source
Molecular Weight	317.3 g/mole	44350601	301.3 g/mole	EPISuite 4.0
Chemical Formula	$C_{11}H_{12}NO_4PS_2$	44350601	$C_{11}H_{12}NO_5PS$	47919901
Density/ Relative Density/ Bulk Density	1.44 g/cm^3	40274801		
Vapor Pressure	4.9 x10^{-7} torr @ 25^{o}C	40344401	2.1 x10^{-8} torr @ 25^{o}C	EPISuite 4.0
Henry's Law Constant	1.0 x 10^{-8} atm-m^3/mole @ 25^{o}C	Estimated from water solubility and vapor pressure	2.8 x 10^{-12} atm-m^3/mole @ 25^{o}C	Estimated from water solubility and vapor pressure
Water Solubility	20 mg/L @ 20^{o}C	40344401	2941 mg/L @ 25^{o}C	EPISuite 4.0
Octanol – water partition coefficient (K_{OW})	912 @ 25^{o}C	40344401	5.25	EPISuite 4.0
Air-water partition coefficient (K_{AW})	3.43 x 10^{-7}	EPISuite 4.0	7.98 x 10^{-10}	EPISuite 4.0
Octanol-air partition coefficient (K_{OA})	1.76 x 10^{9}	EPISuite 4.0	6.58 x 10^{9}	EPISuite 4.0

A new hydrolysis study (MRID 47919901) was submitted by the registrant in 2009 and was classified as acceptable. The half-lives for phosmet at 25˚C were 11.1, 0.5, and 0.02 days for pH 4, 7, and 9, respectively. Major degradates at pH 7 include phthalic acid, n-hydroxymethyl phthalamic acid, phthalimide.

Phosmet degrades ($t_{1/2}$ = 27 d, observed DT_{50} = 3-7 d, pH 7.4) under aerobic conditions in soil (MRIDs 00112304 and 41497801), and under anaerobic conditions ($t_{1/2}$ = 22 d, observed DT_{50} =

3-10 d, pH 7.1) (MRIDs 01671807 and 41497801). No major degradates were found to form under aerobic or anaerobic soil conditions.

Phosmet is slightly to moderately mobile in soils, with Freundlich adsorption coefficients (K_f) that range from 1.17 to 15.8 ml/g (K_{oc} = 716 - 10,400 ml/g_{oc}) for four soils (MRID 40599002). Adsorption to these four soils is weakly correlated to organic carbon content and cation exchange capacity (CEC). As a result, there is more variability in the K_{oc} data than the K_f data.

Three field dissipation studies were submitted by the registrant and were classified as supplemental. The studies provided useful information on the formation of degradates under field conditions. MRID 40599003 provided information regarding the formation of phosmet oxon (0.06 ppm) at a sampling depth of 0-3 inches at day 14. The two other field dissipation studies (MRIDs 41464901 and 41464902) analyzed for phosmet oxon but did not find the degradate product. The degradate N-methoxymethylphthalimide (maximum concentration 0.076 ppm immediately after 3rd application) was also identified in the field dissipation studies exclusively within the 0- to 3.5-inch soil layer. Phthalimide was not identified in the two field studies in which it was monitored. Phosmet was not detected below the 10.5-inch soil layer in any of three field dissipation studies and dissipated to, or below, the level of detection (LOD, <0.05 ppm in MRID 40599003 and 0.01 ppm in MRIDs 41464901 and 41464902) prior to the completion of the studies.

Table 2-2. Summary of Phosmet Environmental Fate Properties

Study	Value and unit	Major Degradate Minor Degradates	MRID # or Citation	Study Classification, Comment
Abiotic Hydrolysis	Half-life1 = 0.5 days, pH 7 and 25˚C	phthalic acid, n-hydroxymethyl phthalamic acid, phthalimide	47919901	Acceptable
Direct Aqueous Photolysis	Stable		42607901	Acceptable
Soil Photolysis	Stable		40759801	Acceptable
Aerobic Soil Metabolism	Half-life1 = 27 days, loam	*phosmet oxon, pthalamic acid, n-hydroxymethyl phthalamic acid, pthalimide, n-methoxymethl pthalimide*	00112304 41497801	Acceptable
Anaerobic Soil Metabolism	Half-life1 = 22 days, loam	*phosmet oxon, pthalamic acid, n-hydroxymethyl phthalamic acid, pthalimide, n-methoxymethl pthalimide*	00161807 41497801	Acceptable
Aerobic Aquatic Metabolism	No data	--	--	--
Anaerobic Aquatic Metabolism	No data	--	--	--
Freundlich solid-water	12.4 L/kg, 1/n=0.97, sandy	--	40599002	Acceptable

Study	Value and unit	Major Degradate Minor Degradates	MRID # or Citation	Study Classification, Comment
distribution coefficient (KF)	loam 1.17 L/kg, 1/n=0.98, sand 13.6 L/kg, 1/n=0.93, loam 15.8 L/kg, 1/n=0.89, silt loam			
Organic-carbon normalized distribution coefficient (KOC)	10,400 L/kgoc, sandy loam 975 L/kgoc, sand 757 L/kgoc, loam 716 L/kgoc, silt loam	--	40599002	Acceptable
Terrestrial Field Dissipation	Foster fine sandy loam (CA): $t_{1/2}$ = 5 d (0-7 in) Bosket fine sandy loam (MS): $t_{1/2}$ = 8 d (0-7 in) California loam soil: $t_{1/2}$ =19 d (0-3 in)	*phosmet oxon, n-methoxymethyl phthalimide*	40599003, 41464901, 41464902	Supplemental
Bioconcentration Factor (BCF)	No acceptable data	--		

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.

2.4.1. Environmental Transport Mechanisms

Potential transport mechanisms include pesticide surface water runoff, spray drift, and secondary drift of 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 phosmet.

In general, deposition of drifting pesticides is expected to be greatest close to the site of application. Computer models of spray drift (*e.g.*, AgDRIFT) are used to determine potential exposures to aquatic and terrestrial organisms via spray drift. Using AgDRIFT, the distance of potential impact away from the use sites is determined by the distance required to fall below the LOC for the taxonomic group that has the largest RQ-to-LOC ratio relevant to aquatic and terrestrial-phase CTS, which are the freshwater invertebrates [based on the scud (*Gammarus fasciatus*)] and terrestrial invertebrates [based on the honey bee (*Apis mellifera*)], respectively. Due to model limitations, it may not be possible to provide a quantitative estimate of exposure with certainty beyond the range of AgDRIFT.

2.4.2. Mechanism of Action

Phosmet is an organophosphate insecticide which inhibits the acetylcholinesterase (AchE) enzyme essential for post-synaptic neuroimpulse transmission in cholinergic neurons. Unlike AChE inhibition promoted by exposure to other pesticides, *e.g.*, carbamates, organophosphate AChE inhibition is an irreversible effect (Saadeh *et al.*, 1996). Organophosphorous compounds may also preferentially affect second messenger systems, independent of AChE inhibition, by acting as agonists at the muscarinic receptors (Ward and Mundy, 1996).

2.4.3. Use Characterization

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

Current labels allow use of phosmet on alfalfa, orchard crops (*e.g.* almonds, walnuts, apples, and cherries), blueberries, citrus, grapes, ornamental trees (not for use in residential, park, or recreational areas) and non-bearing fruit trees, Christmas trees and conifers (tree farms), potatoes and peas (January 2010). Table 2-3 presents the uses and corresponding application rates considered in this assessment, based on stamped labels dated January 27, 2010. In cases where application parameters are not explicitly prescribed on the labels, reasonable conservative assumptions were employed. For example, alfalfa crops are labeled for use once per cutting, but no annual maximum is specified on the label. For this assessment, nine cuttings per year were assumed based on information provided by the Biological and Economic Analysis Division (BEAD) which identifies the maximum number of alfalfa cuttings in California to be nine. As a result, a retreatment interval for alfalfa was assumed to be 30 days, as this allows for an equal distribution of applications throughout the year. Where retreatment intervals were not specified, a default value of 3 was assumed. This is estimated as the minimum amount of time necessary to apply the pesticide, evaluate the effects of the application, and determine if subsequent applications are required.

Where the maximum number of applications was not specified, the maximum annual application rate was divided by the maximum single application rate. If an additional application could be made, and it was greater than 0.1 lbs ai/A, then the maximum number of applications was incremented. For instance, for applications to apples, dividing the maximum annual application rate by the maximum single application rate yields 3 applications (15.5/4), with 3.5 lbs ai/A that could still be applied. The maximum number of applications is therefore incremented to 4.

Table 2-3. Phosmet Uses Assessed for California

Use (App. Method)	Form.	Maximum Single App. Rate (lbs a.i./acre)	Maximum App. Rate per Year (lbs a.i./acre)	Maximum Number of App. per Year	Minimum Retreatment Interval (days)
Alfalfa	WP	0.75	6.75	9[1]	NS[2] (30 assumed)
Almonds	WP	3.0	7.4	2	NS (3 assumed)
Apples	WP	4.0	15.5	NS (4 assumed)	NS (3 assumed)
Apricots, nectarines, plums, prunes	WP	3.0	9.1	NS (3 assumed)	NS (3 assumed)
Blueberries	WP	1.0	5.0	5	NS (3 assumed)
Crabapples	WP	3.7	15.5	NS (5 assumed)	NS (3 assumed)

Use (App. Method)	Form.	Maximum Single App. Rate (lbs a.i./acre)	Maximum App. Rate per Year (lbs a.i./acre)	Maximum Number of App. per Year	Minimum Retreatment Interval (days)
Cherries, tart	WP	1.5	5.25	NS (4 assumed)	NS (3 assumed)
Citrus[3]	WP	2.1	4.2	2	NS (3 assumed)
Grapes	WP	1.5	4.55	NS (3 assumed)	NS (3 assumed)
Peas	WP	1.0	3.0	NS (3 assumed)	NS (3 assumed)
Peaches	WP	3.0	11.9	NS (4 assumed)	NS (3 assumed)
Pears	WP	4.0	11.2	NS (3 assumed)	NS (3 assumed)
Pecans	WP	2.25	7.0	NS (4 assumed)	NS (3 assumed)
Pistachios	WP	3.0	12.0	NS (4 assumed)	NS (3 assumed)
Potatoes	WP, EC	1.0	5.0	NS (5 assumed)	10
Sweet potatoes	WP	0.9	4.5	NS (5 assumed)	10
Walnuts, filberts, other nuts	WP	5.95	11.9	5	NS (3 assumed)
Christmas, pine trees	WP, EC	1.0	NS	3	14
Conifer and deciduous trees	WP, EC	1.1	3.3	3	NS (3 assumed)
Ornamental	WP, EC	2.0[4]	6.0	3	NS (3 assumed)

Abbreviations: App. = applications; Form. = formulation; WP – wettable powder; EC – emulsifiable concentrate

1. Based on information provided by BEAD identifying the maximum number of alfalfa cuttings in CA as 9.
2. NS – not specified.
3. Residue data are needed to support this use.
4. Label indicates 0.75 lbs ai/100 gals water. Assuming a 1/100 inch layer of water is necessary for complete coverage of foliage, approximately 270 gallons of water are needed for a 1 acre field.

Labels indicate that groundboom and airblast applications should not occur within 25 feet of permanent water bodies; residential, commercial, or business buildings; and outdoor recreational areas during growing season. Groundboom and airblast applications should not occur within 50 feet of residential, commercial, or business buildings and outdoor recreational areas during the dormant season. Aerial applications to crops other than potatoes should not occur within 50 feet of permanent water bodies; residential, commercial, or business buildings; and outdoor recreational areas. Aerial applications to potatoes should not occur within 150 feet of permanent water bodies.

Apricots and cherries may have more than one growing season per year in California (U.S. EPA 2009a). Since standard PRZM scenarios only consist of one crop per year, applications to only one crop per year were modeled. If phosmet is applied for multiple cropping cycles within a year, EECs presented in this assessment may underpredict exposures. For all other labeled uses, it was assumed that a maximum seasonal application specified on the label was equivalent to a maximum annual application.

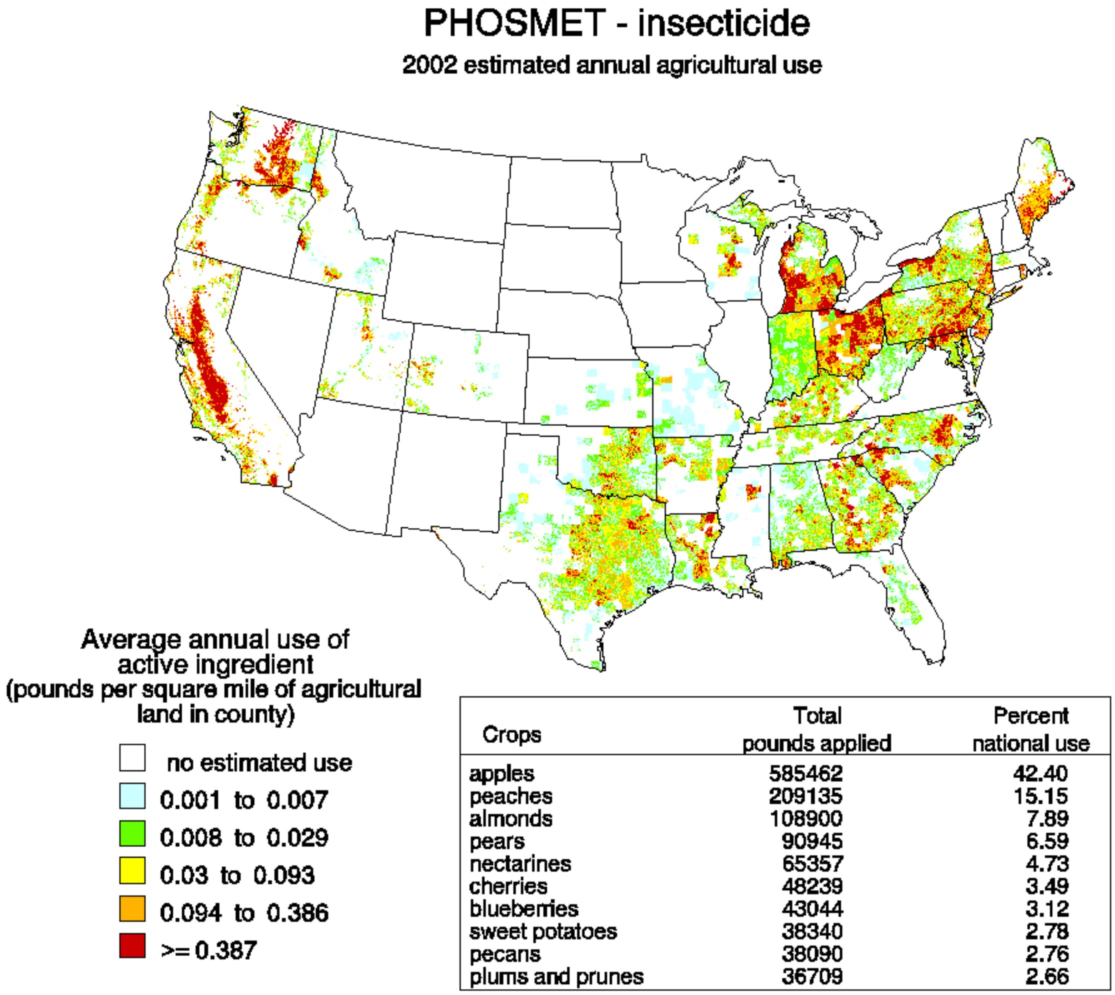
According to the United States Geological Survey's (USGS) national pesticide usage data (based on information from 1999 to 2004), an average of 1.3 million lbs of phosmet is applied nationally to agricultural use sites in the U.S. (non-agricultural uses are not included) (Figure 2-1). Most of the use was concentrated in California, the Pacific Northwest, the Midwest, and in portions of the eastern and southeastern United States. Orchard uses dominated the use patterns at that time with apples accounting for an estimated 42% and peaches, almonds, pears, nectarines and cherries combined accounting for an additional estimated 38% of phosmet usage (USGS 2009). The map was downloaded from the U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website (http://water.usgs.gov/nawqa/pnsp/usage/maps/).

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (USEPA, 2009b) using state-level usage data obtained from USDA-NASS[1], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature), and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[2]. 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 phosmet by county in this California-specific assessment were generated using CDPR PUR data. Nine years (1999-2007) of usage data were included in this analysis. Data from CDPR PUR were obtained for every agricultural pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system.[3] 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 nine years. The units of area treated are also provided where available.

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

[2] The California Department of Pesticide Regulation's Pesticide Use Reporting database provides a census of pesticide applications in the state. See http://www.cdpr.ca.gov/docs/pur/purmain.htm.

[3] 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).



Crops	Total pounds applied	Percent national use
apples	585462	42.40
peaches	209135	15.15
almonds	108900	7.89
pears	90945	6.59
nectarines	65357	4.73
cherries	48239	3.49
blueberries	43044	3.12
sweet potatoes	38340	2.78
pecans	38090	2.76
plums and prunes	36709	2.66

Figure 2-1. Phosmet Use in Total Pounds per County
(from http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m6051)[4]

A summary of phosmet usage for all California use sites is provided below in Table 2-4. The majority of the phosmet is used on nut trees (approximately 295,000 lbs ai annually) and fruit trees (205,000 lbs ai annually). Table 2-5 depicts average annual usage of phosmet by county in California. Based on annual usage data, 90% of phosmet is used annually in 10 counties; Kern, Fresno, Tulare, Kings, San Joaquin, Stanislaus, Madera, Sacramento, Butte, and Yuba counties.

[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.

Table 2-4. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2007 for Currently Registered Phosmet Uses[1]

Site Name	Average Annual Pounds Applied	Average Application Rate (lbs a.i./A)	Maximum Application Rate[2] (lbs a.i./A)
Alfalfa	9,486	0.68	0.7
Grape	6,495	1.4	1.4
Grape, Wine	6,481	1.4	1.5
Fruit trees			
Apple	48,805	2.8	4.0
Apricot	2,725	2.3	3.0
Cherry	170	2.0	2.0
Nectarine	47,166	2.4	3.0
Peach	56,638	2.5	3.0
Pear	20,892	3.3	3.9
Plum	26,127	2.6	3.0
Prune	1,817	2.5	3.0
Pome Fruit	1	1.4	1.4
Stone Fruit	147	2.1	2.8
Citrus trees			
Citrus	1	0.7	0.7
Kiwi	1.2	2.0	2.0
Lemon	339	2.9	2.1
Orange	129	1.6	1.4
Tangelo	42	1.4	0.7
Nut trees			
Almond	169,423	3.3	3.5
Pecan	23	1.5	2.2
Pistachio	61,289	3.6	3.6
Walnut	64,036	3.3	5.95
Nursery / Ornamentals			
Landscape maintenance	32	1.0	2.8
Outdoor flower	18	2.3	3.5
Outdoor plants in containers	175	2.4	9.8
Outdoor transplants	14	3.1	3.1
Uncultivated agriculture use	20	2.4	3.7
Christmas tree	12	1.1	1.1

1. Based on data supplied by BEAD (USEPA 2009b).
2. Maximum application rates reported in PUR database that were greater than the maximum annual application rate permitted on the labels were removed from the analysis and considered outliers/errors.

The average application rate for all sites in Table 2-4 are below the maximum application limits for phosmet outlined in Table 2-3. It should be noted that CDPR PUR documentation explains that errors in the data can occur for many reasons such as a misplaced decimal, an incorrect measure, area treated or units are incorrect, or if a diluted concentration of a pesticide is reported. BEAD removed outliers flagged by CDPR PUR before calculating the reported statistics as well as identified other records of questionable validity.

Table 2-5. Annual Average Phosmet Use, by County, from CDPR PUR Data from 1999 to 2007 for Currently Registered Uses

County	Average Annual Use (lbs ai)	Percent of Total Use
KERN	182,107	35%
FRESNO	97,361	19%
TULARE	79,780	15%
KINGS	27,823	5.3%
SAN JOAQUIN	16,832	3.2%
STANISLAUS	16,390	3.1%
MADERA	16,309	3.1%
SACRAMENTO	12,362	2.4%
BUTTE	10,921	2.1%
YUBA	9,362	1.8%
GLENN	7,468	1.4%
MERCED	7,057	1.3%
SUTTER	5,949	1.1%
SONOMA	5,689	1.1%
TEHAMA	5,008	1.0%
YOLO	4,935	0.9%
CONTRA COSTA	2,662	0.5%
SANTA CRUZ	2,096	0.4%
SOLANO	1,610	0.3%
SANTA BARBARA	1,577	0.3%
COLUSA	1,303	0.2%
SAN BENITO	995	0.2%
LAKE	967	0.2%
LOS ANGELES	965	0.2%

2.5. Assessed Species

Table 2-6 provides a summary of the current distribution, habitat requirements, and life history parameters for the CTS. More detailed life-history and distribution information can be found in Attachment 2. See Figure 2-2 for a map of the current CTS range and designated critical habitat.

The CTS is found in grassland and oak savannah communities in central California, where it seasonally utilizes standing bodies of water (*e.g.*, fishless ponds) for breeding, egg-laying, and as larval habitat. In 2004, the USFWS listed the CTS as threatened throughout its entire range; this included a downlisting of the Santa Barbara County and Sonoma County DPSs from endangered to threatened and a new listing of the Central Calfornia DPS as threatened. The downlisting of the Santa Barbara County and Sonoma County DPSs was vacated by the U.S. District Court in August 2005. As a result, the Santa Barbara County and Sonoma County CTS DPSs are currently listed as endangered, while the Central California CTS DPS remains listed as threatened.

Table 2-6. Summary of Current Distribution, Habitat Requirements, and Life History Information for the CTS[1]

Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Primary Diet**
California Tiger Salamander (*Ambystoma californiense*)	50 g (average weight of terrestrial adult)	This assessment applies to three DPSs: **Central California, Santa Barbara County,** and **Sonoma County**.	Freshwater pools or ponds (natural or man-made, vernal pools, ranch stock ponds, other fishless ponds); grassland or oak savannah communities, in low foothill regions; small mammal burrows	Yes (Central California DPS and Santa Barbara County DPS)	Adults: migrate from burrows to ponds during fall and winter rains and return to burrows after breeding Eggs: laid in pond primarily Dec. – Feb., hatch after 10 to 14 days Larvae: remain aquatic for 3-6 months or until the ponds dry out; metamorphose late spring or early summer; migrate to small mammal burrows	Aquatic Phase: algae and zooplankton; small crustaceans, snails, and other invertebrates; smaller tadpoles of Pacific tree frogs, CRLF, and toads; small fish Terrestrial Phase: insects, worms, and other terrestrial invertebrates; frogs; small mammals

DPS Distinct Population Segment(s)
1 For more detailed information on the distribution, habitat requirements, and life history information of the CTS, see Attachment 2.

2.6. Designated Critical Habitat

Critical habitat has been designated for CTS in the Central California and Santa Barbara County DPSs. Potential modification of critical habitat is evaluated separately from risk to 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 where there is a need for special management to protect the listed species. It may include areas outside the occupied

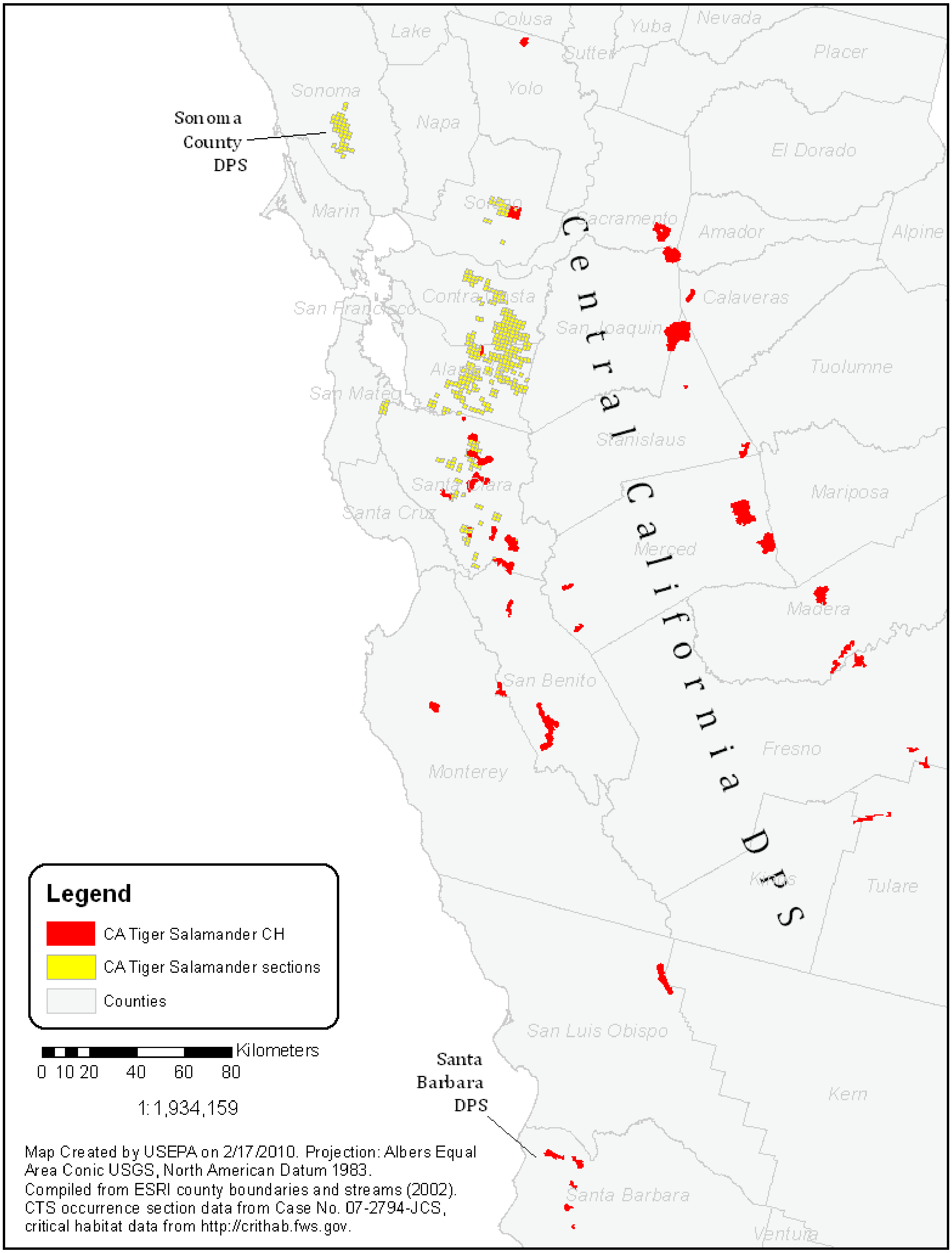


Figure 2-2. CTS Critical Habitat and Occurrence Sections Identified in Case No. 07-2794-JCS

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 2-7 describes the PCEs for the critical habitat designated for the CTS.

Table 2-7. Designated Critical Habitat PCEs for the CTS[1].

Species	PCEs		Reference
California tiger salamander	**1**	Standing bodies of fresh water, including natural and man-made (*e.g*., stock) ponds, vernal pools, and dune ponds, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (*i.e*., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle[2]	FR Vol. 69 No. 226 CTS, 68584, 2004
	2	Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend upon for food, shelter, and protection from the elements and predation	
	3	Upland areas between breeding locations (PCE 1) and areas with small mammal burrows (PCE 2) that allow for dispersal among such sites	

[1] These PCEs are in addition to more general requirements for habitat areas that provide essential life cycle needs of the species, such as space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.
[2] Abiotic PCEs, including (but not limited to) availability of fresh water and specific physical-chemical water quality parameters such as salinity, pH, and hardness, are not evaluated in this assessment.

In addition to the PCEs listed above, critical habitat for the CTS includes a prey base suitable to sustain the individual CTS and the designated DPS. More detail on the designated critical habitat applicable to this assessment can be found in Attachment 2. Activities that may destroy or modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of phosmet that may alter the PCEs of the designated critical habitat for the CTS form the basis of the critical habitat impact analysis.

As previously noted in Section 2.1, the Agency uses the analysis of direct and indirect effects to listed species as the basis for analysis of potential effects on the designated critical habitat. Phosmet may directly impact living organisms within the action area; for the purposes of this assessment, the critical habitat analysis for phosmet is limited to the PCEs and other elements (*i.e.*, prey base) of critical habitat that are biological or are linked to biologically mediated processes.

2.7. Action Area and Effects Determination Area

2.7.1. Action Area

The action area is used to identify areas 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 area 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 adverse (*e.g.,* toxic) effects to the assessed species, including reductions in survival, growth, and fecundity; sublethal effects described in the literature; and any potential modification of its designated critical habitat.

The overall action area for the national registration of phosmet is likely to encompass considerable portions of the United States, based on the large array of agricultural and/or non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of CTS 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 and downstream dilution that could influence the CTS. For example, although the CTS primarily occupies standing bodies of water as aquatic habitat for breeding and larval development, these bodies of water may be connected with or supplied by flowing surface waters that can introduce phosmet from the target application site. Additionally, the concept of a state-wide action area takes into account the potential for direct and indirect effects and potential modification to critical habitat based on ecological effect measures that are associated with reductions in survival, growth, and reproduction, as well as sublethal effects documented in the 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 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 CTS and designated critical habitat may be affected or modified via endpoints associated with reduced survival, growth, or reproduction.

2.7.2. Effects Determination Area

A stepwise approach is used to define and assess risk within the Effects Determination Area. In the case of phosmet, the Effects Determination Area includes each area where it is expected that labeled use of the pesticide may directly or indirectly affect the CTS and/or modify its critical habitat, based upon the scope of the assessment, standard assessment procedures (see Attachment 1; USEPA, 2004), and effects endpoints related to survival, growth, and reproduction. In other words, this is the area where the "Potential Area of Effects" (initial area of concern, defined by the action area and phosmet use patterns, plus drift distance and downstream dilution distance) overlaps with the designated portions of CTS range and/or critical habitat (*i.e.*, Central California, Santa Barbara County, and Sonoma County DPSs). If there is no overlap between the potential area of effects and the designated habitat or occurrence areas, or if overlap is present but the assessment indicates that adverse effects are not expected, a "no effect" determination is made. Alternatively, a "likely to adversely affect (LAA)" determination applies when it is expected that use of the pesticide will directly or indirectly affect the CTS and/or modify its designated critical habitat,.

The first step in establishing the Effects Determination Area is to understand the federal action, as defined by the currently labeled uses for phosmet. Based upon an analysis of labeled phosmet uses and review of available product labels, the following agricultural uses are considered relevant to the CTS and, therefore, comprise the federal action evaluated in this assessment:

- Alfalfa
- Blueberries
- Citrus
- Grapes
- Peas
- Tree fruits (e.g., apples, apricots, cherries, crabapples, nectarines, prunes, plums, peaches, and pears)
- Tree nuts (e.g., almonds, pecans, pistachios, walnuts, and filberts)
- Potatoes and sweet potatoes

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

- Christmas, pine, conifer and deciduous trees (tree farms)
- Nursery (flowering trees, ornamental plants, non-bearing fruit trees, non-bearing nut trees)

Several other currently labeled uses are excluded from this assessment because they are either special local needs (SLN) uses not specified for use in California or are restricted to specific states.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of phosmet 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 inclusive of all land cover types and stream reaches within the land cover areas that represent the specified labeled uses of phosmet; the land cover types include orchards and vineyards, cultivated crops, forest, and pasture and hay. A map representing all land cover types that make up the initial area of concern for phosmet is presented in Figure 2-3.

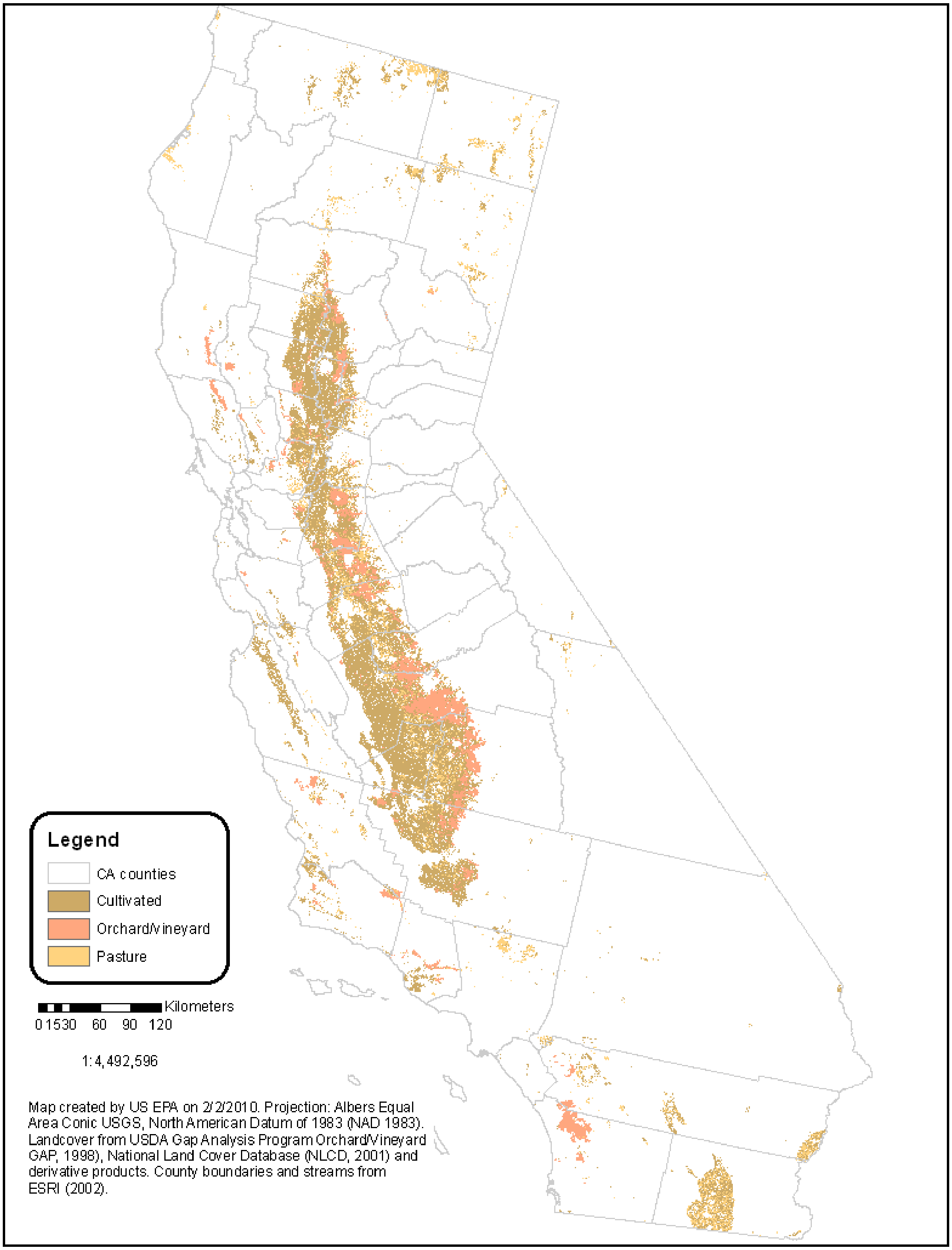


Figure 2-3. Initial area of concern, or "footprint" of potential use, for phosmet.

Once the initial area of concern is defined, the next step is to define the boundaries of the Potential Area of Effects, by determining the extent of offsite transport via spray drift and runoff where exposure of one or more taxonomic groups to the pesticide will result in exceedances of the LOCs. The AgDRIFT model (Version 2.01) was used to define how far from the initial area of concern an effect may be expected based on spray drift (*e.g.*, the drift distance). The spray drift analysis for phosmet used the most sensitive endpoints for freshwater and terrestrial invertebrates (based on the scud and the honey bee, respectively). Further detail on the spray drift analysis is provided in Section 5.2.4.b. In addition to the buffered area from the spray drift analysis, the Potential Area of Effects considered the extent of downstream phosmet exposure that exceeded LOCs, based on downstream dilution analysis. Although aquatic-phase CTS primarily utilize static or slow-flowing water bodies, phosmet may move through the watershed and be introduced into CTS aquatic habitat via moving surface waters that supply the pond (discussed in Section 5.2.4.c).

Finally, an evaluation of usage information was used to define the area(s) where phosmet use may impact CTS. The usage analysis characterizes where predicted exposures are most likely to occur, but it does not preclude uses in other portions of the action area. A more detailed review of county-level usage information suggests that 90% of phosmet has historically been used in 10 counties: Kern, Fresno, Tulare, Kings, San Joaquin, Stanislaus, Madera, Sacramento, Butte, and Yuba. Notably, several of these counties (Fresno, Tulare, San Joaquin, Stanislaus, Madera, and Sacramento) contain designated critical habitat areas for the CTS (see Figure 2-2). For the purposes of this assessment, the Effects Determination Areas encompass counties within the Central California, Santa Barbara County, and Sonoma County DPSs, respectively. The Effects Determination Areas for designated critical habitat include the Central California and Santa Barbara County DPSs.

2.8. Assessment Endpoints and Measures of Ecological Effect

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 2-8 identifies the taxa used to assess the potential for direct and indirect effects from the uses of phosmet for each listed species assessed here. Where toxicity data specific to phosmet are unavailable (*i.e.*, for aquatic and terrestrial plants), surrogate toxicity data from other organophosphate insecticides are used to assess risk. The specific assessment endpoints used to assess the potential for direct and indirect effects to each listed species are provided in Table 2-9. For more information on the assessment endpoints, see Attachment 1.

Table 2-8. Taxa Used in the Analyses of Direct and Indirect Effects for the CTS.

Taxonomic Groups	Nature of Effects on CTS (Direct and/or Indirect)	Ecological Impact (for Indirect Effects)
Freshwater Fish (and Aquatic-Phase Amphibians)	Direct	NA
	Indirect	Reduction in prey
Freshwater Invertebrates	Indirect	Reduction in prey
Freshwater Plants	Indirect	Reduction in forage and habitat

Taxonomic Groups	Nature of Effects on CTS (Direct and/or Indirect)	Ecological Impact (for Indirect Effects)
Estuarine/Marine Fish	NA	NA
Estuarine/Marine Invertebrates	NA	NA
Birds (and Terrestrial-Phase Amphibians)	Direct	NA
	Indirect	Reduction in prey
Mammals	Indirect	Reduction in prey and habitat
Terrestrial Invertebrates	Indirect	Reduction in prey
Terrestrial Plants	Indirect	Reduction in habitat

[NA] Not applicable.

Table 2-9. Taxa and Assessment Endpoints Used to Evaluate the Potential for Phosmet Uses to Result in Direct and Indirect Effects to the CTS and/or the Modification of Critical Habitat.

Taxonomic Groups	Nature of Effect(s) on CTS (Direct and/or Indirect)	Ecological Effects	Assessment Endpoints
1. Freshwater Fish[1] (and Aquatic-Phase Amphibians)	Direct Effect	Survival, growth, and reproduction of individuals via direct effects	1a. Most sensitive fish acute LC_{50} (guideline study) 1b. Estimated fish chronic NOAEC (based on freshwater invertebrate acute-to-chronic ratio) 1c. Most sensitive fish early-life stage NOAEC (guideline study)
	Indirect Effect (prey)	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on aquatic prey food supply (*i.e.*, fish and aquatic-phase amphibians)	
2. Freshwater Invertebrates	Indirect Effect (prey)	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	2a. Most sensitive freshwater invertebrate EC_{50} (guideline study) 2b. Most sensitive freshwater invertebrate chronic NOAEC (guideline study)
3. Aquatic Plants (freshwater/marine)	Indirect Effect (food/habitat)	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Vascular plant acute EC_{50} (guideline study with naled) 3b. Non-vascular plant (*i.e.*, freshwater algae) acute EC_{50} (guideline study with naled)
4. Birds[2] (and Terrestrial-Phase Amphibians)	Direct Effect	Survival, growth, and reproduction of individuals via direct effects	4a. Most sensitive bird* acute LC_{50} (guideline study) 4b. Most sensitive bird* chronic NOAEC (guideline study)
5. Mammals	Indirect Effect (prey/habitat from burrows/rearing sites)	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on terrestrial prey (mammals) and/or	5a. Most sensitive laboratory mammalian acute LD_{50} (guideline study) 5b. Most sensitive laboratory mammalian chronic NOAEC (guideline study)

Taxonomic Groups	Nature of Effect(s) on CTS (Direct and/or Indirect)	Ecological Effects	Assessment Endpoints
		burrows/rearing sites	
6. Terrestrial Invertebrates	Indirect Effect (prey)	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on terrestrial prey (terrestrial invertebrates)	6a. Most sensitive terrestrial invertebrate acute LD_{50} (guideline study) 6b. Most sensitive terrestrial invertebrate chronic NOAEC (guideline study)
7. Terrestrial Plants	Indirect Effect (food/habitat) (non-obligate relationship)	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on food and habitat (*i.e.*, riparian and upland vegetation)	7. Most sensitive EC_{25} for terrestrial plants (guideline seedling emergence study with propenofos)

[1] Freshwater fish are used as a surrogate for aquatic-phase amphibians.
[2] Birds are used as a surrogate for terrestrial-phase amphibians (T-REX).

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, this assessment evaluates actions related to the use of phosmet that may alter the CTS prey base or PCEs of the CTS designated critical habitat and therefore jeopardize the continued existence of the salamander. PCEs for the CTS were previously described in Section 2.6 and are relevant only to the Central California and Santa Barbara County DPSs. Assessment endpoints used to evaluate potential modification of PCEs as a result of phosmet use are 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 phosmet effects data are available.

The assessment endpoints used to evaluate potential modification of designated critical habitat are equivalent to the assessment endpoints used to evaluate the potential for direct and indirect effects to the CTS. If a potential for direct or indirect effects is found, then there is also a potential for effects to critical habitat. Some components of PCEs associated with physical abiotic features are not expected to be measurably altered by use of pesticides (*e.g*., presence and/or depth of a water body, distance between two sites); these components are not evaluated in this assessment.

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 phosmet to the environment. The following risk hypotheses are presumed in this assessment:

The labeled use of phosmet within the action area may:

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

2.9.2. Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the phosmet release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for the aquatic and terrestrial-phase CTS and PCEs of designated critical habitat are shown in Figure 2-4 and Figure 2-5.

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 CTS and modification to designated critical habitat is expected to be negligible.

This assessment does not quantify potential atmospheric transport in estimating environmental concentrations or potential exposure via ground water, as phosmet does not readily volatilize and has relatively short aqueous half-lives and it is not expected to persist long enough to reach ground water. Furthermore, this assessment does not account for ingestion of phosmet residues by animals in contaminated grit, ingestion through preening activities, by uptake through inhalation, or by uptake through dermal absorption by terrestrial animals. Exposure to terrestrial animals is based primarily on dietary consumption of foliar and insect surface residues.

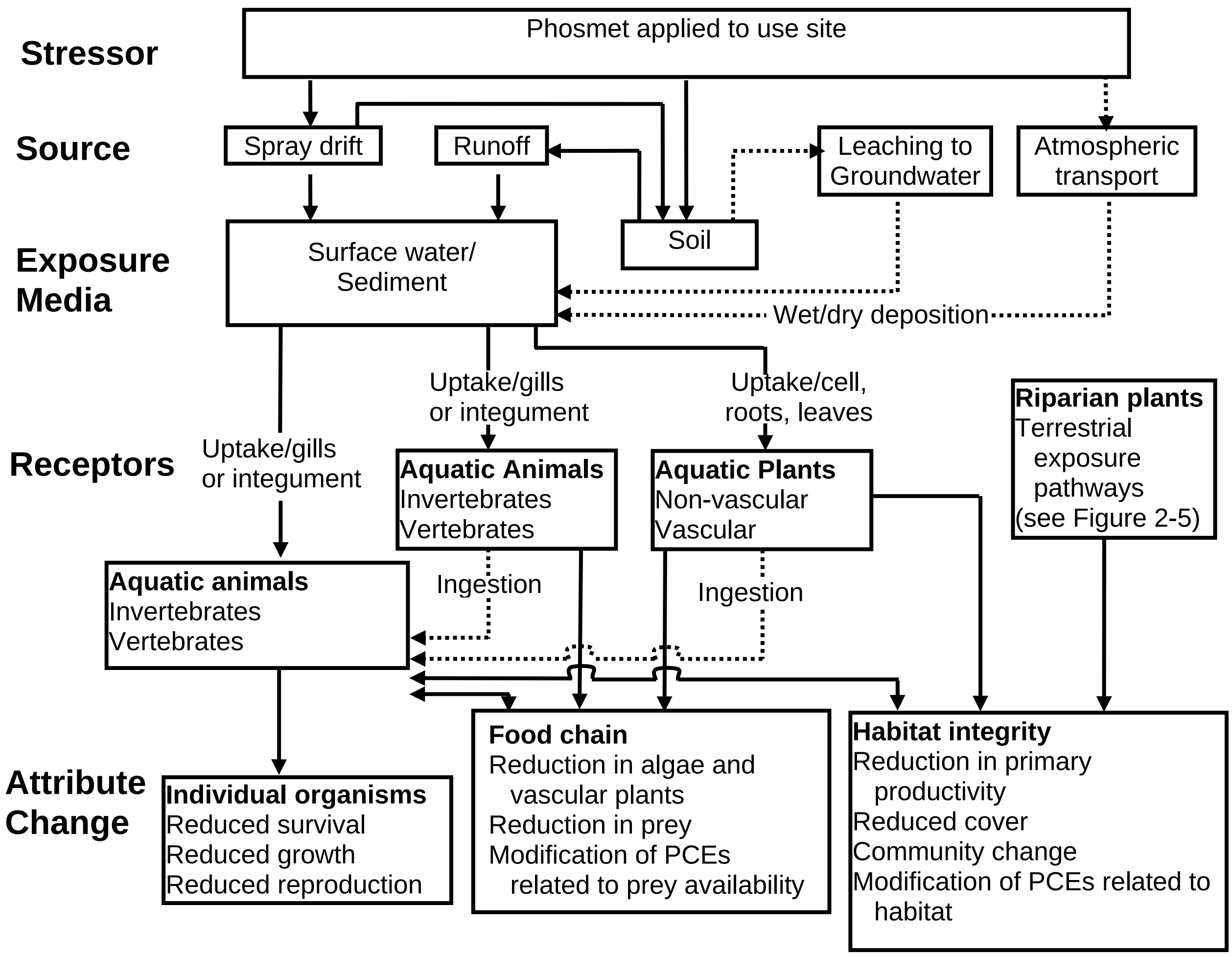


Figure 2-4. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Aquatic-Phase CTS from the Use of Phosmet.
Dotted lines indicate exposure pathways expected to have a low likelihood of contributing to ecological risk.

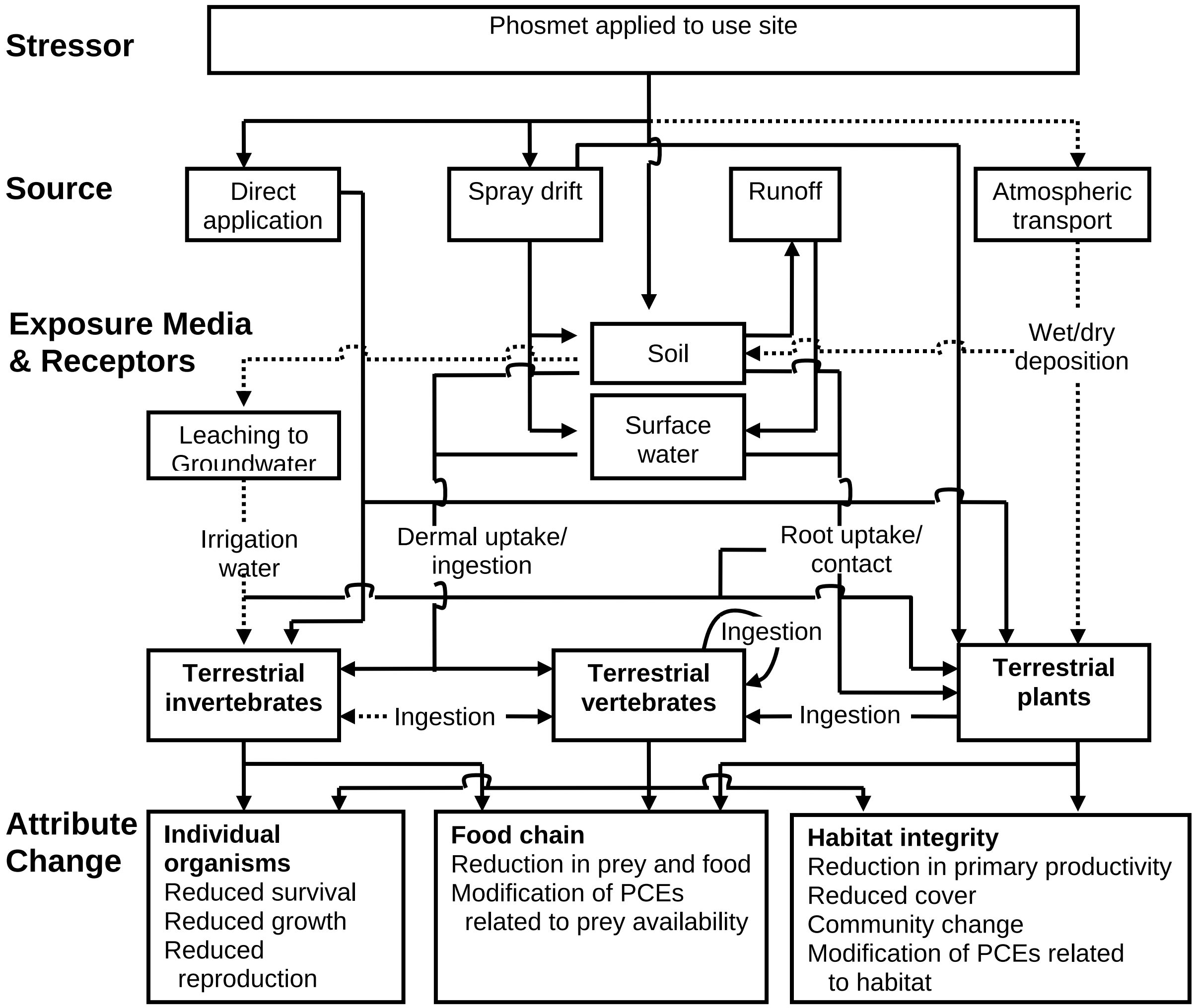


Figure 2-5. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Terrestrial-Phase CTS from the Use of Phosmet.
Dotted lines indicate exposure pathways expected to have a low likelihood of contributing to ecological risk.

2.10. Analysis Plan

To address the risk hypotheses, a taxon-level approach is used to estimate the potential for direct and indirect effects to the assessed species, prey items, and habitat. In the following sections, the use, environmental fate, and ecological effects of phosmet 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 CTS from particular uses of phosmet 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 (*e.g.*, CTS) are provided in Attachment 1.

2.10.1. Measures of Exposure

The environmental fate properties of phosmet, along with available monitoring data, indicate that water and sediment runoff and spray drift are the principle potential transport mechanisms of phosmet to aquatic and terrestrial habitats. In this assessment, transport of phosmet through runoff and spray drift is considered in deriving quantitative estimates of exposure to the CTS and its prey and habitats. There are no data on the bioaccumulation potential of phosmet in fish. However, the octanol/water partition coefficient ranges from 602 to 1096, suggesting a low potential for bioaccumulation.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of phosmet using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to predict terrestrial EECs on food items is Terrestrial Residue Exposure (T-REX) model. The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. More information on these models is available in Attachment 1.

2.10.1.a. Estimating Exposure in the Aquatic Environment

For this assessment, aquatic EECs are calculated using the PRZM/EXAMS model described above. Additionally, as the labels for phosmet require a buffer of at least 50 feet (150 feet for potatoes) during aerial application, default spray drift values are not used; rather spray drift values, used as inputs in the PRZM/EXAMS model, are calculated using AgDRIFT.

2.10.1.b. Estimating Exposure in the Terrestrial Environment

In addition to the methods described above, two models are used to further characterize the potential for exposure to plants and animals in terrestrial environments to phosmet. As described above, AgDRIFT is used to estimate the distance of spray drift associated with aerial applications of phosmet. These spray drift estimates are then used as input values in TerrPlant, unless otherwise specified. In addition, T-HERPS is used to estimate dietary exposures of herpetofauna (*i.e.*, reptiles and amphibians) to phosmet; the resulting values are compared to estimated avian exposures from the T-REX model. Although, based on the surrogate taxa approach, avian T-REX values remain the standard for risk estimation for terrestrial phase amphibians, exposure values from T-HERPS are used to refine exposure estimates when RQs generated by T-REX exceed the Agency's Level of Concern (LOC).

2.10.2. Measures of Effect

Data identified in Section 2.8 were used as measures of effect for direct and indirect effects. In the absence of toxicity data specific to effects of phosmet on aquatic and terrestrial plants, potential effects to these taxonomic groups were presumed and were further characterized, based on the available toxicity data from other organophosphate insecticides, in the Risk Descrption. However, unlike previous assessments for phosmet (*e.g.*, USEPA, 2008), the surrogate endpoints for phytotoxicity of the other organophosphate pesticides are not used quantitatively in Risk Estimation. Phosmet data were obtained from registrant submitted studies and from literature studies identified by ECOTOX. A query for data on the phosmet oxon was also conducted, but no toxicity data specific to the oxon degradate were found. More information on the ECOTOXicology (ECOTOX) database and how toxicological data are used in assessments is provided in Attachment 1.

2.10.2.a. Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterizations to determine the potential ecological risk from agricultural and non-agricultural uses of phosmet, and the associated likelihood of direct and indirect effects to the CTS in aquatic and terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. The risk quotient (RQ) method is used to compare exposure and measured toxicity values: EECs are divided by acute and chronic toxicity values, and the resulting RQs are compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see Appendix C). More information on standard assessment procedures is available in Attachment 1.

2.10.3. Data Gaps

The studies submitted to fulfill environmental fate data requirements for phosmet are sufficient for exposure assessment, with a few important exceptions. Submission of aerobic and anaerobic aquatic metabolism studies, used to describe the fate of phosmet in surface water bodies, have not been submitted, and additional information is needed to better quantify potential exposure to the phosmet oxon under environmental conditions.

The ecological effects data set for mammals, birds, fishes, and invertebrates exposed to phosmet is largely complete. For these taxonomic groups, assessment endpoints are from registrant-submitted toxicity studies with phosmet; however, these studies lack specific dose-response curve data (*i.e.*, probit slope). Therefore, a default slope of 4.5 (±2.5) is used in the probit analysis for all animal taxa.

Toxicity data specific to the effects of phosmet on non-target aquatic and terrestrial plants have not been submitted by the registrant and are unavailable in the ECOTOX open literature. In the absence of data, risks to these taxa cannot be precluded. The potential for risk to non-target aquatic and terrestrial plants is characterized in the Risk Description based on surrogate toxicity data for the pesticides naled and profenofos, respectively. These endpoints were selected because they represent the lowest toxicity values from available tests for organophosphate insecticides. However, it is unknown whether phosmet is more toxic or less toxic than these surrogates. The lack of phytotoxicity data for phosmet is a source of uncertainty in assessing the potential for direct effects on non-target plants and indirect adverse effects on other non-target organisms, including the CTS.

Given the breadth of crop species for which phosmet is labeled, the mode of action of the compound, and the lack of plant incident data, the potential for injury to nontarget plants may be minimal. However, label restrictions state that sweet cherry (*Prunus* spp.) crops should not be treated with phosmet, because it is known to cause premature leaf drop in certain sweet cherry cultivars. Other *Prunus* species and crops in the same family (Rosaceae) are labeled uses. This suggests that sensitivity to phosmet exposure may vary according to plant variety, species, or class (*i.e.*, monocots versus dicots). The chemically-related organothiophosphate insecticide profenofos is known to have phytotoxic effects on cucumber (*Cucumis sativus*), lettuce (*Lactuca sativa*), and cabbage (*Brassica oleracea*). Other organophosphate (OP) insecticides, including naled, sulprofos, fenthion, and isazofos, have shown phytotoxic effects in tests with duckweed (*Lemna gibba*). In addition, naled adversely affected non-vascular aquatic plants in tests with green algae (*Selanastrum caprocornutum*), bluegreen algae (*Anabaeba flos-aquae*), and the freshwater diatom (*Navicula pelliculosa*).

3. Exposure Assessment

Phosmet is formulated as a wettable powder (applied as a liquid) and an emulsifiable concentrate. Application equipment includes chemigation, ground application, aerial application, airblast, and a variety of sprayers (*e.g.*, hydraulic sprayers, mist blowers). Risks from airblast and aerial applications are considered in this assessment because they are expected to result in the highest off-target levels of phosmet due to generally higher spray drift levels.

3.1. Label Application Rates and Intervals

Phosmet labels may be categorized into two types: labels for manufacturing uses (including technical grade phosmet and its formulated products) and end-use products. While technical products which contain phosmet 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 a variety of insects (*e.g.*, maggots, aphids, beetles, fruitworms, weevils, and moths). The formulated product labels legally limit phosmet's potential use to only those sites that are specified on the labels.

Currently registered agricultural and non-agricultural uses of phosmet within California include alfalfa, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, citrus, grapes, ornamental trees (not for use in residential, park, or recreational areas) and non-bearing fruit trees, Christmas trees and conifers (tree farms), potatoes and peas. The uses being assessed are summarized in Table 3-1. The application rates, application efficiency, and spray drift fractions in some cases differ from those assessed in EPA's 2008 California Red-Legged Frog Assessment (CRLF) (USEPA, 2008), as mitigation measures were included on the phosmet labels in January

Table 3-1. Phosmet Uses, Scenarios, and Application Information[1]

Uses	Scenario for Uses	App. Method	App. Rate (lbs a.i./A)[2]	Max. Num. of Apps.	App. Interval	Date of 1st App.	Comments	Canopy Height (ft)	App. Efficiency	Spray Drift Fraction
Alfalfa	CA alfalfa	Aerial	0.75	9	NS (30 days)	March 1st	Cal PUR: majority of applications in March	2.5[3]	0.97	0.038
Almond, pecan, pistachio, filbert, walnut, other tree nuts	CA almond	Aerial	5.95	2	NS (3 days)	May 15th	Cal PUR: majority of applications occur between May - August	40[3]	0.61	0.72
Apples, crabapples	CA fruit	Aerial	4.0 (4.0, 4.0, 4.0, 3.5)	4	NS (3 days)	May 1st	Cal PUR: majority of applications occur between May - August	10[3]	0.92	0.14
Apricots, cherries, nectarines, peaches, plums, prunes	CA fruit	Aerial	3.0 (3.0, 3.0, 3.0, 2.9)	4	NS (3 days)	April 15th	Cal PUR: majority of applications occur between April - August	20[3]	0.85	0.47
Blueberries	CA wine grapes	Aerial	1.0	5	NS (3 days)	April 1st	Cal PUR: No application; spring applications assumed	12[5]	0.92	0.10
Christmas, pine trees, conifer and deciduous trees	CA forestry	Aerial	1.0	3	14	May 1st	Cal PUR: limited data suggest spring and summer applications	8[4]	0.95	0.07
Citrus	CA citrus	Aerial	2.1	2	NS (3 days)	March 1st	Cal PUR: Applications occur all year, w/ majority starting in March	12[3]	0.92	0.12
Grapes	CA grapes	Airblast	1.5	3	NS (3 days)	May 1st	Cal PUR: majority of applications in May	NA	0.99	0.003

Uses	Scenario for Uses	App. Method	App. Rate (lbs a.i./A)[2]	Max. Num. of Apps.	App. Interval	Date of 1st App.	Comments	Canopy Height (ft)	App. Efficiency	Spray Drift Fraction
Ornamental	CA nursery	Airblast	2.0	3	NS (3 days)	January 1st	Cal PUR: Applications occur all year	8[6]	0.98	0.02
Pears	CA fruit	Aerial	4.0 (4.0, 4.0, 3.2)	3	NS (3 days)	April 15th	Cal PUR: majority of applications occur between April - August	15[3]	0.88	0.22
Peas	CA row crop	Aerial	1.0	3	NS (3 days)	April 1st	Cal PUR: No application; spring applications assumed	0	0.97	0.038
Potatoes, sweet potatoes	CA potato	Aerial	1.0	5	10	April 1st	Cal PUR: No application; spring applications assumed	0	0.97	0.02

Abbreviations: App.: Application, Max.: Maximum, Num.: Number

1 Uses assessed based on memorandum from Pesticide Re-evaluation Division (PRD) dated January 27, 2010, and EFED Label Data report and associated Label Use Information Reports prepared on November 30, 2009.

2 Numbers in parentheses indicate the rates used for modeling when the maximum number of applications times the maximum single application rate exceeded the maximum annual application rate. For instance, the maximum annual application rate for apples is 15.5 lbs a.i./A. The maximum single application rate for apples is 4 lbs a.i./A. Therefore, a farmer could apply phosmet to apples 3 times at 4 lbs a.i./A and 1 time at 3.5 lbs a.i./A.http://www.epa.gov/oppefed1/models/water/met_ca_alfalfa.htm

3 California Master Gardener's Handbook, canopy heights for dwarf-sized trees

4 Crop Profile for Christmas Trees in Oregon and Washington (http://www.ipmcenters.org/CropProfiles/docs/orwachristmastrees.pdf)

5 US Highbush Blueberry Council (http://www.blueberrycouncil.org/kids-teachers-how-blueberries-grow.php)

6 Airblast scenario for sparse (young) trees and plants.

2010. Additionally, while the ornamental/nursery scenario was qualitatively assessed in the 2008 CRLF document, this assessment quantitatively evaluates the use.

3.2. Aquatic Exposure Assessment

3.2.1. Modeling Approach

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

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

Use-specific management practices for all of the assessed uses of phosmet were used for modeling, including application rates, number of applications per year, application intervals, spray drift values modeled from AgDRIFT, and the first application date for each use. The date of first application was developed based on several sources of information including data provided by BEAD, a summary of individual applications from the CDPR PUR data, and Crop Profiles maintained by the USDA. When a range of application dates was possible, the first application was chosen to correspond to the wetter portion of the year, winter/early spring. A representative sample of the distribution of phosmet applications to tree nuts (e.g., almonds, pistachios, and walnuts) from the CDPR PUR data for 2006 is shown in Figure 3-1. The figure indicates that phosmet could be applied to tree nuts at any time of the year, but most of the applications occur between the middle of May and September. Therefore, an application date of May 15th was chosen.

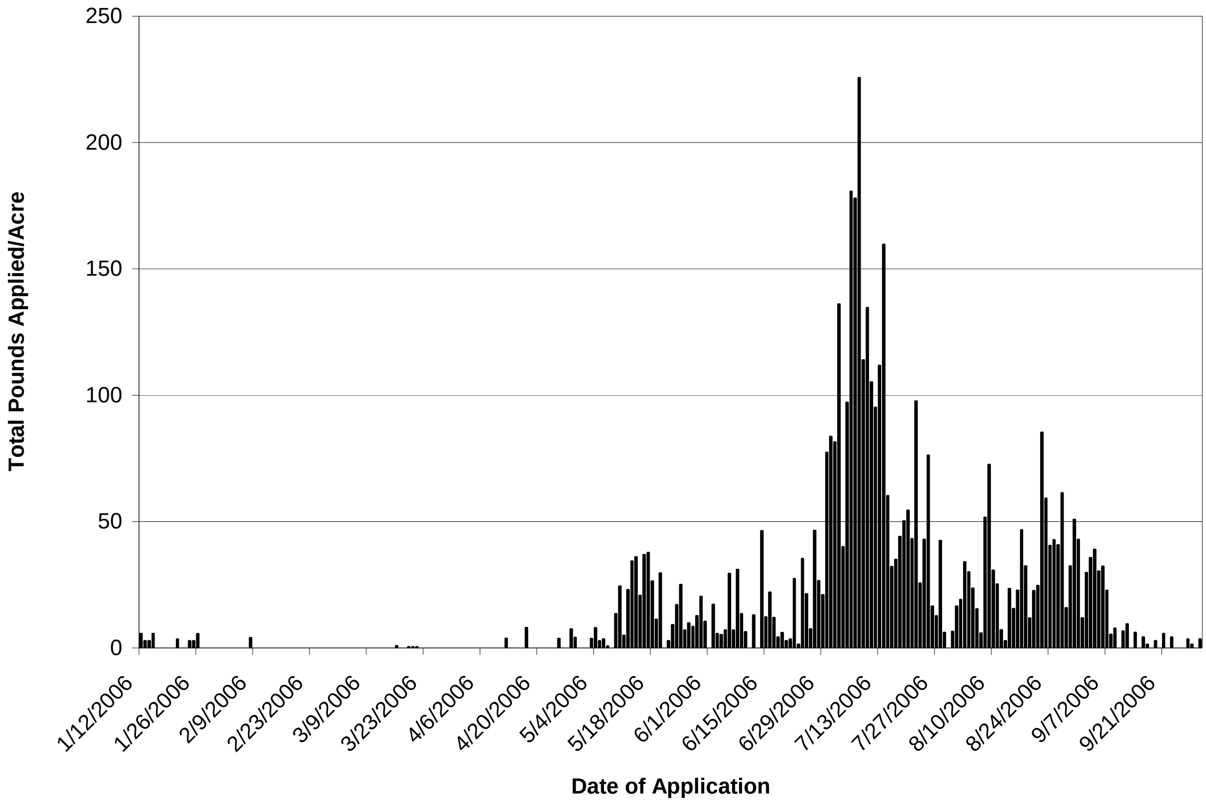


Figure 3-1. Summary of Applications of Phosmet to Tree Nuts in 2006 from CDPR PUR data. More detail on the crop profiles and the previous assessments may be found at http://www.ipmcenters.org/CropProfiles/.

3.2.2. Model Inputs

The PRZM and EXAMS input parameters for phosmet and related compounds were selected from the environmental fate data submitted by the registrant and in accordance with US EPA-OPP EFED water model parameter selection guidelines, *Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1*, October 22, 2009 and *PE5 User's Manual. (P)RZM (E)XAMS Model Shell, Version (5)*, November 15, 2006. Input parameters can be grouped by physical-chemical properties and other environmental fate data application information, and use scenarios. Physical and chemical properties relevant to assess the behavior of phosmet and its degradates in the environment are presented in Table 2-1 and Table 2-2, and application information from the label in Table 2-3 and Table 3-1. The input parameters for PRZM and EXAMS are in Table 3-2. Modeling inputs were selected according to EFED's Input Parameter Guidance (USEPA, 2009c). Pesticide applications were simulated as aerial spray applications as prescribed by product labels for all uses except grapes (prohibited aerial applications), which was simulated as an air blast application. Foliar applications (PRZM chemical application method, CAM = 2) were simulated and default spray drift estimates were assumed. The disposition of the pesticide remaining on foliage after harvest (PRZM variable IPSCND) was selected according to post-harvest cropping practices. Spray drift and application efficiency estimates were derived using AgDrift and information from the labels (see Appendix M). Appendix D contains example model output files and tables showing the data used to calculate input values.

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

Fate Property	Value (unit)	MRID (or source)	Comment
Molecular Weight	317.3 g/mole	40344401	
Henry's constant	1.0 x 10-8 atm-m3/mole	Product chemistry data	Estimated from water solubility and vapor pressure
Vapor Pressure	4.9 x10-7 torr	40344401	
Solubility in Water	20 mg/L	40344401	
Photolysis in Water	Stable	42607901	
Aerobic Soil Metabolism Half-lives	81 days	41497801 [1]	3x aerobic soil t1/2
Hydrolysis Half-lives	0.5 days	47919901	pH=7
Aerobic Aquatic Metabolism Half-life (water column)	0	No data	Assumed stable. Aquatic degradation driven by hydrolysis
Anaerobic Aquatic Metabolism Half-life (benthic)	0	No data	Assumed stable. Aquatic degradation driven by hydrolysis
Solid-water distribution coefficient (Kd, L/kg soil)	10.7	MRID 40599002 [1]	Mean of four values
Application rate and frequency	See Table 3-1	Label	
Application intervals	See Table 3-1	Label	
Chemical Application Method (CAM)	2	Label	
Application Efficiency	See Table 3.1	Label	
Spray Drift Fraction	See Table 3.1	Input guidance[1]	
Incorporation Depth	0 cm	Input guidance[1]	
Post-harvest foliar pesticide disposition (IPSCND)	2 for alfalfa, 3 for almond and citrus, and 1 for all other scenarios	Input guidance[1]	
Decay rate on foliage (PLDKRT)	0	Input guidance[1]	Assume stable (default)

1. Inputs determined in accordance with EFED "*Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides. Version 2.1*" dated October 22, 2009.

3.2.3. Results

The aquatic EECs for the various scenarios and application practices are listed in Table 3-3. An example output from PRZM-EXAMS is provided in Appendix D. Peak aquatic EECs for all uses modeled ranged from 2.08 – 245 µg/L for potatoes and nut trees, respectively; 21-day EECs ranged from 0.12 to 19.2 for grapes and nut trees, respectively; and, 60-day EECs ranged from 0.04 to 6.79 for grapes and nut trees, respectively. The variability in EECs is driven by yearly application rate, application timing relative to rainfall events and variability in the vulnerability of the PRZM scenario (rainfall and soils).

Table 3-3. Aquatic EECs (µg/L) for Phosmet Uses in California

Crops/Uses Represented	Scenario (Application Method/ Formulation)	App. Rate (kg a.i./ha)	Date of 1st App.	Number of App.	App. Interval (days)	EECs (µg/L)		
						Peak	21-day avg.	60-day avg.
Alfalfa	CA alfalfa	0.84	March 1st	9	30	6.64	0.43	0.20
Almond, pecan, pistachio, filbert, walnut, other tree nuts	CA almond	6.67	May 15th	2	3	245	19.2	6.79
Apples, crabapples	CA fruit	4.48	May 1st	6	3	31.8	4.82	1.71
Apricots, cherries, nectarines, peaches, plums, prunes	CA fruit	3.36	April 15th	3	3	46.2	7.20	2.58
Blueberries	CA wine grapes	1.12	April 1st	5	3	6.70	1.29	0.46
Christmas, pine trees, conifer and deciduous trees	CA forestry	1.12	May 1st	3	14	8.16	0.37	0.17
Citrus	CA citrus	2.35	March 1st	2	3	14.3	1.16	0.43
Grapes	CA grapes	1.68	May 1st	3	3	2.89	0.12	0.04
Ornamentals	CA nursery	2.28	January 1st	3	3	40.4	2.04	1.08
Pears	CA fruit	4.48	April 15th	3	3	50.0	5.57	2.03
Peas	CA row crop	1.12	April 1st	3	3	5.34	0.49	0.17
Potatoes, sweet potatoes	CA potato	1.12	April 1st	5	10	2.08	0.21	0.14

3.2.4. Existing Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. Monitoring data for phosmet and phosmet oxon from the USGS NAWQA program (http://water.usgs.gov/nawqa) were available. Surface water and sediment monitoring data from the California Department of Pesticide Regulation (CDPR) were available and are considered in this assessment. No air monitoring data were located.

3.2.4.a. USGS NAWQA Surface Water Data

Surface water monitoring data from the United States Geological Survey (USGS) NAWQA program were obtained on December 29, 2009. A total of 4,797 water samples across various sites throughout the US were analyzed for phosmet. A total of 346 water samples were analyzed for phosmet in CA at 15 sites located in five counties (Merced, Riverside, Sacramento, San Joaquin, and Stanislaus) between October 2001 and July 2009. There were no positive detections of phosmet reported above the level of detection which ranged from 0.0018 to 0.21 µg/L.

A total of 4,426 water samples across various sites throughout the US were analyzed for phosmet oxon. A total of 377 water samples were analyzed for phosmet oxon in CA at 15 sites located in five counties (Merced, Riverside, Sacramento, San Joaquin, and Stanislaus) between October 2001 and July 2009. Of these samples, six samples had positive detections with estimated concentrations ranging from 0.0069 to 0.045 µg/L. Reported levels of detection ranged from 0.022 to 0.26 µg/L. The six detections were reported from three sites in Merced County, CA all sampled in February 2004. These detections of phosmet oxon were not concurrent with detections of phosmet parent (as noted above, phosmet has not been reported above detection limits in NAWQA). One of the three sites is reported as being in a watershed with agricultural land use and two are reported as “other” land use.

3.2.4.b. USGS NAWQA Groundwater Data

Groundwater monitoring data from the United States Geological Survey (USGS) NAWQA program were obtained on December 29, 2009. A total of 2,385 water samples across various sites throughout the US were analyzed for phosmet. A total of 398 water samples were analyzed for phosmet in CA at 264 sites located in seventeen counties between July 2001 and June 2009. There were no positive detections of phosmet reported above the level of detection which ranged from 0.0079 to 0.2 µg/L.

A total of 2,185 water samples across various sites throughout the US were analyzed for phosmet oxon. A total of 321 water samples were analyzed for phosmet oxon in CA at 264 sites located in seventeen counties between July 2001 and June 2009. There were no positive detections of the phosmet oxon reported above the level of detection which ranged from 0.051 to 0.06 µg/L.

3.2.4.c. California Department of Pesticide Regulation (CDPR) Data

Surface water monitoring data from the California Department of Pesticide Regulation (CDPR) were assessed on December 29, 2009, and all data with analysis for phosmet or phosmet oxon were extracted. The CDPR data were dated June 2008. A total of 2,940 water samples were analyzed for phosmet and 635 samples analyzed for phosmet oxon. There were two detections of phosmet (0.3 and 0.63 µg/L) and no detections of phosmet oxon. Both detections of phosmet were reported from two sites on the Alamo River in Imperial County on March 15, 1993.

3.2.4.d. Pesticides in Ground Water Data Base

The *Pesticides in Ground Water Data Base* (U.S. EPA 1992) shows one detection of phosmet (concentration not reported) in limited sampling in several States, including California, (307 wells sampled between 1979 and 1991). No detections of the phosmet oxon were found in three wells that were sampled.

3.3. Terrestrial Animal Exposure Assessment

3.3.1. Exposure to Residues in Terrestrial Food Items

T-REX (Version 1.3.1) is used to calculate dietary and dose-based EECs of phosmet for birds (including terrestrial-phase amphibians and reptiles), mammals, and terrestrial invertebrates. T-REX simulates a 1-year time period. T-HERPS may be used as a refinement for estimating EECs for amphibians when risk quotients from T-REX are higher than LOCs. For this assessment, spray applications of phosmet are considered. Terrestrial EECs were derived for the uses previously summarized in Table 2-3. Exposure estimates generated using T-REX and T-HERPS are for the parent alone.

Terrestrial EECs for foliar formulations of phosmet were derived for the uses summarized in Table 3-4. Data on interception and subsequent dissipation from foliar surfaces are available for phosmet, based on the work of Willis and McDowell (1987); foliar dissipation half-lives for the application of wettable powder formulations to alfalfa, peaches, corn, soybeans, and coastal bermuda grass range from 1.2 to 6.5 days. Previous assessments for phosmet (*e.g.*, USEPA, 2008) utilized a foliar dissipation half-life of 4 days to generate exposure estimates for terrestrial organisms using T-REX and T-HERPS. The 4 day value, which represents the 90^{th} percentile upper confidence bound on the mean of the foliar dissipation half-life data for phosmet in Willis and McDowell (1987), is used as an input for terrestrial exposure modeling in this assessment. Use-specific input values, including number of applications, application rate, and application interval, are provided in Table 3-4. An example output from T-REX and T-HERPS is available in Appendix E.

Table 3-4. Input Parameters Used to Derive Terrestrial EECs for Foliar Applications of Phosmet with T-REX and T-HERPS.

Use (Application method)	Application Rate (lbs a.i./A)	Number of Applications	Application Interval (days)
Alfalfa	0.75	9	30
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	5.95	2[1]	3
Apples, crabapples	4.0	4[2]	3
Apricots, cherries (tart), nectarines, peaches, plums, prunes	3.0	4	3
Blueberries	1.0	5	3
Christmas trees, pine trees, conifer and deciduous trees	1.0	3	14
Citrus	2.1	2	3
Grapes	1.5	3	3
Ornamentals	2.0	3	3
Pears	4.0	3	3
Peas	1.0	3	3
Potatoes, sweet potatoes	1.0	5	10

[1] The label permits up to five applications per year of phosmet to walnuts, filberts, and other nuts. However, given the maximum annual application rate of 12 lbs a.i./A, only two applications per year are permitted at the maximum single application rate of 5.95 lbs a.i./A.
[2] The maximum annual application rate of phosmet to apples and crabapples is 15.5 lbs a.i./A, although maximum single application rates and number of applications differ slightly for each. For modeling purposes, the use on apples is selected to represent both crops because it maximizes the single application rate (up to 4 lbs a.i./A, 4 times per year, not to exceed the annual maximum).

Organisms consume a variety of dietary items and may exist in a range of sizes at different life stages. T-REX estimates exposure based upon the following groups of dietary items: short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, and seeds for granivores. Birds and mammals may consume all of these items; however, the CTS is unlikely to consume items from the short grass, tall grass, and seed categories. The size classes of birds represented in T-REX are small (20 g), medium (100 g), and large (1000 g). The size classes for mammals are small (15 g), medium (35 g), and large (1000 g). As a conservative screen for the potential exposure of terrestrial-phase CTS to phosmet, EECs are calculated for the most sensitive size and dietary class of birds in T-REX (*i.e.*, 20 g bird consuming short grass), as a surrogate for amphibians. Refined EECs based on the consumption of small (*i.e.*, 15 g) herbivorous mammals are then calculated in T-HERPS. In addition, the potential for indirect effects to CTS through direct effects of exposure on prey items, including the most sensitive classes of small mammals (*i.e.*, 15 g mammal consuming short grass) and invertebrates (*i.e.*, small insects), are assessed,using EECs from T-REX.

3.3.1.a. Dietary Exposure to Terrestrial-Phase CTS (*i.e.*, Birds) and Other Amphibians (T-REX)

Direct effects to the terrestrial-phase CTS are assessed based upon EECs for a small bird (20g) consuming short grass, as a surrogate for amphibians (Table 3-5). Upper-bound Kenega nomogram values reported by T-REX are used in the derivation of dietary EECs. Based on the maximum application rates for phosmet, dietary-based EECs range from 181 mg a.i./kg diet (alfalfa) to 2,277 mg a.i./kg diet (nut trees), and dose-adjusted EECs range from 206 mg a.i./kg bw (alfalfa) to 2,593 mg a.i./kg bw (nut trees).

Table 3-5. Upper-Bound Kenega Nomogram EECs Used to Assess Direct Effects of Phosmet Exposure on Terrestrial-Phase CTS (*i.e.*, small bird consuming short grass, T-REX).

Uses	App. Rate (lbs a.i./A), # Apps., Interval (days)			California Tiger Salamander (bird consuming short grass)	
				Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw) for small bird (20 g)
Alfalfa	0.75	9	30	181	206
Almonds, filberts, pecans, pistachios, walnuts, other nut trees	5.95	2	3	2,277	2,593
Apples, crabapples	4.0	4	3	2,072	2,360
Apricots, cherries (tart), nectarines, peaches, plums, prunes	3.0	4	3	1,554	1,770
Blueberries	1.0	5	3	548	624
Christmas trees, pine trees, conifer and deciduous trees	1.0	3	14	263	300
Citrus	2.1	2	3	804	915
Grapes	1.5	3	3	701	799
Ornamentals	2.0	3	3	935	1,065
Pears	4.0	3	3	1,870	2,130
Peas	1.0	3	3	468	533
Potatoes, sweet potatoes	1.0	5	10	291	332

3.3.1.b. Dietary Exposure to Small Mammals

EECs for the most sensitive size and dietary category of small mammals (as prey of CTS) are calculated in T-REX and are presented in Table 3-6. Dietary-based EECs for a 15 g mammal consuming short grass range from 181 mg a.i./kg diet (alfalfa) to 2,277 mg a.i./kg bw (nut trees). Dose-adjusted EECs are slightly lower and range from 173 mg a.i./kg bw (alfalfa) to 2,171 mg a.i./kg bw (nut trees).

Table 3-6. Upper-Bound Kenaga Nomogram EECs Used to Assess Indirect Effects of Phosmet Exposure on Terrestrial-Phase CTS via Direct Effects on Small Mammals as Prey (T-REX).

Uses	App. Rate (lbs a.i./A), # Apps., Interval (days)			Mammals (consuming short grass)	
				Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw) for small mammal (15 g)
Alfalfa	0.75	9	30	181	173
Almonds, filberts, pecans, pistachios, walnuts, other nut trees	5.95	2	3	2,277	2,171

Uses	App. Rate (lbs a.i./A), # Apps., Interval (days)			Mammals (consuming short grass)	
				Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw) for small mammal (15 g)
Apples, crabapples	4.0	4	3	2,072	1,976
Apricots, cherries (tart), nectarines, peaches, plums, prunes	3.0	4	3	1,554	1,482
Blueberries	1.0	5	3	548	522
Christmas trees, pine trees, conifer and deciduous trees	1.0	3	14	263	251
Citrus	2.1	2	3	804	766
Grapes	1.5	3	3	701	669
Ornamentals	2.0	3	3	935	892
Pears	4.0	3	3	1,870	1,783
Peas	1.0	3	3	468	446
Potatoes, sweet potatoes	1.0	5	10	291	278

3.3.1.c. Exposure to Terrestrial Invertebrates

Because terrestrial invertebrates are a potential prey item of the CTS, dietary-based EECs for small insects (the more sensitive category of invertebrates in T-REX) exposed to phosmet are used as an upper-bound estimate of exposure for terrestrial invertebrates (Table 3-7). An example output from T-REX v. 1.3.1 is available in Appendix E. EECs for small insects range from 102 µg a.i./g (alfalfa) to 1,281 µg a.i./g (nut trees).

Table 3-7. Upper-Bound Kenaga Nomogram EECs Used to Estimate Risk to Terrestrial Invertebrates from California Uses of Phosmet (T-REX).

Use	Application Rate (lbs a.i./acre), # of app, App interval (days)			Small Insect EEC (ppm)
Alfalfa	0.75	9	30	102
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	5.95	2	3	1,281
Apples, crabapples	4.0	4	3	1,166
Apricots, cherries (tart), nectarines, peaches, plums, prunes	3.0	4	3	874
Blueberries	1.0	5	3	308
Christmas trees, pine trees, conifer and deciduous trees	1.0	3	14	148
Citrus	2.1	2	3	452
Grapes	1.5	3	3	395
Ornamentals	2.0	3	3	526
Pears	4.0	3	3	1,052
Peas	1.0	3	3	263
Potatoes, sweet potatoes	1.0	5	10	164

3.3.1.d. Dietary Exposure to Terrestrial-Phase CTS and Other Amphibians (T-HERPS)

Estimates of dietary exposure for terrestrial-phase CTS and for terrestrial-phase amphibians as potential prey items are based upon the use of birds as a surrogate. However, birds are homeotherms, indicating that their temperature is regulated, constant, and largely independent of environmental temperatures, whereas terrestrial-phase amphibians are poikilotherms, indicating that their body temperature varies with environmental temperature. As a consequence, the average caloric requirements of terrestrial-phase amphibians are markedly lower than those of birds. On a daily dietary intake basis, birds consume more food than terrestrial-phase amphibians. This can be seen when comparing the caloric requirements, represented by the free-living metabolic rate (FMR), of the free living iguanid lizard (used as a surrogate for poikilotherms, including amphibians) to song birds (USEPA, 1993):

$$\text{iguanid FMR (kcal/day)} = 0.0535\ (\text{bw g})^{0.799}$$

$$\text{passerine FMR (kcal/day)} = 2.123\ (\text{bw g})^{0.749}$$

With relatively comparable slopes to the allometric functions, when given a comparable body weight, the FMR of birds can be 40 times higher than the iguanid lizard and therefore terrestrial-phase amphibians. The differences diminish with high body weights. Because the existing risk assessment process for terrestrial animals is driven by the dietary route of exposure, a finding of safety for birds, with their much higher feeding rates and therefore higher potential dietary exposure, is reasoned to be protective of terrestrial-phase amphibians. Although there are no dietary toxicity studies for terrestrial-phase amphibians exposed to phosmet, based on these calculations, terrestrial-phase amphibians would have to be 40 times more sensitive than birds for the differences in dietary uptake to be negated.

To quantify the potential differences in food intake between birds and poikilotherms, *i.e.*, reptiles and terrestrial-phase amphibians, the food intake equations for the iguanid lizard were used to replace the food intake equation in T-REX for birds and presented in a model called T-HERPS (available at http://www.epa.gov/oppefed1/models/terrestrial/index.htm). Dietary items beyond those addressed in T-REX are assessed, including small mammals, reptiles, and amphibians. In the case of phosmet, the refined EECs for terrestrial-phase CTS and for terrestrial-phase amphibians as prey items are are calculated using T-HERPS and are shown in Table 3-8. Potential risk is discussed in the risk characterization.

Input parameters for terrestrial exposure modeling with T-HERPS were the same as those for T-REX with respect to both application rates and intervals (see Table 3-4) and the foliar dissipation half-life (estimated at four days). T-HERPS calculates EECs and associated RQs for three size classes of amphibians: 2 g , 20 g, and 200 g. Terrestrial-phase CTS range from approximately 14 g to 80 g (Trenham *et al*., 2000); therefore, EECs are presented for the 20 g amphibian. Dietary items in T-HERPS that are relevant to the terrestrial-phase CTS and other amphibians include small and large insects, small herbivorous and insectivorous mammals, and amphibians; EECs and RQs are presented for the dietary class most sensitive to phosmet exposure (small herbivorous mammals). Further discussion of potential exposure relative to feeding strategy is presented in the Uncertainties section (6.1.4). It is unlikely that an individual amphibian, including the CTS, would consume a single prey item (*i.e.*, small mammal or amphibian) that is larger-than-self; therefore, this assessment relies upon the default assumption in T-HERPS that the maximum prey size for an amphibian is 2/3 of the amphibian's mass (*i.e.*, 13.3 g) (*e.g.*, Cook, 1997).

Dose-based adjustments in T-HERPS result in EECs that are lower than the purely dietary-based values for the consumption of small herbivorous mammals. Dietary-based EECs for terrestrial-phase CTS and amphibians as prey items range from 182 mg a.i./kg diet (alfalfa) to 2,285 mg a.i./kg diet (nut trees). Dose-based EECs range from 121 mg a.i./kg bw (alfalfa) to 1,524 mg a.i./kg bw (nut trees).

Table 3-8. Upper-Bound Kenaga Nomogram EECs for Dietary- and Dose-Based Exposures of Terrestrial-Phase CTS from California Uses of Phosmet (T-HERPS)

Use(s)	App. Rate (lbs a.i./A), # Apps., Interval (days)			EECs for CTS (consuming herbivorous mammals)	
				Dietary-Based (mg/kg-diet)	Dose-Based (mg/kg-bw) for 20 g CTS
Alfalfa	0.75	9	30	182	121
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	5.95	2	3	2,285	1,524
Apples, crabapples	4.0	4	3	2,080	1,386
Apricots, cherries (tart), nectarines, peaches, plums, prunes	3.0	4	3	1,560	1,040
Blueberries	1.0	5	3	550	367
Christmas trees, pine trees, conifer and deciduous trees	1.0	3	14	264	176
Citrus	2.1	2	3	807	538
Grapes	1.5	3	3	704	469
Ornamentals	2.0	3	3	939	626
Pears	4.0	3	3	1,877	1,251
Peas	1.0	3	3	469	313
Potatoes, sweet potatoes	1.0	5	10	293	195

App.=Application

3.4. Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.1.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. EECs relevant to terrestrial plants consider pesticide concentrations in spray drift and in runoff. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method (Table 3-4). For aerial application methods, the spray drift fraction is determined according to buffer requirements on the labels for the assessed uses (see Section 3). A runoff fraction of 0.02 is utilized based on phosmet's solubility, which is classified by TerrPlant as 10 to 100 mg/L. These EECs are listed by use in Table 3-9. An example output from TerrPlant v.1.2.2 is available in Appendix F. It should be noted that EECs for the exposure of non-target terrestrial plants are based upon labeled application methods, maximum single application rates, and chemical properties of phosmet; however, RQ values for phosmet exposure are not calculated in the Risk Estimation because phytotoxicity data specific to phosmet are unavailable. Potential risks to terrestrial plants based on the estimated exposures of phosmet are discussed in the Risk Description (see Section 5.2.2).

Table 3-9. TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Phosmet via Runoff and Drift[1]

Use	Application rate (lbs a.i./A)	Drift Value (%)[3]	Spray drift EEC (lbs a.i./A)	Dry area EEC (lbs a.i./A)	Semi-aquatic area EEC (lbs a.i./A)
Alfalfa	0.75	4	0.03	0.05	0.18
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	5.95	72	4.28	4.40	5.47
Apples, crabapples	4.0	14	0.56	0.64	1.36
Apricots, cherries (tart), nectarines, peaches, plums, prunes	3.0	47	1.41	1.47	2.01
Blueberries	1.0	10	0.10	0.12	0.30
Christmas trees, pine trees, conifer and deciduous trees[2]	1.0	7	0.07	0.09	0.27
Citrus	2.1	12	0.25	0.29	0.67
Grapes	1.5	0.3	<0.01	0.03	0.30
Ornamentals	2.0	2	0.04	0.08	0.44
Pears	4.0	22	0.88	0.96	1.68
Peas	1.0	4	0.04	0.06	0.24
Potatoes, sweet potatoes	1.0	2	0.02	0.04	0.22

1 Only aerial spray results are shown because ground spray is expected to result in less spray drift and therefore lower EECs. Ground spray is permitted according to the product label but is considered, for orchard uses, to be less likely than aerial blast.
2 Forestry, nursery, and ornamental applications differ appreciably from agricultural uses and are addressed qualitatively in the Risk Description.
3 Spray drift fraction calculations for aerial and air blast applications of phosmet are based on label-specific spray drift buffers and are described in Section 2.4.3 (Use Characterization).

4. Effects Assessment

This assessment evaluates the potential for phosmet to directly or indirectly affect CTS 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. Direct effects to the aquatic-phase CTS are based on toxicity information for freshwater fish, while terrestrial-phase amphibian effects are based on avian toxicity data, given that birds are generally used as a surrogate for terrestrial-phase amphibians and reptiles.

As described in the Agency's Overview Document (USEPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater fish (used as a surrogate for aquatic-phase amphibians), freshwater invertebrates, birds (used as a surrogate for terrestrial-phase amphibians), mammals, and terrestrial invertebrates. Acute (short-term) and chronic (long-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on phosmet. Aquatic and terrestrial plants are not evaluated in the risk estimation because phytotoxicity data specific to phosmet are unavailable; however, potential effects to these taxonomic groups are characterized in the Risk Description based on estimated phosmet exposures and the available phytotoxicity data for other organophosphate insecticides. The surrogate toxicity endpoints described in the Risk Description for aquatic and terrestrial plants are obtained from tests with naled and profenofos, respectively, because they provide the lowest available toxicity values for the organophosphate insecticides.

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 the USEPA Reregistration Eligibility Decision (RED) for phosmet (USEPA, 2006b) as well as ECOTOX information obtained on February 22, 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, EC_{50}, *etc.*), but rather are intended to identify a dose that maximizes a particular effect (*e.g.*, EC_{100}). Therefore, efficacy data and non-efficacy toxicological target insect data are not included in the ECOTOX open literature summary table provided in Appendix I. 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 I. The list of citations including toxicological and/or efficacy data on target insect species not considered in this assessment is provided in Appendix H.

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 open literature that were not considered as part of this assessment are included in Appendix H**.** Open literature studies may have been excluded because they were rejected by the ECOTOX or OPP screens or because they were accepted but were not useful for risk assessment purposes (*e.g*., less sensitive endpoint). The rationale for the exclusion of specific open literature studies reviewed by ECOTOX is provided in Appendix H.

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

In addition to registrant-submitted and open literature toxicity information, other sources of information, including both the use of an acute probit dose-response relationship to establish the probability of effects and reviews of ecological incident data, are considered to further refine the characterization of potential ecological effects associated with exposure to phosmet. A summary of the available aquatic and terrestrial ecotoxicity information and the incident information for phosmet are provided in Sections 4.1 through 4.4.

Toxicity effects data for the phosmet oxon are unavailable in the ECOTOX open literature as of February 2010, although effects data for oxon degradates of other organophosphate chemicals indicate that it may be up to 100 times more toxic than parent phosmet (USEPA, 2006a). This data gap, compounded with uncertainty regarding the environmental fate of the phosmet oxon, presents uncertainty in evaluating the potential exposure and effects of the phosmet oxon for CTS. No multi-a.i. products containing phosmet are registered and toxicity data are not available for phosmet mixtures with other pesticides.

4.2. Toxicity of Phosmet to Aquatic Organisms

Table 4-1 summarizes the most sensitive aquatic toxicity endpoints for CTS, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A summary of submitted and open literature data considered relevant to this ecological risk assessment for the CTS is presented below and in Appendix G. All endpoints are expressed in terms of the active ingredient (a.i.) unless otherwise specified.

Table 4-1. Freshwater Aquatic Toxicity Profile for Phosmet

Assessment Endpoint	Species	Endpoint[1]	Concentration (mg a.i./L)	Classification, Reference (*e.g.*, MRID)	Effects
Direct Toxicity to Aquatic-Phase CTS	Bluegill Sunfish (*Lepomis macrochirus*)	Acute 96-hr LC_{50}	0.07	Acceptable 00063194	Mortality
	Bluegill Sunfish (*Lepomis macrochirus*)	Chronic NOAEC	0.001	ACR[3] Rainbow Trout	Reduction in growth
Indirect Toxicity to Aquatic-Phase CTS via Toxicity to Freshwater Invertebrates (*i.e.* prey items)	Scud (*Gammarus fasciatus*)	Acute 96-hr EC_{50}	0.002	Supplemental: Raw data not reported 00063193	Mortality
	Scud (*Gammarus fasciatus*)	Chronic NOAEC	0.0003	ACR[4] Waterflea	Reduced growth and number of offspring
Indirect Toxicity to Aquatic-Phase CTS via Toxicity to Aquatic Plants[2]	NA	NA	NA	NA	NA

[NA] Not available.
[1] The ecotoxicology studies did not contain sufficient information to determine slope-response relationships for probit analysis. A default slope of 4.5 (95% CI 2.0 – 7.0) is assumed for all taxa assessed.
[2] No toxicity data were available for aquatic vascular and non-vascular plants exposed to phosmet. Phytotoxicity data for other organophosphate insecticides and the implications for potential risks associated with phosmet use are discussed in the Risk Description.
[3] Acute-to-chronic ratio (ACR) based on toxicity to rainbow trout: *LC_{50} (0.23 mg a.i./L) / NOAEC (0.00032 mg a.i./L) = ACR (71.9).* Estimated chronic endpoint for bluegill sunfish, based on rainbow trout ACR: *LC_{50} (0.07 mg a.i./L) / ACR (71.9) = NOAEC (0.001 mg a.i./L).*
[4] Waterflea ACR: EC_{50} (0.006 mg a.i./L) / NOAEC (0.0008 mg a.i./L) = ACR (7.5). Estimated chronic endpoint for scud, based on waterflea ACR: EC_{50} (0.002 mg a.i./L) / ACR (7.5) = NOAEC (0.0003 mg a.i./L).

Toxicity to fish and aquatic invertebrates is categorized using the system shown in Table 4-2 (USEPA, 2004). Toxicity categories for aquatic plants have not been defined.

Table 4-2. Categories of Acute Toxicity for Fish and Aquatic Invertebrates

Toxicity Category	LC_{50} (ppm)
Very highly toxic	< 0.1
Highly toxic	> 0.1 - 1
Moderately toxic	> 1 - 10
Slightly toxic	> 10 - 100
Practically nontoxic	> 100

4.2.1. Toxicity to Freshwater Fish and Aquatic-Phase Amphibians

Given that no guideline phosmet toxicity data are available for aquatic-phase amphibians, freshwater fish data were used as a surrogate to estimate direct acute and chronic risks to CTS. Freshwater fish toxicity data were also used to assess potential indirect effects of phosmet to CTS. Effects to freshwater fish resulting from exposure to phosmet could indirectly affect CTS via reduction in available food. As shown in Table 2-6, a portion of the prey mass of CTS may consist of vertebrates such as mice, frogs, and fish. A summary of acute and chronic freshwater fish data are included in Sections 4.2.1.a through 4.2.1.c.

4.2.1.a. Freshwater Fish: Acute Exposure (Mortality) Studies

There are several reviewed studies that have evaluated the acute toxicity of phosmet technical to freshwater fish. Based on reported study results, 96-hr LC_{50}s ranged from 0.07 mg a.i./L for bluegill sunfish (*Lepomis macrochirus*) to 11.0 mg a.i./L for channel catfish (*Ictalurus punctatus*) (MRID 00063194). Since the LC_{50} values ranged from 0.07 - 11.0 mg a.i./L, phosmet technical is classified as slightly toxic to very highly toxic to freshwater fish on an acute exposure basis. The lowest LC_{50} from a guideline rainbow trout (*Oncorhynchus mykiss*) study is 0.23 mg a.i./L (MRID 00109135), but the more sensitive endpoint, i.e., bluegill sunfish 96-hr LC_{50} of 0.07 mg a.i./L, is used for RQ calculation (MRID 00063194). In the absence of slope-response data for bluegill sunfish, a default value of 4.5 (± 2.5) is used in probit analysis to determine the likelihood of individual effects to freshwater fish and terrestrial-phase amphibians.

No studies with freshwater fish exposed to currently registered formulated phosmet products are available.

4.2.1.b. Freshwater Fish: Chronic Exposure (Growth/Reproduction) Studies

A fish early life stage (ELS) study is available to evaluate the chronic toxicity of phosmet to rainbow trout (MRID 40938701). The NOAEC is 0.0032 mg/L, based on a 4% reduction in 35-day post-hatch growth at the LOAEC (0.006 mg/L). The reduction in growth (length) persisted through 60-days post-hatch, the last measured time-step. Growth was reduced by 15% 35-day post-hatch at the highest concentration tested (0.051 mg/L). Fry survival was reduced 7% at 0.012 mg/L 35-day post-hatch.

For RQ calculation, an acute-to-chronic ratio (ACR) from toxicity studies with the rainbow trout is used to derive a chronic endpoint for bluegill sunfish, the more acutely sensitive species, as follows:

Rainbow Trout	*LC_{50} (0.23 mg a.i./L) / NOAEC (0.00032 mg a.i./L) = ACR (71.9)*
Bluegill Sunfish	*LC_{50} (0.07 mg a.i./L) / ACR (71.9) = NOAEC (0.001 mg a.i./L)*

The resulting estimated NOAEC (0.001 mg a.i./L) for bluegill sunfish is used as the assessment endpoint for chronic risk to freshwater fish and aquatic-phase amphibians.

4.2.1.c. Freshwater Fish: Sublethal Effects and Additional Open Literature Information

Data from a guideline study evaluating the toxicity of phosmet (Imidan) to freshwater fish and invertebrates (MRID 00063194) were published by Julin and Sanders (1977); the paper was accepted by ECOTOX and was classified as acceptable (upgraded from supplemental) according to OPP guidelines in 1991. The authors reported two additional rainbow trout 24-hr LC_{50} values, equal to approximately 0.75 mg a.i./L, and a channel catfish 24-hr LC_{50} = 13 mg a.i./L.

Subacute toxicity tests with Atlantic salmon (*Salmo salar*) yolk-sack larvae (YSL) exposed to phosmet reported statistically significant effects on mortality, growth, and physiological endpoints at concentrations ranging from 0.00085 mg a.i./L to 0.008 mg a.i./L (Nieves-Puigdoller, 2007; MRID 47988201, supplemental). Exposure of YSL to phosmet for 12 days at 0.008 mg a.i./L resulted in an 80% decrease in cholinesterase level and an increase in whole larvae protein content, as compared to controls (NOAEC < 0.008 mg a.i./L). Exposure at this level was associated with decreased opercular movement, reduced length and weight, and increased yolk sac size. Effects on mortality were not reported.

In a 21-day toxicity test (Nieves-Puigdoller, 2007; supplemental), exposure of YSL to phosmet at 0.00085 mg a.i./L significantly decreased cholinesterase and increased whole-larvae moisture content (NOAEC < 0.00085 mg a.i./L). Phosmet exposure at 0.0044 mg a.i./L resulted in 80% reduction in cholinesterase and statistically significant mortality (12%); however, it was not reported at what point in the study mortality occurred (NOAEC < 0.0044 mg a.i.L). Fulton and Key (2001) note that mortality in estuarine fish exposed to organophosphorous pesticides has been correlated with 70-90% inhibition of cholinesterase activity; it is uncertain whether equivalent effects occur in freshwater systems. Although both the 12-day and 21-day phosmet exposures resulted in the same level of cholinesterase inhibition (80%), effects on mortality in the 12-day study were not reported. Additional sublethal effects at 0.0044 mg a.i./L included decreased sodium and potassium ion and ATPase activity, decreased opercular movement, and increased moisture content.

Although a definitive NOAEC could not be established in the subacute toxicity tests with Atlantic salmon YSL, the LOAEC (0.00085 mg a.i./L) for physiological effects is similar to the chronic, ACR-derived endpoint for freshwater fish (NOAEC = 0.001 mg a.i./L). However, for the purposes of this assessment, the endpoints for physiological effects are not appropriate for RQ calculation because a direct link has not been established between the sublethal effects noted and effects on survival, growth, and reproduction. Additionally, an LC_{50} for Atlantic salmon YSL was not established within the range of concentrations tested, although mortality to Atlantic salmon YSL occurred at a lower concentration (LOAEC = 0.0044 mg a.i./L) than the LC_{50} for freshwater fish (0.070 mg a.i./L, bluegill).

No additional data are available in ECOTOX on either the acute or chronic toxicity of phosmet to freshwater fish.

4.2.1.d. Aquatic-Phase Amphibians: Acute and Chronic Studies

No registrant-submitted or ECOTOX data are available on either the acute or chronic toxicity of phosmet to aquatic-phase amphibians.

4.2.2. Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data are used to assess potential indirect effects of phosmet to CTS. Effects to freshwater invertebrates resulting from exposure to phosmet could indirectly affect CTS via reduction in available food items. As shown in Table 2-6, the diets of juvenile and adult tiger salamanders in the aquatic environment are comprised largely of aquatic invertebrates found in benthos and in the water column, including (but not limited to) caddis fly larvae, fairy shrimp, and copepods.

A summary of acute and chronic freshwater invertebrate data, including available data published in the open literature, is provided below in Sections 4.2.2.a through 4.2.2.c.

4.2.2.a. Freshwater Invertebrates: Acute Exposure Studies

There are two studies on the acute toxicity of phosmet to freshwater aquatic invertebrates. The 96-hour EC_{50} for the scud (*Gammarus fasciatus*) is 0.002 mg a.i./L (MRID 00063193, supplemental) and the EC_{50} for waterfleas (*Daphnia magna*) is 0.006 mg a.i./L (MRID 4004602, acceptable), resulting in phosmet being classified as very highly toxic to freshwater invertebrates on an acute exposure basis. No additional acute data are available on sublethal effects to aquatic invertebrates.

No acute toxicity studies with freshwater invertebrates exposed to currently registered formulated phosmet products are available.

4.2.2.b. Freshwater Invertebrates: Chronic Exposure Studies

In a flow-through life-cycle test with *D. magna* (MRID 40652801, acceptable), phosmet reduced the growth of daphnid adults (6%) and the mean number of offspring (27%) at exposure concentrations as low as 0.001 mg a.i./L (NOAEC = 0.0008 mg a.i./L).

For RQ calculation, an acute-to-chronic ratio (ACR) from toxicity studies with the waterflea is used to derive a chronic endpoint for the scud, the more acutely sensitive species, as follows:

Waterflea *EC_{50} (0.006 mg a.i./L) / NOAEC (0.0008 mg a.i./L) = ACR (7.5)*

Scud *EC_{50} (0.002 mg a.i./L) / ACR (7.5) = NOAEC (0.0003 mg a.i./L)*

The resulting estimated NOAEC (0.0003 mg a.i./L) for scud is used as the assessment endpoint for chronic risk to freshwater invertebrates.

4.2.2.c. Freshwater Invertebrates: Open Literature Data

Acceptable data evaluating the toxicity of phosmet to the aquatic sowbug (*Asellus brevicaudus*) and the scud (*Gammerus pseudolimnaeus*) are available in Julin and Sanders (1977). The reported 48-hr LC_{50} values are 0.1 mg a.i./L for the sowbug and 0.0024 mg a.i./L for the scud.

4.2.3. Toxicity to Aquatic Plants

Primary productivity is essential for maintaining the health of the ecosystem and therefore for promoting the growth and abundance of CTS. In addition, aquatic plants may serve as forage of larval CTS, and vascular aquatic plants provide refuge and structure necessary for attachment of egg masses. Phytotoxicity data specific to the effects of phosmet on aquatic plants are unavailable. In the absence of data, risks to aquatic plants cannot be precluded. The Risk Description addresses the available toxicity data for organophosphate insecticides (summarized below) and the implications of these data for risk to aquatic plants, based on estimated exposures from California use patterns for phosmet.

4.2.3.a. Vascular Aquatic Plants

Neither guideline laboratory studies nor open literature data are available to determine whether phosmet may cause direct effects to aquatic vascular plants. Toxicity data are available for four organophosphate insecticides (naled, fenthion, isazofos, and sulprofos) from tests with duckweed (*Lemna gibba*); only three of four tests (naled, fenthion, and isazofos) were performed with the technical grade of the active ingredient. Furthermore, none of the tests with the technical grade a.i. yielded a definitive $EC_{50.}$ Given the paucity of data, the lowest NOAEC (naled,1.8 mg a.i./L) is used in the Risk Description to characterize the potential for effects on aquatic vascular plants from phosmet exposure (MRID 42529601, supplemental). No adverse effects were observed in the study with naled, and the NOAEC was equal to the highest concentration in the test. Adverse effects were observed in the studies with fenthion (NOAEC = 2.8 mg a.i./L, MRID 40186714), isazofos (NOAEC = 56 mg a.i./L, MRID 00119013), and sulprofos (NOAEC = 26.3 mg a.i./L, formulated product; MRID 46000702). However, phosmet may be more toxic or less toxic than these pesticides.

4.2.3.b. Non-Vascular Aquatic Plants

There are no laboratory studies evaluating the effects of phosmet on nonvascular aquatic plants. However, ecotoxicity data for nonvascular plants exposed to 15 other organophosphate insecticides and acaricides include EC_{50} values that are generally greater than 1.0 mg a.i./L.

EC_{50} values for two chemicals (naled and chlorpyrifos) are below that threshold. Results from toxicity testing with naled range from 0.012 mg a.i./L for diatoms (*Navicula pellicosa*) to 0.64 mg a.i./L for bluegreen algae (*Anabaena flos-aquae*); the mean EC_{50} value for freshwater, nonvascular species is 0.224 mg a.i./L (MRIDs 42529603 – 05). The EC_{50} for diatoms (*Thalassiosira* sp.) exposed to chlorpyrifos is 0.15 mg a.i./L (MRID 40228401).

In the absence of toxicity data for phosmet, the EC_{50} (0.012 mg a.i./L) for diatoms exposed to naled (MRID 42529603, acceptable) is used in the Risk Description to characterize the potential for phosmet effects on nonvascular plants, because it provides the most sensitive endpoint for the organophosphate insecticides tested. The actual potential for adverse effects to nonvascular aquatic plants may be lower, given that a QSAR (Quantitative Structural-Activity Relationship) model yielded a higher EC_{50} of 2.2 mg a.i./L for green algae exposed to phosmet (ECOSAR, 2008). Additionally, phosmet may be more toxic or less toxic than naled and the other organophosphate pesticides.

4.2.4. Aquatic Field/Mesocosm Studies

No freshwater field or mesocosm studies are available for phosmet.

4.3. Toxicity of Phosmet to Terrestrial Organisms

Table 4-3 summarizes the most sensitive terrestrial toxicity endpoints for CTS, 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 G.

Table 4-3. Terrestrial Toxicity Profile for Phosmet

Assessment Endpoint	Species	Endpoint[1]	Concentration	Classification, Reference (*e.g.*, MRID)	Effects
Direct Toxicity to Terrestrial-Phase CTS	Mallard duck (*Anas platyrhynchos*)	Acute 24-hr LD_{50}	>2000 mg/kg bw	Acceptable 00084460	Mortality
	Bobwhite Quail (*Colinus virginianus*)	(Sub)acute 8-day LC_{50}	501 mg/kg diet	Acceptable 00022923	Mortality
Direct Toxicity to Terrestrial-Phase CTS	Mallard Duck (*Anas platyrhyncho*) Bobwhite Quail (*Colinus virginianus*)	Chronic NOAEC LOAEC	60 mg/kg diet 150 mg/kg diet	Acceptable 00125786 00105999	Reduction in number of eggs and viable 14-day old chicks

Assessment Endpoint	Species	Endpoint[1]	Concentration	Classification, Reference (*e.g.*, MRID)	Effects
Indirect Toxicity to Terrestrial-Phase CTS (via toxicity to mammalian prey items)	Laboratory Rat (*Rattus norvegicus*)	Acute 96-hr LD_{50}	113 mg/kg bw	Acceptable 0046189	Mortality
	Laboratory Rat (*Rattus norvegicus*)	Chronic NOAEC LOAEC	1.5 mg/kg/day 6.1 mg/kg/day	Acceptable 41520001	Reductions in adult body weight, number of live pups per litter, and pup body weight
Indirect Toxicity to Terrestrial-Phase CTS (via toxicity to terrestrial invertebrate prey items)	Honey Bee (*Apis mellifera*)	Acute 48-hr LD_{50}	1.1 µg/bee	Acceptable 00066220	Mortality
Indirect Effects to Terrestrial- and Aquatic-Phase CTS (via toxicity to terrestrial plants)[2]	Monocots	NA	NA	NA	NA
	Dicots				

NA = Not available
bw = body weight
[1] Insufficient information was available from the ecotoxicity studies to determine slope-response relationships for probit analysis. A default slope of 4.5 (95% CI 2.0 – 7.0) is assumed for all taxa assessed.
[2] No toxicity endpoints were available for the effects of phosmet on terrestrial plants. The potential for effects on terrestrial plants is characterized in the Risk Description, based on estimated exposures from California uses of phosmet and the available toxicity data for other organophosphate insecticides.

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

Table 4-4. Categories of Acute Toxicity for Avian and Mammalian Studies

Toxicity Category	Oral LD_{50} (mg/kg)	Dietary LC_{50} (ppm)
Very highly toxic	< 10	< 50
Highly toxic	10 – 50	50 – 500
Moderately toxic	51 – 500	501 – 1000
Slightly toxic	501 – 2000	1001 – 5000
Practically non-toxic	> 2000	> 5000

4.3.1. Toxicity to Birds (and Terrestrial-Phase Amphibians)

As specified in the Overview Document, the Agency uses birds as a surrogate for reptiles and terrestrial-phase amphibians when toxicity data for each specific taxon are not available (USEPA, 2004). Because no guideline or open-literature studies are available that specifically evaluate the effects of phosmet on terrestrial-phase amphibians, a summary of the most sensitive endpoints from acute and chronic guideline studies with birds is provided below in Sections

4.3.1.a through 4.3.1.b. No more sensitive avian endpoints or sublethal effects data are available in the open literature.

4.3.1.a. Birds: Acute Exposure (Mortality) Studies

Only one avian acute oral toxicity test, classified as acceptable, is available to evaluate the effect of phosmet on birds (MRID 00084460). A limit study with the mallard duck (*Anas platyrhynchos*) resulted in an LD_{50} of > 2000 mg a.i./kg bw; therefore, phosmet is classified as practically nontoxic to birds on an acute oral exposure basis. Sublethal effects at the limit dose included lethargy, wing droop and loss of coordination.

Subacute dietary toxicity tests with the ring-necked pheasant (*Phasianus colchicus*), bobwhite quail (*Colinus virginianus*), and mallard duck exposed to technical grade phosmet resulted in LC_{50} values ranging from 501 to > 5000 mg a.i./kg diet (MRID 00022923, acceptable). Given these values, phosmet ranges from practically nontoxic to moderately toxic to birds on a subacute dietary exposures basis,. The most sensitive endpoint, the bobwhite quail LC_{50} = 501 mg/kg diet, is used to evaluate potential risk to the terrestrial-phase CTS.

No acute toxicity studies with birds exposed to currently registered formulated products are available.

4.3.1.b. Birds: Chronic Exposure (Growth, Reproduction) Studies

Two acceptable avian reproduction studies are available with bobwhite quail and mallard duck exposed to phosmet technical (MRIDs 00125786 and 00105999). For both species, dietary exposure to phosmet was associated with 17 to 30% reductions in number of eggs produced at 150 mg a.i./kg diet (LOAEC, the highest dose tested), with a NOAEC of 60 mg a.i./kg diet. Bobwhite quail treated with 150 mg a.i./kg diet produced significantly fewer viable 14-day old chicks. Pathological examination revealed a dose-dependent decrease in gall bladder fluid of treated bobwhite quail; a greater proportion of females were affected than males.

4.3.2. Toxicity to Mammals

A summary of acute and chronic mammalian data, including available data published in the open literature, is provided below in Sections 4.3.2.a through 4.3.2.b. A more complete analysis of toxicity data to mammals is available in Appendix J, which is a copy of the Health Effects Division (HED) chapter prepared in support of the reregistration eligibility decision completed in 2006.

4.3.2.a. Mammals: Acute Exposure (Mortality) Studies

A summary of endpoints from the Health Effects Division (HED) risk assessment (Appendix G) indicates an acute oral LD_{50} for rats (*Rattus norvegicus*) dosed with phosmet is 113 mg/kg-bw (MRID 0046189, acceptable). Therefore, phosmet is classified as moderately toxic to mammals on an acute oral exposure basis.

4.3.2.b. Mammals: Chronic Exposure (Growth, Reproduction) Studies

A summary of endpoints from the HED risk assessment for a 2-generation reproduction study in rats indicated phosmet caused effects on adult body weights and fertility, i.e., live pups/litter and decreased pup weight at exposures at the LOAEC, 6.1 mg a.i./kg/day, with a corresponding NOAEC = 1.5 mg a.i./kg/day (MRID 41520001, acceptable).

4.3.3. Toxicity to Terrestrial Invertebrates

Terrestrial invertebrate toxicity data are used to assess potential indirect effects of phosmet to terrestrial-phase CTS; effects to terrestrial invertebrates resulting from exposure to phosmet could also indirectly affect the CTS via reduction in available food. A summary of acute terrestrial invertebrate data, including data published in the open literature, is provided below in Sections 4.2.3.1 through 4.2.3.2.

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

Phosmet is characterized as highly toxic to terrestrial insects based on a honeybee (*Apis mellifera*) acute contact LD_{50} of 1.1 μg/bee (MRID 00066220, acceptable). For the purposes of this assessment, the honeybee endpoint is used to derive RQs for terrestrial invertebrates (*e.g.*, insects). This toxicity value is converted to units of μg a.i./g (of bee) by multiplying by 1 bee/0.128 g (Mayer and Johansen, 1990), thereby resulting in an LD_{50} = 8.59 μg a.i./g.

4.3.3.b. Terrestrial Invertebrates: Open Literature Studies

There are no more sensitive data on the toxicity of phosmet to terrestrial invertebrates in the open literature available through ECOTOX. However, most of the reported incidents with phosmet involved honey bee mortality, as discussed in Section 4.4.1

4.3.4. Toxicity to Terrestrial Plants

There are no guideline studies available to evaluate the potential toxicity of phosmet to terrestrial plants. Based on label warnings against application of phosmet to sweet cherries due to a phytotoxic effect (premature leaf drop), some adverse effects to terrestrial plants may occur.

Minimal data are available in the open literature regarding toxicity of phosmet to terrestrial plants. The available data are generally from efficacy studies; although these studies may pass the ECOTOX screen, they do not meet the OPP/EFED requirements for quantitative use in risk assessments. Hagley (1983) reports a NOAEC for fruit set on apples (*Malus* spp.) of 1.12 lbs a.i./A. McLeod *et al.* (1993). report a NOAEC of 1.0 lb - 70 - a.i./A for alfalfa (*Medicago sativa*) in a study of weevil control. In each of these cases, the reported NOAEC is the highest rate applied, which is lower than the maximum allowable single application rate of 5.95 lbs a.i./A. Phytotoxic effects may occur at higher rates than those tested.

Some chemicals that can be classified as organophosphate pesticides, such as glyphosate and glufosinate, are registered herbicides. In addition, the organothiophosphate insecticide and acaricide profenofos is known to have phytotoxic effects. In tests for the effects of profenofos on seedling emergence in cucumber (*Cucumis sativus*), cabbage (*Brassica oleracea*), and lettuce (*Lactuca sativa*), definitive EC_{25} values ranged from 0.13 lbs a.i./A to 0.27 lbs a.i./A (MRID 41627307, acceptable).

The Pesticide Ecotoxicity Database (PED) contains additional phytotoxicity data on the organophosphates diazinon, disulfoton, fosthiazate, and isofenfos. Most of the EC_{25} values reported for these pesticides exceeded the highest concentration tested. Diazinon has reported EC_{25} values of > 5.3 lbs a.i./A for 6-day seedling emergence study on oat (*Avena sativa*), carrot (*Daucus carota*) and tomato (*Lycopersicon esculentum*), as well as vegetative vigor EC_{25} values of > 3.2 lbs a.i./A for carrot, tomato, onion (*Allium cepa*), lettuce, and cucumber. Reported EC_{25} values for disulfoton on the seedling emergence of nine species are > 1.9 lbs a.i./A as well as vegetative vigor EC_{25} values for corn (*Zea mays*; > 2.4 lbs a.i./A) and onion (> 2.4 lbs a.i./A). The EC_{25} values for fosthiazate seedling emergence on multiple species is > 6.0 lbs a.i./A. The vegetative vigor EC_{25} values for fosthiazate effects to radish (*Raphanus sativus*) and two sorghum species (*Sorghum bicolor* and *S. halepense*) are > 6.0 lbs a.i./A, while EC_{25} values for buckwheat, pepper (*Capsicum frutescens*) and cucumber are > 3.3 lbs a.i./A. Reported EC_{25} values for isofenphos for seedling emergence and vegetative vigor in multiple species were greater than 2.0 lbs a.i./A, with the following exception. Two species were more sensitive in vegetative vigor tests with disulfoton and isofenphos, respectively, and tests resulted in non-definitive EC_{25} values that were below the lowest concentration tested: for buckwheat (*Fagopyrum esculentum*) exposed to disulfoton (EC_{25} < 2.4 lbs a.i./A) and for onion exposed to isofenphos (EC_{25} < 2.0 lbs a.i./A).

In the absence of phytotoxicity data that are specific to phosmet and suitable for Risk Estimation, risk to terrestrial plants cannot be precluded. The potential for risk is characterized in the Risk Description, based on phosmet use patterns and the definitive endpoint for profenofos (seedling emergence EC_{25} = 0.13 lbs a.i./A), the only organothiophosphate for which there are data. However, phosmet may be more toxic or less toxic than profenofos and the other organophosphate pesticides.

In addition to the uncertainties described above, commercial crop species have been selectively bred and may be more or less resistant to particular stressors than wild herbs and forbs. The direction of this uncertainty for specific plants and stressors, including phosmet, is largely unknown. For example, homogenous test plant seed lots lack the genetic variation that occurs in natural populations, so the range of effects seen from tests may be smaller than would be expected in wild populations. Conversely, deliberate or incidental development of resistance in agricultural crop varieties may correspond with decreased sensitivity to pesticide (*e.g.* phosmet) exposure, as compared to wild populations.

4.4. Toxicity of Chemical Mixtures

No toxicity data are available for mixtures of phosmet with other pesticide active ingredient. No phosmet products with multiple active ingredients are presently registered.

4.5. Incident Database Review

A review of the Ecological Incident Information System (EIIS, version 2.1), the 'Aggregate Incident Reports' (v. 1.0) database, and the Avian Monitoring Information System (AIMS) for ecological incidents involving phosmet was completed on December 22, 2009. The results of this review for terrestrial, plant, and aquatic incidents are discussed below in Sections 4.5.1 through 4.5.3. A complete list of the incidents involving phosmet including associated uncertainties is included as Appendix L.

4.5.1. Terrestrial Incidents

The only terrestrial animal incident reports associated with phosmet use involve bees; six bee kill incidents have been reported. An application to beans in Chelan County, Washington, resulted in the loss of 102 hives in 1998 and is classified as having a "possible" association with the use of phosmet; it is uncertain in this incident whether phosmet was applied in accordance with label requirements. An additional incident involved an unspecified crop and the loss of more than 100 hives occurred in the same county and year and is classified as having a "probable" association with phosmet use. Four incidents involving bee mortalities via phosmet drift in orchards crops have been reported: three in Henderson County, North Carolina, in 1993 and one in Merced County, California, in 1997. One NC incident is classified as having a "highly probable" association with an accidental misuse of phosmet, one is classified as having a "possible" association of an undetermined nature, and the third is classified as having an "unlikely" association with a registered use of phosmet. The one incident reported in CA is classified as having a "highly probable" association with the registered use of phosmet.

4.5.2. Plant Incidents

No incidents involving either terrestrial or aquatic plants have been reported for phosmet.

4.5.3. Aquatic Incidents

There is one reported incident, involving mortality of unspecified aquatic fish species via runoff from orchard application in Henderson County, North Carolina, in 1994. It is classified as having a "possible" association with an accidental misuse of phosmet. Heavy rains occurred "several days" after reported application of multiple insecticides, prior to the fish kill. Phosmet was detected at 7.3 µg/L in vegetation samples that were taken from the orchard nine days after effects were noticed. Other pesticides, including additional organophosphates, were detected in the vegetation samples and in water, soil, and sediment samples: benomyl was detected in water, chlorpyrifos and Captan were detected in soil, and all three were detected in vegetation.

4.6. 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 individuals and populations of listed species and to populations of fish (*eg*., amphibian), mammal, bird (*eg*., amphibian), and invertebrates that may indirectly affect the listed species of concern (USEPA, 2004b). As part of the risk characterization, an interpretation of acute RQs for listed species is discussed. This interpretation is presented in terms of the individual or proportional chance of an event (*i.e*., mortality or immobilization), should exposure at the EEC for a species with sensitivity to phosmet occur at a level equal to the acute toxicity endpoint selected for RQ calculation. In the absence of data regarding dose-response relationships in the available toxicity studies, a default probit slope value of 4.5 (± 2.5) is used to establish the likelihood of effects for each taxonomic group relevant to this assessment.

Individual and population-level effect probabilities are calculated for each assessed use using an Excel spreadsheet tool, Individual Effect Chance Model Version 1.1 (IECv1.1; USEPA, 2004a). In the case of phosmet, the default slope estimate (*i.e.*, 4.5) and the 95% confidence bounds of that estimate (*i.e.,* 2 – 7) are entered as the slope parameters in the spreadsheet because probit slope data specific to phosmet were not provided in the toxicity test reports. The acute RQ is entered as the desired threshold. Outputs include a probability (*e.g.*, %) and associated chance (*e.g.*, 1 in xxx) that an individual or population of the specified taxon will experience adverse effects (*i.e.*, mortality) as a result of the specified use pattern, as relevant to the specified toxicity data and RQ value.

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 CTS or for modification to their designated critical habitat from the use of phosmet 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 the aquatic animals, as well as terrestrial invertebrates, the LOC is 0.05. For acute exposures to the birds (and, thus, reptiles and terrestrial-phase amphibians) and mammals, the LOC is 0.1. The LOC for chronic exposures to animals, as well as acute exposures to plants is 1.0.

Acute and chronic risks to aquatic organisms are estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs in Table 3-3 based on the label-recommended phosmet usage scenarios summarized in Table 3-1 and the appropriate aquatic toxicity endpoint from Table 4-1. Acute and chronic risks to terrestrial animals are estimated based on exposures resulting from applications of phosmet (Table 3-5 through Table 3-8) and the appropriate toxicity endpoint from Table 4-3.

Although estimated phosmet exposures are calculated for aquatic (Table 3-3) and terrestrial (Table 3-9) plants, RQs are not calculated in the Risk Estimation because toxicity data specific to phosmet are unavailable. The Risk Description characterizes the potential for adverse effects to plants, based on estimated phosmet exposures and the lower bound of known toxicity estimates for the organophosphate insecticides, represented by the toxicity endpoints for naled and profenofos.

5.1.1. Exposures in the Aquatic Habitat

5.1.1.a. Direct Effects to Aquatic-Phase CTS

i. Freshwater Fish and Aquatic-Phase Amphibians

Direct acute effects to aquatic-phase CTS are assessed based on 1-in-10 year peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish (bluegill sunfish LC_{50} = 70 µg a.i./L). Chronic risk to CTS is assessed based on 1-in-10 year 60-day EECs and the lowest chronic toxicity value for freshwater fish (bluegill sunfish NOAEC = 1.0 µg a.i./L, based on ACR for rainbow trout). RQ values and the calculated probability of individual acute effects are shown in Table 5-1.

Based on RQs that exceed the acute LOC for listed species of freshwater fish for the California uses of phosmet on alfalfa, blueberries, tree farms (*i.e.*, Christmas trees, pine trees, other conifer and deciduous trees), fruit trees, nut trees, ornamentals, and peas, and by 70 times for the highest single application rate (nut trees), phosmet has the potential to directly affect aquatic-phase CTS. The probabilities of acute effects (*i.e.*, mortality) in individuals and populations of aquatic-phase CTS range from 1 in 2.76 x 10^{11} (potatoes and sweet potatoes) to 1 in 1.01 (up to 99.3%, nut trees).

Maximum application rates for California uses of phosmet result in chronic RQs that range from 0.04 (grapes) to 6.79 (nut trees) and exceed the chronic risk LOC for freshwater fish for the uses on nut trees, fruit trees (except citrus), and ornamentals.

Table 5-1. Summary of Acute RQs Used to Estimate Direct Effects to Aquatic-Phase CTS from Phosmet Uses in California.

Use	Application Rate (lbs a.i./A)[1]	EECs (µg/L)		RQs for CTS		Probability of Acute Effect (1 in …)
		Peak	60-day	Acute Bluegill Sunfish LC_{50} = 70 µg a.i./L	Chronic Bluegill Sunfish[3] NOAEC =1 µg a.i./L	
Alfalfa	0.75	6.64	0.20	**0.09**	0.20	791,000
Almonds, pecans, pistachios, filberts, walnuts, other tree nuts	5.95	245	6.79	**3.50**	**6.79**	1.01
Apples, crabapples	4.0 (4.0, 4.0, 4.0, 3.5)[2]	31.8	1.71	**0.45**	**1.71**	16.9
Apricots, cherries, nectarines, peaches, plums, prunes	3.0 (3.0, 3.0, 3.0, 2.9)[2]	46.2	2.58	**0.66**	**2.58**	4.8
Blueberries	1.0	6.70	0.46	**0.10**	0.46	294,000
Christmas, pine trees, conifer and deciduous trees	1.0	8.16	0.17	**0.12**	0.17	58,500
Citrus	2.1	14.3	0.43	**0.20**	0.43	1,210
Grapes	1.5	2.89	0.04	0.04	0.04	6.33×10^9
Ornamentals	2.0	40.4	1.08	**0.57**	**1.08**	7.35
Pears	4.0 (4.0, 4.0, 3.2)[2]	50.0	2.03	**0.71**	**2.03**	3.97
Peas	1.0	5.34	0.17	**0.08**	0.17	2,510,000
Potatoes, sweet potatoes	1.0	2.08	0.14	0.03	0.14	2.76×10^{11}

Bolded values indicate RQs that exceed the LOC for acute (listed species RQ $\geq$ 0.05) or chronic (RQ $\geq$ 1) effects.

1 Uses assessed based on memorandum from Pesticide Re-evaluation Division (PRD) dated 12/17/2009 and EFED Label Data report and associated Label Use Information Reports prepared on 11/30/2009.

2 Numbers in parentheses indicate the rates used for modeling when the maximum number of applications times the maximum single application rate exceeded the maximum annual application rate. For instance, the maximum annual application rate for apples is 15.5 lbs a.i./A. The maximum single application rate for apples is 4 lbs a.i./A. Therefore, a farmer could apply phosmet to apples 3 times at 4 lbs a.i./A and 1 time at 3.5 lbs a.i./A.

3 Based on an acute-to-chronic ratio for rainbow trout of 71.9.

5.1.1.b. Indirect Effects to Aquatic-Phase CTS via Prey and Forage

i. Freshwater Fish and Aquatic-Phase Amphibians

Small fish and aquatic-phase amphibians may serve as dietary items of CTS in aquatic environments. RQs associated with direct acute and chronic toxicity to CTS (*i.e.*, for freshwater fish; Table 5-1) are used to assess potential indirect effects to aquatic-phase CTS based on a reduction in freshwater fish and amphibians as food items. Acute and chronic RQs range from 0.01 to 3.74 and from 0.02 to 7.22, respectively. RQ values exceed the LOCs for acute (RQ $\geq$ 0.05) and chronic (RQ $\geq$ 1) risk to freshwater fish for the uses of phosmet on nut trees, fruit trees (except citrus), and ornamentals. In addition, the acute listed species LOC (RQ $\geq$ 0.05) is exceeded for all uses except grapes, potatoes, and sweet potatoes.

ii. Freshwater Invertebrates

Indirect effects to aquatic-phase CTS based upon availability of aquatic invertebrates as prey items are assessed based on direct acute and chronic risk to freshwater invertebrates. RQs for acute risk are based upon 1-in-10 year peak EECs in the standard pond and the lowest available acute toxicity value for freshwater invertebrates (scud EC_{50} = 2 µg a.i./L). Chronic risk RQs are based upon 1-in-10 year 21-day EECs and the lowest available chronic toxicity value for freshwater invertebrates (scud NOAEC = 0.3 µg a.i./L). Risk quotients for freshwater invertebrates are shown in Table 5-2.

RQs exceed the acute risk LOC for non-listed species of freshwater invertebrates for all California uses of phosmet and by more than two orders of magnitude for the maximum application rate on nut trees. The probability of acute effects (*i.e.*, likelihood of mortality) in the freshwater invertebrate population as a result of phosmet use ranges from 1 in 1.88 (53.1%, potatoes and sweet potatoes) to 1 in 1 (100%, nut treees). The chronic LOC is exceeded for all uses except grapes, potatoes, and sweet potatoes.

Table 5-2. Summary of Acute and Chronic RQs for Freshwater Invertebrates as Prey Items of CTS, based on California Uses of Phosmet.

Use	Application Rate (lbs a.i./A)[1]	EECs (µg/L)		RQs* Scud EC_{50} = 2 µg a.i./L Scud NOAEC = 0.3 µg a.i./L[3]	
		Peak	21-day	Acute	Chronic
Alfalfa	0.75	6.64	0.43	**3.32**	**1.43**
Almond, pecan, pistachio, filbert, walnut, other tree nuts	5.95	245	19.2	**123**	**64.0**
Apples, crabapples	4.0 (4.0, 4.0, 4.0, 3.5)[2]	31.8	4.82	**15.9**	**16.1**
Apricots, cherries, nectarines, peaches,	3.0 (3.0, 3.0, 3.0, 2.9)[2]	46.2	7.20	**23.1**	**154**

Use	Application Rate (lbs a.i./A)[1]	EECs (µg/L)		RQs* Scud EC_{50} = 2 µg a.i./L Scud NOAEC = 0.3 µg a.i./L[3]	
		Peak	21-day	Acute	Chronic
plums, prunes					
Blueberries	1.0	6.70	1.29	**3.35**	**4.30**
Christmas, pine trees, conifer and deciduous trees	1.0	8.16	0.37	**4.08**	**1.23**
Citrus	2.1	14.3	1.16	**7.15**	**3.87**
Grapes	1.5	2.89	0.12	**1.45**	0.40
Ornamentals	0.038	40.4	2.04	**20.2**	**6.8**
Pears	4.0 (4.0, 4.0, 3.2)[2]	50.0	5.57	**25.0**	**18.6**
Peas	1.0	5.34	0.49	**2.67**	**1.63**
Potatoes, sweet potatoes	1.0	2.08	0.21	**1.04**	0.70

* = LOC exceedances (acute listed species RQ $\geq$ 0.05; acute non-listed species RQ $\geq$ 0.5; chronic RQ $\geq$ 1.0) are **bolded**.

1 Uses assessed based on memorandum from Pesticide Re-evaluation Division (PRD) dated 12/17/2009 and EFED Label Data report and associated Label Use Information Reports prepared on 11/30/2009.

2 Numbers in parentheses indicate the rates used for modeling when the maximum number of applications times the maximum single application rate exceeded the maximum annual application rate. For instance, the maximum annual application rate for apples is 15.5 lbs a.i./A. The maximum single application rate for apples is 4 lbs a.i./A. Therefore, a farmer could apply phosmet to apples 3 times at 4 lbs a.i./A and 1 time at 3.5 lbs a.i./A.

3 The chronic NOAEC value for scud is estimated based on an acute-to-chronic ratio of effects in the waterflea.

iii. Aquatic Non-Vascular Plants

RQ values are not calculated for non-vascular aquatic plants because phytotoxicity data specific to phosmet are unavailable. In the absence of these data, risk cannot be precluded. The potential for risk to non-vascular aquatic plants is characterized in the Risk Description, based on phosmet use patterns and the available toxicity data for other organophosphate insecticides.

5.1.1.c. Indirect Effects to Aquatic-Phase CTS via Reduction in Habitat and/or Primary Productivity

i. Aquatic Plants

Indirect effects on aquatic-phase CTS may result from direct effects on aquatic plants that provide ecosystem services in terms of primary productivity and salamander habitat. In the absence of phytotoxicity data specific to phosmet, risk to aquatic vascular and non-vascular plants cannot be precluded. The potential for risk is characterized in the Risk Description, based on estimated exposures of phosmet and the available toxicity data for other organophosphate insecticides.

5.1.2. Exposures in the Terrestrial Habitat

5.1.2.a. Direct Effects to Terrestrial-Phase CTS

i. Birds (and Terrestrial-Phase Amphibians)

Potential direct effects to terrestrial-phase CTS are assessed based upon exposures resulting from foliar applications of phosmet and the associated dietary-based RQs for the most sensitive dietary class of birds in T-REX [*i.e.*, bird consuming short grass], given the lowest available toxicity values (bobwhite quail LC_{50} = 501 mg a.i./kg diet, bobwhite quail and mallard duck NOAEC = 60 mg a.i./kg diet). Dietary RQs are presented in Table 5-3. Acute, dose-based RQs for terrestrial-phase CTS were not calculated because a definitive endpoint was unavailable (*i.e.*, LD_{50} > 2000 mg a.i./kg bw). The potential for direct effects to terrestrial-phase CTS from California uses of phosmet is characterized further in the Risk Description.

Acute dietary-based RQs exceed the listed species LOC (RQ $\geq$ 0.1) for all California uses of phosmet and exceed the non-listed species LOC (RQ $\geq$ 0.5) for all uses except alfalfa.

Chronic dietary-based RQs exceed the Agency's LOC (RQ $\geq$ 1) for all indicated uses of phosmet and by 38 times for the maximum single application rate on nut trees.

Table 5-3. Acute and Chronic RQs Used to Estimate Direct Effects to Terrestrial-Phase CTS, Derived for Foliar Applications of Phosmet (T-REX).

Uses	**RQs for CTS (bird consuming short grass)** Bobwhite Quail LC_{50} = 501 mg a.i./kg diet Bobwhite Quail/Mallard Duck NOAEC = 60 ppm	
	Acute Dietary Based	**Chronic Dietary Based**
Alfalfa	**0.36**	**3.02**
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	**4.55**	**38.0**
Apples, crabapples	**4.14**	**34.5**
Apricots, cherries (tart), nectarines, peaches, plums, prunes	**3.10**	**25.9**
Blueberries	**1.09**	**9.13**
Christrmas trees, pine trees, conifer and deciduous trees	**0.53**	**4.38**
Citrus	**1.60**	**13.4**
Grapes	**1.40**	**11.7**
Ornamentals	**1.87**	**15.6**
Pears	**3.73**	**31.2**
Peas	**0.93**	**7.79**
Potatoes, sweet potatoes	**0.58**	**4.86**

LOC exceedances (acute listed species RQ $\geq$ 0.1; acute non-listed species RQ $\geq$ 0.5; chronic RQ $\geq$ 1.0) are **bolded**.
[1]Acute dose-based RQs for CTS and for birds are not calculated because the most sensitive endpoint was non-definitive (*i.e.*, LD_{50} > 2000 mg a.i./kg bw).

Refined RQs for terrestrial-phase amphibians are calculated using T-HERPS if RQs from T-REX indicate potential risk. Although the maximum size of a prey item that can be consumed is not documented, all size classes of terrestrial-phase CTS may consume a variety of small and large insects, small mammals, and amphibians.. T-HERPS uses a default assumption that the maximum prey size is 2/3 the mass of the herptile being assessed (*i.e.*, 13.3 g for prey consumed by a 20 g CTS; see Cook, 1997). The highest RQs for the CTS are based on the consumption of a 13.3 g herbivorous mammal (Table 5-4).

As in T-REX, dietary-based RQs were calculated based on the bobwhite quail LC_{50} = 501 mg a.i./kg diet and NOAEC = 60 mg a.i./kg diet. Although EECs for both dietary and dose-based exposure were presented in Section 3.3.1.d, dose-based RQs were not calculated because (1) the most sensitive dose-based acute endpoint was a non-definitive value (bobwhite quail LD_{50} > 2000 mg a.i./kg bw) and (2) no chronic dose-based endpoints were available. Further characterization of the potential for risk to the CTS is provided in the Risk Description (Section 5.2).

Acute dietary-based RQ values range from 0.36 (alfalfa) to 4.56 (nut trees) and exceed the acute listed species LOC (RQ $\geq$ 0.1) for all uses. The acute non-listed species LOC (RQ $\geq$ 0.5) is exceeded for all uses except alfalfa. Based on these data, the probabilities of acute effects in CTS individuals and populations range from 1 in 43.6 (alfalfa) to 1 in 1.00 (or up to 99.8%, nut trees). Chronic dietary-based RQ values range from 3.03 (alfalfa) to 38.1 (nut trees) and exceed the chronic LOC (RQ $\geq$ 1) for all uses.

Table 5-4. Dietary RQs Used to Refine the Assessment of Potential Risk to the CTS from California Uses of Phosmet (T-HERPS).

Use(s)	**Dietary-Based RQs for CTS (consuming herbivorous mammals)** Bobwhite Quail LC_{50} = 501 mg a.i./kg diet Bobwhite Quail/Mallard Duck NOAEC = 60 ppm		Probability of Acute Effect (1 in …)
	Acute	**Chronic**	
Alfalfa	**0.36**	**3.03**	43.6
Almonds, filberts, pecans, pistachios, walnuts, other nut trees	**4.56**	**38.1**	1.00
Apples, crabapples	**4.15**	**34.7**	1.00
Apricots, cherries (tart), nectarines, peaches, plums, prunes	**3.11**	**26.0**	1.01
Blueberries	**1.10**	**9.17**	1.74
Christrmas trees, pine trees, conifer and deciduous trees	**0.53**	**4.40**	9.32
Citrus	**1.61**	**13.4**	1.21
Grapes	**1.41**	**11.7**	1.34
Ornamentals	**1.87**	**15.6**	1.12
Pears	**3.75**	**31.3**	1.00
Peas	**0.94**	**7.82**	2.21
Potatoes, sweet potatoes	**0.58**	**4.88**	6.97

RQ values that exceed the Agency's LOC (acute listed species RQ $\geq$ 0.1, acute non-listed species RQ $\geq$ 0.5, chronic RQ $\geq$ 1) are **bolded**.

5.1.2.b. Indirect Effects on Terrestrial-Phase CTS via Reduction in Prey

i. Amphibians

Terrestrial-phase CTS may consume small amphibians and therefore may experience indirect effects if phosmet use directly affects amphibian prey items. Potential risks to amphibians in the terrestrial environment are assessed in the manner described above for birds and terrestrial-phase CTS. Based on a small bird consuming short grass, which is the most sensitive screening-level scenario used for amphibians in T-REX, RQs exceed the acuted listed species LOC and chronic LOC for all uses of phosmet (Table 5-4). In addition, RQ values for all uses except alfalfa exceed the acute non-listed species LOC. Refined RQ values calculated by T-HERPS result in LOC exceedances for the same use patterns as those identified in T-REX, which reinforces the risk conclusions for direct and indirect effects on amphibians.

ii. Mammals

Potential for indirect effects to terrestrial-phase CTS may result from direct effects to small mammals that reduce the number of prey available. Potential risks to mammals are estimated in a similar manner to risk estimates for birds, based on foliar application of phosmet and the most sensitive available endpoints for small mammals (laboratory rat LD_{50} = 113 mg a.i./kg bw, NOAEC = 1.5 mg a.i./kg diet). The highest RQs for small mammals (as calculated in T-REX) are based upon consumption of short grass; acute dose-based and chronic dietary-baed RQ values for this category are presented in Table 5-6. However, acute dietary-based RQs are not calculated in this assessment because an acute dietary endpoint is unavailable. Potential risks to CTS associated with effects of phosmet on small mammals are discussed further in the Risk Description.

Acute dose-based RQs exceed the LOC (RQ $\geq$ 0.5) for all Califonia uses of phosmet and by more than an order of magnitude for the highest single application rate on tree nuts. The probability of acute effects in the small mammal population ranges from 1 in 4.27 (alfalfa) to 1 in 1 (100%; nut trees). In addition, chronic dietary-based RQs exceed the LOC (RQ $\geq$ 1) for all uses and by approximately 75 times for the use on nut trees.

Table 5-5. Acute and Chronic RQs Used to Estimate Indirect Effects to Terrestrial-Phase CTS from Direct Effects of Phosmet Use on Mammals (T-REX).

Uses	**RQs for Small Mammals**[1] **(small mammals consuming short grass)** Laboratory Rat LD_{50} = 113 mg a.i./kg bw NOAEC = 1.5 mg a.i./kg diet	
	Acute Dose-Based	**Chronic Dietary Based**
Alfalfa	**0.69**	**6.03**
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	**8.74**	**75.9**
Apples, crabapples	**7.95**	**69.1**
Apricots, cherries (tart), nectarines, peaches, plums, prunes	**5.97**	**51.8**
Blueberries	**2.10**	**18.3**

	RQs for Small Mammals[1] (small mammals consuming short grass) Laboratory Rat LD_{50} = 113 mg a.i./kg bw NOAEC = 1.5 mg a.i./kg diet	
Christrmas trees, pine trees, conifer and deciduous trees	**1.01**	**8.77**
Citrus	**3.09**	**26.8**
Grapes	**2.69**	**23.4**
Ornamentals	**3.59**	**31.2**
Pears	**7.18**	**62.3**
Peas	**1.79**	**15.6**
Potatoes, sweet potatoes	**1.12**	**9.72**

LOC exceedances (acute listed species RQ $\geq$ 0.1; acute non-listed species RQ $\geq$ 0.5; chronic RQ $\geq$ 1.0) are **bolded**.
[1]Acute dietary-based RQs are not calculated because an acute dietary-based toxicity endpoint for mammals was unavailable.

iii. Terrestrial Invertebrates

Potential for indirect effects to the CTS may result from direct acute effects to terrestrial invertebrates as potential prey items. The honey bee is used as a representative species to assess the risks of phosmet use to terrestrial invertebrates. The toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available honey bee acute contact LD_{50} (1.1 µg a.i./bee) for phosmet by 1 bee/0.128 g, based on the average weight of an adult honey bee (Mayer and Johansen, 1990). Dietary-based EECs calculated by T-REX (µg a.i./g) for small insects, the more sensitive size class, are then divided by the adjusted toxicity value for terrestrial invertebrates (8.59 µg a.i./g). The resulting risk quotients are shown in Table 5-7.

RQs for small insects exceed the LOC (RQ $\geq$ 0.05)) for all uses of phosmet by at least two to three orders of magnitude. The probability of acute effects in the small insect population is approximately 1 in 1 (100%).

Table 5-6. RQs Used to Estimate Indirect Effects on Terrestrial-Phase CTS via Reduction in Availability of Terrestrial Invertebrates as Prey.

Use	RQs* Acute Honey Bee Contact LD_{50} = 1.1 µg a.i./bee (or 8.59 µg a.i./g)
	Small Insects
Alfalfa	**11.9**
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	**149**
Apples, crabapples	**136**
Apricots, cherries (tart), nectarines, peaches, plums, prunes	**102**
Blueberries	**35.9**
Christrmas trees, pine trees, conifer and deciduous trees	**17.2**
Citrus	**52.6**
Grapes	**46.0**
Ornamentals	**61.2**
Pears	**122**
Peas	**30.6**
Potatoes, sweet potatoes	**19.1**

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

5.1.2.c. Indirect Effects to Terrestrial-Phase CTS via Direct Effects on Terrestrial Plant Community

Terrestrial-phase CTS may experience indirect effects if phosmet exposure directly affects terrestrial plants that provide riparian and upland habitat and primary productivity. 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, toxicity data for effects of phosmet on non-target terrestrial plants are unavailable. In the absence of data, risk to terrestrial plants cannot be precluded. The potential for adverse effects is characterized in the Risk Description, based on estimated phosmet exposures and the available phytotoxicity data for other organophosphate insecticides.

5.1.3. Primary Constituent Elements of Designated Critical Habitat

For phosmet use, the assessment endpoints for the designated critical habitat prey base and PCEs involve the same endpoints as those being assessed relative to direct and indirect effects to the CTS. Therefore, the potential for direct and indirect effects are used as the basis of the effects determination for potential modification to designated critical habitat. As described in Table 2-7, the designated PCEs for the Central California and Santa Barbara County CTS DPSs are as follows:

PCE1: Standing bodies of fresh water, including natural and man-made (e.g., stock) ponds, vernal pools, and dune ponds, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (i.e., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle[2]

PCE2: Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend upon for food, shelter, and protection from the elements and predation

PCE3: Upland areas between breeding locations (PCE 1) and areas with small mammal burrows (PCE 2) that allow for dispersal among such sites

Assessment endpoints used to evaluate risk to the CTS prey base, associated with the California uses of phosmet, include direct effects upon aquatic non-vascular plants, freshwater fish (*i.e.*, aquatic-phase amphibians), freshwater invertebrates, birds (*i.e.*, terrestrial-phase amphibians), small mammals, and terrestrial invertebrates. Risk to aquatic non-vascular plants is presumed because phytotoxicity data for phosmet are unavailable. RQs for freshwater fish exceed the acute ($RQ \geq 0.5$) and chronic ($RQ \geq 1$) LOCs for the uses on nut trees, fruit trees (except citrus), and ornamentals; they exceed the listed species LOC ($RQ \geq 0.05$) for all uses except grapes, potatoes, and sweet potatoes. All uses result in RQs that exceed the LOC for acute risk to freshwater invertebrates ($RQ \geq 0.5$), and the chronic LOC ($RQ \geq 1$) is exceeded for all uses except grapes, potatoes, and sweet potatoes. For birds (*i.e.*, terrestrial-phase amphibians), RQs for all uses except alfalfa exceed the acute (RQ $\geq$ 0.5) and chronic LOCs (RQ $\geq$ 1), and all uses exceed the LOC for acute risk to listed species (RQ $\geq$ 0.1). RQ values for small mammals exceed the acute (RQ $\geq$ 0.5) and chronic (RQ $\geq$1) LOCs for all uses. Similarly, all uses result in RQ values that exceed the LOC for terrestrial invertebrates (RQ $\geq$ 0.05). Given these results, phosmet use may adversely affect the CTS prey base in designated critical habitat areas.

Assessment endpoints used to evaluate potential risk to CTS PCEs include direct effects upon aquatic vascular and non-vascular plants (PCE1), terrestrial plants (PCE1, PCE2, PCE3), and small mammals (PCE2, PCE3). In the absence of phytotoxicity data for phosmet, risk to plants cannot be precluded; phosmet may modify PCEs for CTS via adverse effects on aquatic and terrestrial plants. Effects on plants are expected to impact all three PCEs via habitat modification and potential reductions in primary productivity. Finally, RQs for mammals exceed acute and chronic LOCs. Based on these results, phosmet may modify PCE2 and PCE3 via direct acute and chronic effects on small mammals, whose burrows structure the subsurface terrestrial habitat and facilitate migration and dispersal of CTS.

5.2. Risk Description

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

If the RQs presented in the Risk Estimation (Section 5.1) show no direct or indirect effects for the CTS and suggest no modification to PCEs of the designated critical habitat, a "no effect" determination is made based on phosmet's use within the action area. However, if LOCs for direct or indirect effects 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 phosmet. A summary of the risk estimation results are provided in Table 5-9 for direct and indirect effects to the CTS and in Table 5-10 for PCEs of the designated critical habitat.

The phosmet oxon is not quantitatively assessed in this document. There are no effects data for the phosmet oxon, although, as previously stated, comparative toxicity data for other organophosphate chemicals indicate that it could be as much as 100 times more toxic than the parent. The oxon formed only in minute amounts (< 0.5% of parent) in a limited number of environmental fate studies. Although there were six detections of phosmet oxon in monitoring data, they all occurred in one month of one year in one location and were not correlated with phosmet detections, so there is uncertainty regarding the potential for exposure of CTS to the phosmet oxon. Consequently, the undetermined potential for the phosmet oxon to affect the CTS contributes uncertainty to this assessment.

Table 5-7. Summary of Preliminary Effects Determination for Direct and Indirect Effects of Phosmet Use on CTS

Assesment Endpoint	Preliminary Effects Determination	Basis for Determination
Aquatic-Phase CTS (*eggs, larvae, juveniles, submerged adults*)		
Direct effects on survival, growth, and reproduction of CTS	May affect	RQ values exceed acute and chronic LOCs[1]
Indirect[2] effects on survival, growth, and reproduction of CTS via direct effects on food supply	May affect	RQ values exceed acute and chronic LOCs for freshwater fish (*i.e.*, aquatic-phase amphibians), freshwater invertebrates and, based on surrogate data for OP naled and the uses of phosmet on fruit trees, nut trees, and ornamentals, exceed the non-listed species LOC for non-vascular aquatic plants (see Risk Description)
Indirect[2] effects on survival, growth, and reproduction of CTS via direct effects on habitat, cover, and/or primary productivity	May effect	Phosmet toxicity data are unavailable; RQ values for aquatic non-vascular plants exceed LOC for the uses on fruit trees, nut trees, and ornamentals, based on surrogate data for OP naled (see Risk Description)
Indirect[2] effects on survival, growth, and reproduction of CTS via direct effects on riparian vegatation (*eg.*, on water quality and edge-of-pond habitat)	May affect	Phosmet toxicity data are unavailable; RQ values for terrestrial plants in semi-aquatic areas exceed LOC based on surrogate data for OP profenofos (see Risk Description)
Terrestrial-Phase CTS (*metamorphs and adults in terrestrial environment*)		
Direct effects on survival, growth, and reproduction of CTS	May affect	RQ values exceed acute and chronic LOCs[1]
Indirect effects on survival, growth, and reproduction of CTS via direct effects on food supply	May affect	RQ values for small mammals, terrestrial invertebrates, and terrestrial-phase amphibians (*i.e.*, birds) exceed acute and chronic LOCs
Indirect[2] effects on survival, growth, and reproduction of CTS via direct effects on habitat, cover, and/or primary productivity	May affect	Phosmet toxicity data are unavailable; RQ values for terrestrial plants in dry and semi-aquatic areas exceed LOC based on surrogate data for OP profenofos (see Risk Description)

[1] In the case of phosmet, RQ values that exceed the acute LOC also exceed the listed species LOC.
[2] Only non-listed LOCs were used as the basis of determination for indirect effects via effects on aquatic and terrestrial plants because CTS is not known to have an obligate relationship with listed species.

Table 5-8. Summary of Preliminary Effects Determination for Phosmet Effects on PCEs of Designated Critical Habitat for CTS

Assesment Endpoint	Preliminary Effects Determination	Basis for Determination[1]
PCE1: *Standing bodies of fresh water, including natural and man-made (e.g., stock) ponds, vernal pools, and dune ponds, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (i.e., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle*		
Effects on PCE1 through direct effects on aquatic plants and riparian vegetation (*eg.*,, habitat modification and primary productivity)	May affect	Phosmet toxicity data are unavailable; RQs for non-vascular aquatic plants exceed LOC for the uses on fruit trees, nut trees, and ornamentals, based on surrogate data for OP naled; RQs for terrestrial plants in semi-aquatic areas exceed LOC, based on surrogate data for OP profenofos (see Risk Description)
PCE2: *Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend upon for food, shelter, and protection from the elements and predation*		
Effects on PCE2 through direct effects on terrestrial plants (*eg.*, habitat modification and primary productivity)	May affect	Phosmet toxicity data are unavailable; RQs for terrestrial plants in semi-aquatic and dry areas exceed LOC, based on surrogate data for OP profenofos (see Risk Description)
Effects on PCE2 through direct effects on small mammals (*eg*,, modification or elimination of subterranean upland habitat)	May affect	RQs for small mammals exceed acute and chronic LOCs
PCE3: *Upland areas between breeding locations (PCE1) and areas with small mammal burrows (PCE2) that allow for dispersal among such sites*		
Effects on PCE3 through direct effects on terrestrial plants (*eg.*, habitat modification and primary productivity)	May affect	Phosmet toxicity data are unavailable; RQs for terrestrial plants[1] in semi-aquatic and dry areas exceed LOC, based on surrogate data for OP profenofos (see Risk Description)
Effects on PCE3 through direct effects on small mammals (*eg*,, modification or elimination of subterranean upland habitat)	May affect	RQs for small mammals exceed acute and chronic LOCs

[1] Only non-listed LOCs were evaluated with respect to aquatic and terrestrial plants because CTS is not known to have an obligate relationship with listed species.

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. For example, if the available toxicity and exposure data indicate that effects may occur as a result of the use of phosmet, and spatial analysis indicates that the location of the CTS DPS and/or designated critical habitat coincides with the area affected by the use, then a final "may effect" determination is made. However, if there is no overlap, then the final determination is "no effect" because exposure is not expected to occur.

In addition, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that are "likely to adversely affect" the CTS 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: For the purposes of this assessment, insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where "take" occurs for even a single individual. "Take" in this context means to harass or harm, defined as the following:
    - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.
    - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.
- Likelihood of the Effect Occurring: Discountable effects are those that are extremely unlikely to occur.
- Nature of Effect: Effects that are wholly beneficial without any adverse effects are not considered adverse.

A description of the risk and effects determination for each of the established assessment endpoints for the CTS and its designated critical habitat is provided in Sections 5.2.1 through 5.2.3. Sections 5.2.1.a and 5.2.1.b discuss the potential for direct effects to aquatic and terrestrial-phase CTS, respectively. The potential indirect effects to CTS via loss of prey and modification of habitat are described in Section 5.2.2. Section 5.2.3 discusses the potential for modification to the designated critical habitat as a result of phosmet use. A discussion of overlap between the areas of concern and the locations of CTS (including designated critical habitat) assessed here is presented in the spatial analysis section (Section 5.2.4). If there is no overlap of the species habitat and occurrence sections with the Potential Area of Effects, a No Effect determination is made.

5.2.1. Direct Effects on CTS

5.2.1.a. Aquatic-Phase Salamanders

For the purposes of this assessment, "aquatic-phase" refers to life stages of CTS that are obligatory aquatic organisms, *i.e.*, eggs, larvae, and metamorphosing juveniles, and to juvenile (*i.e.*, metamorph) and adult terrestrial-phase salamanders in the aquatic environment. Although CTS spend the majority of their adult lives in the terrestrial environment, critical periods are spent submerged in water bodies for breeding (and possibly foraging) purposes. Based on a preliminary analysis of overlap between the Action Area and the listed distinct population segments (DPS) of the CTS (see Section 2.7), these water bodies may receive runoff and spray drift containing phosmet. More refined spatial analysis is presented in Section 5.2.4.

As discussed previously, assuming the default dose-response slope of 4.5 and at the highest RQ value for freshwater fish (RQ = 3.50; nut trees), *i.e.*, the surrogate for aquatic-phase amphibians, the likelihood of an individual effect on CTS is approximately 1 in 1. In addition, runoff from an apparent orchard application of phosmet and other insecticides, promoted by heavy rains, may have contributed to a fish kill reported in North Carolina in 1997 (see Section 4.5.3).

Chronic RQs discussed in Section 5.1.1.a.i range from 0.03 (potatoes and sweet potatoes) to 6.79 (nut trees); the chronic risk LOC is exceeded for the uses of phosmet on nut trees, fruit trees (except citrus), and ornamentals. The Pesticide Effects Determination for the potential effects of phosmet exposure on another listed amphibian species, the California Red Legged Frog (CRLF), also indicated a potential for chronic risk to aquatic-phase amphibians, specifically following uses on fruit trees. The current determination for the CTS reflects mitigation measures that have reduced the number of applications per year for this use; however, the chronic risk LOC is still exceeded for the uses on nut trees, fruit trees (except citrus), and ornamentals. The current exceedances are driven primarily by the relatively high single application rates and the incorporation of spray drift label language into calculations of the spray drift fractions used as inputs in exposure modeling. For uses on nut trees, fruit trees, blueberries, and tree farms (*i.e.*, Christmas trees, pine trees, other conifer and deciduous trees), the calculated spray drift fractions are greater than the default value (*i.e.*, 5%) that would otherwise be assumed for aerial applications of phosmet. Additional uncertainty surrounds the calculations of usage and exposure because supplies of phosmet products with the previous label language might continue to be used until depleted; therefore, actual use patterns may not immediately reflect the mitigation actions.

Modeled exposure concentrations for the phosmet oxon could not be estimated in this assessment, as fate data were not available. As the oxon degradates for other organophosphorus pesticides have been reported to be equally or more toxic than the parent, the EECs could be underestimated. However, the modeled estimated exposure concentrations for phosmet were based on conservative input parameters (*e.g.*, assumed stable to aquatic degradation, increased the aerobic half-life by three times) and PRZM/EXAMS scenarios. As such, the modeled EECs were designed to be conservative. Additionally, the modeled estimated exposure concentrations for phosmet in aquatic environments exceed the concentrations reported in the available monitoring data, which are not targeted to find peak concentrations. Therefore, use of the modeled exposure concentrations as the basis of risk estimation in this assessment is expected to result in a protective determination with respect to potential effects of phosmet on aquatic-phase CTS.

Although the aquatic-phase CTS primarily uses standing (*i.e.*, static or slow-flowing) bodies of water for breeding and larval habitat, as opposed to faster-moving waters such as streams and rivers, phosmet may be introduced into CTS habitat via surface water transport from a target application site. To determine the extent of the area potentially affected by phosmet transported via moving surface water, the downstream dilution model was used to calculate the distance downstream beyond which phosmet concentrations are expected to be diluted below levels of concern for aquatic organisms relevant to the CTS. The most sensitive aquatic endpoint, based the greatest RQ to LOC ratio for phosmet, is used as a threshold: where concentrations result in RQs for this endpoint that are at or above the LOC, the area is included in the potential area of effects. The distance beyond which concentrations yield RQs that no longer exceed the LOC is termed the "downstream dilution distance." For phosmet, the downstream dilution distance for the most senstitive aquatic endpoint (freshwater invertebrates) is 300 km.

5.2.1.b. Terrestrial-Phase Salamanders

Screening-level dietary RQ values exceed the acute risk LOC for direct mortality of terrestrial-phase CTS for all uses of phosmet. The highest RQ value (RQ = 4.55, tree nuts, T-REX) is approximately 45 times the LOC for acute risk to listed species. Refining the assessment using T-HERPS provides insight into the contribution of additional dietary items (*e.g.*, mammals) to overall risk potential, although dietary-based RQ calculations do not include adjustments for differences in the frequency of dietary intake between birds and mammals. Acute dietary RQs (and the associated potential for risk) are highest for small terrestrial-phase CTS consuming small herbivorous mammals (Table 5-5). Based on the highest RQ value from T-HERPS (RQ = 4.56, nut trees), the calculated probability of individual effects is 99.8% (but may range from 90.6% to 100% based on 95% confidence limits).

Chronic RQs for terrestrial-phase CTS also exceed the LOC, by a factor of approximately 38 for the maximum use rate (nut trees, T-REX). Given these risk estimates and the reductions in fertility (*e.g.*, number of eggs) observed in phosmet toxicity studies with the bobwhite quail and mallard duck, phosmet may result in direct effects to terrestrial-phase CTS through adverse chronic effects on reproduction.

Based on the weight-of-evidence, the preliminary determination is that phosmet exposure "may affect" the CTS through direct effects in both aquatic and terrestrial environments.

5.2.2. Indirect Effects on CTS

5.2.2.a. Potential Loss of Prey

As discussed in Section 2.5, the diet of an individual CTS varies according to life stage and habitat, *e.g.*, aquatic versus terrestrial. Young larvae consume algae and zooplankton, larger larvae consume small aquatic vertebrates (*i.e.*, fish and other amphibians) and invertebrates, and juveniles and adults are opportunistic feeders that may consume a variety of aquatic and terrestrial invertebrates, fish, amphibians, and small mammals.

Young larvae may consume aquatic non-vascular plants (*e.g.*, algae) deliberately and/or incidentally while foraging on zooplankton. In addition, because zooplankton depend upon aquatic non-vascular plants for sustenance, effects of phosmet on non-vascular plants may reduce the availability of zooplankton to the salamander. In the absence of toxicity data for phosmet, potential risk to aquatic non-vascular plants cannot be precluded for any of the evaluated uses. The potential for risk is characterized further by comparing toxicity endpoints from the available tests with organophosphate insecticides to the 1-in-10 year peak EECs of phosmet in the standard pond. Based on the surrogate toxicity data from tests with naled (naled EC_{50} = 12 µg a.i./L), which provide the lowest toxicity endpoints for freshwater non-vascular plants, RQ values range from 0.17 (potatoes and sweet potatoes) to 20.4 (nut trees). The non-listed species LOC is exceeded for the uses of phosmet on nut trees, fruit trees, and ornamentals. However, phosmet may be more toxic or less toxic than naled.

Aquatic invertebrates constitute the majority of CTS diet for juveniles and adults in the aquatic environment. The magnitude of RQ exceedances for direct acute effects to aquatic invertebrates associated with all non-ornamental uses and of chronic LOC exceedances for non-ornamental uses other than grapes, potatoes, and sweet potatoes indicate that phosmet may have indirect adverse effects on the CTS through reductions in aquatic invertebrates as potential prey items. The use of phosmet on ornamentals results in an acute RQ that exceeds the listed species LOC but not the non-listed species LOC; the chronic risk LOC is not exceeded for this use pattern.

Acute effects of phosmet exposure are likely to include an immediate reduction in the numbers of aquatic invertebrate prey available; the mean probability of individual acute effects for non-ornamental use patterns ranges from 51.4% (potatoes and sweet potatoes) to approximately 100% (forestry, fruit trees, and nut trees). For ornamental uses, the probability of an individual acute effect is approximately 2.3% (but may range from to 0.09% to 18.7% based on 95% confidence limits).

Chronic effects may produce longer term impacts by inhibiting the reproduction of invertebrate prey items. Because invertebrate species may have differing degrees of sensitivity to phosmet, effects associated with phosmet exposure may result further in a broader-scale restructuring of the invertebrate community: Even if the overall biomass of invertebrates is not reduced, the availability of favorable prey species may diminish, and more predatory species (*e.g.*, dragonfly larvae) may become more prevalent, or vice versa.

Small fish and aquatic-phase amphibians comprise a relatively small portion of CTS diet but nonetheless represent an important potential energy source for salamanders in the aquatic phase. For example, tiger salamander larvae that consumer other amphibian larvae, including conspecifics, are typically larger and potentially more fit (Denoël *et al.*, 2006; Loeb *et al.*, 1994). Therefore, a reduction in the availability of fish and amphibians as prey may reduce the fitness of individual CTS in the aquatic environment. Conversely, reductions in fish and amphibians other than CTS may lead to reduced inter-specific competition with the salamander. Given that (1) RQs for direct acute effects to freshwater fish exceed the listed species LOC for all non-ornamental uses except grapes, potatoes, and sweet potatoes, (2) both the listed and non-listed species LOCs are exceeded for the uses on fruit trees and nut trees and (3) the mean probability of individual effects for the maximum single application rate (nut trees) is 100% (lower 95% CI bound of 87.4%), phosmet may reduce the numbers of freshwater fish and amphibians available to the CTS as prey. In addition, since chronic RQs for freshwater fish and amphibians exceed the LOC for the uses on fruit trees and nut trees, phosmet may cause indirect effects on CTS through reductions in fish and other amphibian prey items chronically exposed to phosmet.

While it is unknown how frequently terrestrial-phase CTS consume vertebrate prey items, *i.e.*, amphibians and small mammals, both have been detected in anlayses of tiger salamander stomach contents (Lemm, 2006; Kucera, 1997; Stebbins, 1972; Bishop, 1941). Given the magnitude of dietary LOC exceedances for acute effects to terrestrial-phase amphibians, coupled with a probability of individual effects of up to 99.8% (nut trees), phosmet may reduce the availability of terrestrial-phase amphibians as prey. RQ exceedances similarly indicate that chronic effects of phosmet exposure on terrestrial-phase amphibians may inhibit reproduction and therefore reduce the number of potential amphibian prey. Additional indirect effects to the CTS are expected from reductions in the availability of small mammals as prey following acute and/or chronic exposure to phosmet. Acute dose-based and chronic dietary-based RQs exceed the LOC for all non-ornamental uses; the mean probability of individual acute effects to small mammals ranges from approximately 6.03% (alfalfa) to 75.9% (nut trees). Indirect effects are not expected to result of ornamental uses of phosmet, given that acute and chronic RQ values neither exceed nor approach the LOC.

As with aquatic invertebrates for larval and submerged salamanders, terrestrial invertebrates are a critical dietary component of juvenile and adult CTS in the terrestrial environment. The probability of individual effects to small insects as a result of phosmet exposure is approximately 100% for all non-ornamental uses. For ornamental uses, the probability of individual effects is 69.1% (but may range from 58.8% to 78.1% based on 95% confidence limits). The highest RQ value (RQ = 149, nut trees) for small insects exceeds the LOC by more than three orders of magnitude. In addition, incidents of honey bee mortality have been reported in association with phosmet use (see Section 4.5.1). While some uncertainty surrounds the risk estimates for terrestrial invertebrates because the terrestrial-phase CTS consumes primarily soil-dwelling invertebrates and the toxicity endpoint is based on the honey bee, the magnitude of effects and the nature of the pesticide (*i.e.*, as an insecticide) both support the risk conclusion.

Based on the weight of evidence, the preliminary determination is that the evaluated uses of phosmet "may affect" the CTS through indirect effects associated with a reduction in the prey base of the salamander.

5.2.2.b. Potential Modification of Habitat

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

In the absence of phytotoxicity data for phosmet, the potential for indirect effects to CTS based on impacts on habitat or primary productivity via direct effects on aquatic non-vascular and vascular plants cannot be precluded. To characterize the potential for risk, estimated aquatic exposures of phosmet were compared to the toxicity endpoints from tests with naled (non-vascular plants: EC_{50} = 12 µg a.i./L, vascular plants: EC_{50} > 1,800 µg a.i./L; NOAEC = 1,800 µg a.i./L), which provided the lowest toxicity values from freshwater tests with organophosphate insecticides. As described previously, the resulting values for non-vascular plants exceed the non-listed species LOC for phosmet uses on fruit trees, nut trees, and ornamentals. The endpoint for non-listed species of vascular plants was non-definitive (*i.e.*, EC_{50} > 1,800 µg a.i.(naled)/L); therefore, the comparison for vascular aquatic plants relies upon the additional assumption that an EC_{50}-based comparison for non-listed plants would result in lower values (and thus lower risk) than the NOAEC-based comparison for listed plants (NOAEC = 1,800 µg a.i.(naled)/L). Since none of the NOAEC-based values for listed vascular plants exceed the LOC, risk to non-listed vascular plants may be unlikely. However, uncertainty surrounds this conclusion because phosmet may be more toxic or less toxic to aquatic plants than naled. Given these results, the weight-of-evidence indicates that phosmet may indirectly affect the CTS through adverse effects on non-vascular plants that result in decreased primary productivity. Moreover, in the absence of phytotoxicity data specific to phosmet, it is assumed that phosmet may adversely impact the CTS through effects on aquatic vascular plants, although the toxicity data for other organophosphate insecticdes (*i.e.*, naled) indicate that the potential for risk is low.

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

In the absence of phosmet phytotoxicity data suitable for quantitative assessment, the potential for risk to terrestrial plants cannot be precluded. To characterize this potential, estimated environmental concentrations of phosmet are compared to terrestrial plant toxicity data from the available tests with organophosphate insecticides. Using the endpoint from profenofos (EC_{25} = 0.13 lbs a.i./A), which is the lowest definitive toxicity value from seedling emergence and vegetative vigor tests with organophosphate insecticides, the LOC is exceeded for monocot and dicot plants in both dry and semi-aquatic habitats. Adverse effects to both listed and nonlisted terrestrial plants in semi-aquatic environments (*e.g.*, riparian habitat) may occur as a result of aerial spray (airblast for grapes) for all assessed uses. Effects in dry areas are particularly likely following aerial spray at application rates equal to or greater than 1.0 lbs a.i./A, *i.e.*, for the uses on fruit trees and nut trees.

Although the risk description for terrestrial plants incorporates phytotoxicity data from profenofos, phosmet is known to cause premature leaf drop in sweet cherries at 1.5 lbs a.i./A, which is nearly one fourth of the maximum labeled application rate on tree nuts (5.95 lbs a.i./A). Given the wide variety of crop uses intended for phosmet and the apparently species (or variety)-specific nature of phytotoxicity, uncertainty surrounds the expectation of risk associated with LOC exceedances for terrestrial plants. However, in the absence of phosmet-specific data and because of the consistent exceedances for semi-aquatic plants, which are of particular biological relevance to CTS, the determination is that phosmet has the potential to adversely impact CTS through habitat modification and/or reduction in primary productivity associated with the exposure of terrestrial plants to phosmet.

Because metamorphosed juvenile and adult CTS (*i.e.*, terrestrial-phase) salamanders dwell primarily in burrows and fissures, small mammals play a crucial role in shaping the habitat necessary for the terrestrial phase, including corridors for dispersal and migration. Specifically, a reduction in the number or suitability of small mammal burrows (1) may impact reproduction by inhibiting salamander migration between upland habitat and breeding ponds (Trenham and Shaffer, 2005), (2) may impact population-level parameters of survivorship and reproduction (*e.g.*, recruitment) by limiting the salamander's ability to disperse during the breeding season from a less suitable pond to a more suitable site (Petranka *et al*., 2004; Trenham *et al.*,, 2001), and (3) may decrease survival by reducing the extent of subsurface habitat available for foraging and residence (Cook *et al.*, 2006). Additional indirect effects, such as potential effects of crowding associated with a reduction in habitat, have been documented in other fossoreal salamanders (*e.g.*, *Ambystoma maculatum;* see Cooperman *et al.*, 2004) but are not explicitly evaluated in this assessment.

As noted in the previous section, the probability of individual acute effects to mammals, associated with the highest RQ value (RQ = 8.74; nut trees), ranges from approximately 97% to 100%. The highest chronic RQ value (RQ = 75.9; nut trees) is more than 75 times the chronic risk LOC. Given that RQ values for all non-ornamental uses exceed the LOCs for acute risk to both listed and non-listed specied of mammals and exceed the chronic risk LOC, phosmet may affect the CTS indirectly through habitat modification associated with the exposure of small mammals to the pesticide. Adverse effects associated with the use on ornamentals are not expected.

Based on the weight of evidence, the preliminary determination is that phosmet "may affect" CTS through modification of habitat associated with the evaluated uses of phosmet.

5.2.3. Modification of Designated Critical Habitat

As described previously, the assessment endpoints for the designated critical habitat prey base and PCEs involve the same endpoints as those being assessed relative to direct and indirect effects to CTS from the evaluated uses of phosmet. As described in Table 2-7, the designated PCEs for the Central California and Santa Barbara County CTS DPSs are as follows:

PCE1: Standing bodies of fresh water, including natural and man-made (e.g., stock) ponds, vernal pools, and dune ponds, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (i.e., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle[2]

PCE2: Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend upon for food, shelter, and protection from the elements and predation

PCE3: Upland areas between breeding locations (PCE 1) and areas with small mammal burrows (PCE 2) that allow for dispersal among such sites

Assessment endpoints used to evaluate potential risk to the prey base associated with designated critical habitat include direct effects upon aquatic non-vascular plants, fish (*i.e.*, aquatic-phase amphibians), freshwater invertebrates, terrestrial invertebrates, small mammals, and birds (*i.e.*, terrestrial-phase amphibians). In the absence of phytotoxicity data for phosmet, risk to aquatic non-vascular plants is presumed; RQ values based on phosmet EECs and the lowest toxicity endpoints from the available tests with organophosphate insecticides (*e.g.*, naled) support this conclusion. RQ values (based on phosmet toxicity data) for the other taxonomic groups exceed the Agency's LOCs.

Assessment endpoints used to evaluate risk to designated critical habitat PCEs for the CTS include direct effects upon aquatic vascular and non-vascular plants (PCE1), terrestrial plants (PCE1, PCE2, PCE3), and small mammals (PCE2, PCE3). Risk to plants is presumed, in the absence of phosmet toxicity data suitable for risk estimation. Based on phosmet EECs and the surrogate toxicity data for organophosphate pesticides (*e.g.*, naled), non-vascular aquatic plants may be adversely affected by phosmet exposure to an extent that would result in modification of critical habitat for CTS; effects on vascular plants may be unlikely but cannot be dismissed in the absence of data. Phosmet EECs and surrogate data for the organophosphate profenofos indicate that adverse effects on terrestrial plants, especially those in semi-aquatic areas, are possible. Finally, RQ values for small mammals exceed the LOC for all uses of phosmet.

Based on the weight-of-evidence, an overall "habitat modification" determination is made for potential effects of phosmet to the CTS prey base and the specified, biologically mediated PCEs of designated critical habitat for the Central California and Santa Barbara County CTS DPSs.

5.2.4. Spatial Extent of Potential Effects

Given the preliminary "may affect" determination, based on LOC exceedances and other weight of evidence, analysis of the spatial extent of potential effects is needed to determine where effects may occur in relation to the treated site. If the potential area of usage and subsequent Potential Area of Effects overlap with the Central California, Santa Barbara County, or Sonoma County DPSs and/or the designated critical habitat (*i.e.*, Central California and Santa Barbara County DPSs), a "likely to adversely affect (LAA)" determination is made. If the Potential Area of Effects does not overlap with a specified DPS and/or designated critical habitat, a "no effect" determination is made.

To determine this area, the footprint of phosmet's use pattern is identified using corresponding land cover data (see Section 2.7). This area is defined by the following NLCD land cover classes: cultivated crop, based on potential use on nut and fruit trees; orchard and vineyard, based on grapes and blueberries; forest, based on deciduous trees; and pasture and hay, based on alfalfa usage. Actual usage is expected to occur in a smaller area as the chemical is only expected to be used on a portion of the identified area. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by surface water transport and spray drift (Use Footprint plus distance downstream and downwind from use sites where organisms relevant to the CTS may be affected). The determination of the buffer distance and downstream dilution for spatial extent of the effects determination is described below.

5.2.4.a. Use Data

To determine terrestrial and aquatic habitats of concern due to phosmet exposures, it is necessary to identify where phosmet is being used. Eight years of county-level usage data (1999-2007) were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database and included in this analysis. From Table 2-4, the majority of the phosmet is used on nut trees (approximately 295,000 lbs ai annually) and fruit trees (205,000 lbs ai annually). From Table 2-5, 90% of phosmet is used annually in 10 counties; Kern, Fresno, Tulare, Kings, San Joaquin, Stanislaus, Madera, Sacramento, Butte, and Yuba counties. Eight of these counties either contain or border counties that contain areas of CTS critical habitat (Kern, Fresno, Tulare, Kings, San Joaquin, Stanislaus, Madera, and Sacramento counties) (see Figure 2-2).

5.2.4.b. Spray Drift

In order to determine terrestrial and aquatic habitats of concern due to phosmet exposures through spray drift, it is necessary to estimate the distance that spray applications can drift from the treated area and still be present at concentrations that exceed levels of concern. For the flowable uses, a quantitative analysis of spray drift distances was completed using AgDRIFT (v. 2.01) and information available on the labels for phosmet. The maximum application rate used in the assessment was for the California almond scenario (8.5 lbs product/A and 5.95 lbs a.i./A). Labels for phosmet stipulate the following measures for aerial applications:

- Release height of 10 feet above the canopy
- Minimum wind speed of 10 mph
- A coarse spray droplet distribution (a volume mean diameter of 385 microns or greater)
- A boom width 75% of the wing span
- A minimum of 5 gallons per acre of water

The canopy height for the tree nut was assumed to be 50 feet (Pittinger, 2004), making the release height for the AgDrift runs 60 feet. The nonvolatile rate was 8.5 lbs/A, the active rate was 5.95 lbs/A, and the nonvolatile specific gravity was 0.28, based on a density obtained from the Imidan 70-W Material Safety Data Sheet of 15 lbs/ft^3. All other parameters in AgDrift were left as the default values. The AgDrift, Tier III model was run for an aquatic and terrestrial assessment. An example of the input parameters is provided in Appendix M. The most sensitive LOC to RQ ratio was used in each assessment. For the aquatic assessment, the most sensitive ratio was for acute freshwater invertebrates (LOC=0.05, RQ=123). For the terrestrial assessment, the most sensitive ratio was acute terrestrial invertebrates (LOC=0.05, RQ=149). For both the aquatic and terrestrial assessment, AgDrift estimated that the exposures would be expected to be below the LOC at a potential distance greater than 2,640 feet.

5.2.4.c. Downstream Dilution Analysis

The CTS may be exposed to phosmet introduced into its aquatic habitat by downstream transport from a target application site. Although the aquatic-phase CTS primarily utilizes static or very slow-flowing bodies of water, these habitats may be connected with or supplied by moving surface waters. To assess the potential extent of exposure resulting from surface water transport, the downstream dilution model was used to calculate the distance from a target application site within which EECs could be above levels that would exceed the LOC for the most sensitive freshwater endpoint.

For downstream dilution analysis, the most sensitive aquatic endpoint is defined as the endpoint with the greatest RQ to LOC ratio. In the case of phosmet, the toxicity data for freshwater invertebrates (scud 48-hr LC_{50} = 2 µg/L, LOC = 0.05) and peak EEC from PRZM/EXAMS (262 µg/L) were used to establish the RQ to LOC ratio [2,620 (131/0.05)]. Assuming uniform runoff across the landscape, it is assumed that streams flowing through treated areas (*i.e.*, the Initial Area of Concern) are represented by the modeled EECs from PRZM/EXAMS; as those waters move downstream, the influx of non-impacted water is expected to dilute the concentration of phosmet. The land cover class (e.g., cultivated crop, orchards and vineyards, forest, and pastures and hay) is an additional input to the downstream dilution model.

Based on these data, the maximum continuous distance of downstream dilution of phosmet, relative to the edge of the Initial Area of Concern and in which aquatic LOCs relevant to the CTS may be exceeded, is 300 kilometers. The downstream dilution approach is described in more detail in Appendix K.

5.2.4.d. Overlap of Potential Areas of Effect and Habitat and Occurrence of CTS

The spray drift and downstream dilution analyses help to identify areas of potential effect to the CTS from registered uses of phosmet. The Potential Area of Effects on survival, growth, and reproduction for the CTS from phosmet spray drift extend from the site of application to greater than 2,640 feet from the site of application. For exposure via surface water transport (*i.e.*, downstream dilution), the area of potential effects extends up to 300 km downstream from the site of application. When these distances are added to the footprint of the Initial Area of Concern (which represents potential phosmet use sites) and compared to CTS habitat, there are several areas of overlap (Figure 5-1**)**. The overlap between the areas of effect and CTS habitat, including designated critical habitat, indicates that phosmet use in California has the potential to adversely affect the CTS. More information on and detailed views of the spatial analysis are available in Appendix K.

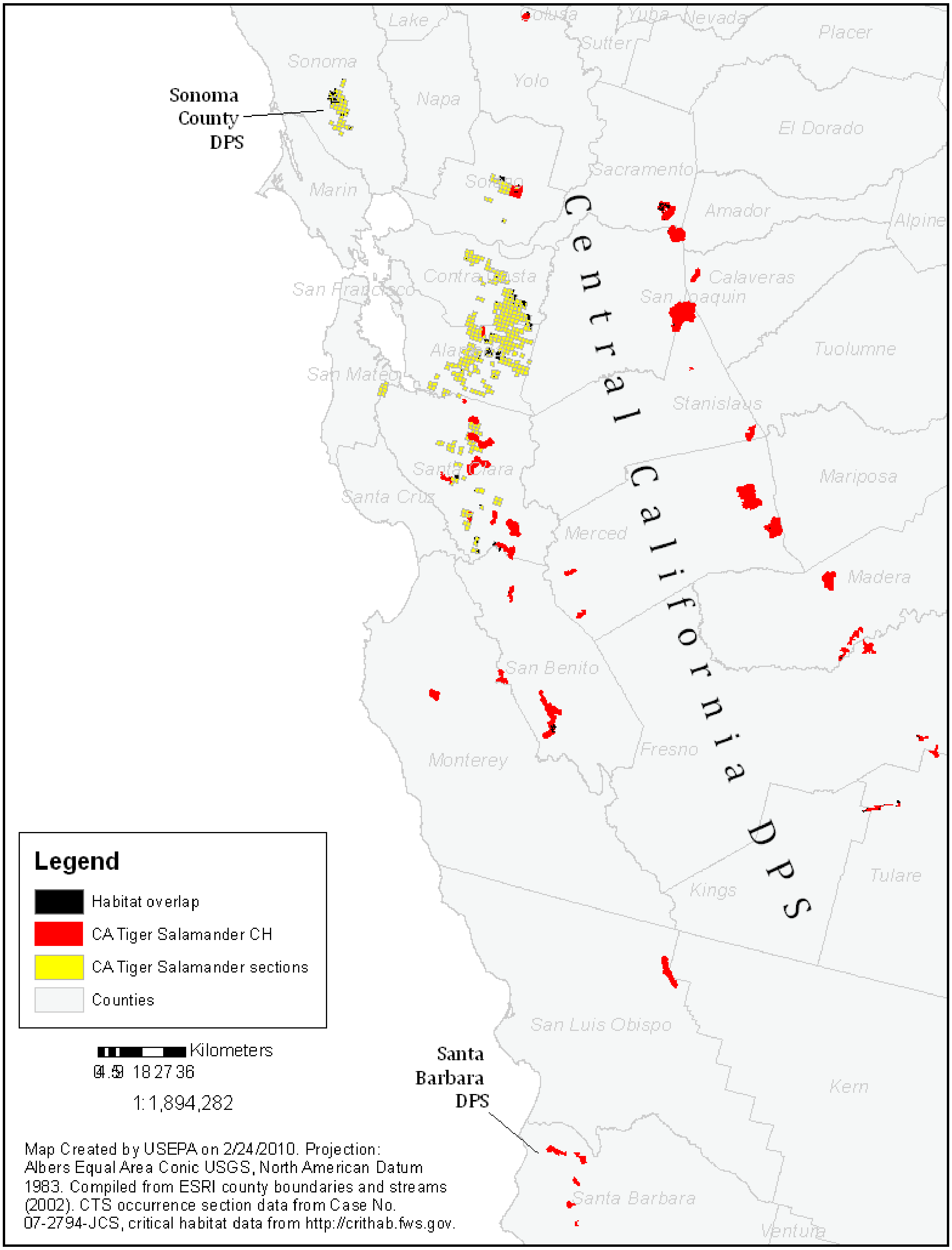


Figure 5-1. Map Showing the Overlap of CTS Critical Habitat and Occurrence Sections Identified by Case No. 07-2794-JCS with the NLCD Cultivated Crop Land Cover Class.

5.3. Effects Determinations

5.3.1. California Tiger Salamander

The effects determination for phosmet is based upon the most sensitive available ecotoxicity data for taxonomic groups considered to be ecologically relevant to CTS, as compared to environmentally relevant concentrations from monitoring data and the modeled uses of phosmet. Phosmet is classified as very highly toxic to freshwater fish and invertebrates on an acute exposure basis, while it is considered moderately toxic to birds on a subacute dietary exposure basis and to mammals on an acute oral exposure basis. In addition, phosmet is highly toxic to honey bees on an acute contact exposure basis. Effects on terrestrial and aquatic plants are uncertain, because toxicity data specific to phosmet are unavailable. However, phosmet is known to cause premature leaf drop in some sweet cherry varieties, and a comparison of phosmet EECs to toxicity endpoints for the organophosphate pesticides naled and profenofos indicate a potential for phytotoxic effects.

When the available toxicity data are compared to EECs for the labeled uses of phosmet in California, the resulting RQ values exceed the LOC for multiple taxa relevant to both direct and indirect effects to CTS. The results similarly indicate a potential for modification of PCEs in CTS designated critical habitat. Finally, spatial analysis indicates a potential for overlap between each of the specified DPSs and the designated critical habitat with potential areas of use. Therefore, the Agency makes a **"may affect"** and **"likely to adversely affect**" determination for CTS in the Central California, Santa Barbara County, and Sonoma County DPSs, and makes a "**habitat modification"** determination for CTS designated critical habitat associated with the Central California and Santa Barbara County DPSs.

5.3.2. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in Section 2.9.1. The risk hypotheses represent concerns in terms of direct and indirect effects of phosmet on CTS and its designated critical habitat; based on the conclusions of this assessment, none of the risk hypotheses can be rejected.

Specifically, the labeled use of phosmet may:

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

- indirectly affect CTS and affect the designated critical habitat by reducing or changing the composition of the aquatic plant community in the species' current range, thus, affecting primary productivity and/or cover.

6. Uncertainties

Uncertainties that apply to most assessments completed for the San Francisco Bay Species Litigation are discussed in Attachment 1. This section describes additional uncertainties specific to the assessment of potential risks to the CTS from California uses of phosmet.

6.1. Exposure Assessment Uncertainties

6.1.1. Usage Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. Eight years of data (1999-2007) were included in this analysis because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was provided by CDPR for these years only. No methodology for removing outliers was provided by CDPR for 1998 and earlier pesticide data; therefore, this information was not included in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been cancelled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide usage data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

6.1.2. Aquatic Exposure Modeling of Phosmet

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

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

The Agency acknowledges that there are some unique aquatic habitats that are not accurately captured by this modeling scenario and modeling results may, therefore, under- or over-estimate exposure, depending on a number of variables. For example, CTS may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than that modeled with the standard farm pond. The Agency does not currently have sufficient information regarding the hydrology of these aquatic habitats to develop a specific alternate scenario for the CTS. The CTS is restricted to vernal pools and seasonal ponds in grassland and oak savannah plant communities in central California. While the CTS may utilize semi-permanent and permanent ponds, to do so would mean they would face greater risk of predation when fish are present. Therefore, the standard farm pond, while not representative of the CTS scenario, is assumed to be conservative of exposure to aquatic-phase CTS. In addition, the Services have agreed that the existing standard farm pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004).

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

Uncertainties associated with each of these individual components add to the overall uncertainty of the modeled concentrations. Additionally, model inputs from the environmental fate degradation studies are chosen to represent the upper confidence bound on the mean values that are not expected to be exceeded in the environment approximately 90 percent of the time. Mobility input values are chosen to be representative of conditions in the environment. The natural variation in soils adds to the uncertainty of modeled values. Factors such as application date, crop emergence date, and canopy cover can also affect estimated concentrations, adding to the uncertainty of modeled values. Factors within the ambient environment such as soil temperatures, sunlight intensity, antecedent soil moisture, and surface water temperatures can cause actual aquatic concentrations to differ for the modeled values.

Unlike spray drift, tools are currently not available to evaluate the effectiveness of a vegetative setback on runoff and loadings. The effectiveness of vegetative setbacks is highly dependent on the condition of the vegetative strip. For example, a well-established, healthy vegetative setback can be a very effective means of reducing runoff and erosion from agricultural fields. Alternatively, a setback of poor vegetative quality or a setback that is channelized can be ineffective at reducing loadings. Until such time as a quantitative method to estimate the effect of vegetative setbacks on various conditions on pesticide loadings becomes available, the aquatic exposure predictions are likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

6.1.3. Modeled Versus Monitoring Concentrations

In order to account for uncertainties associated with modeling, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for phosmet concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (*e.g*., application rates and timing, crops) associated with the agricultural areas are unknown; however, they are assumed to be representative of potential phosmet use areas. Peak model-estimated environmental concentrations resulting from different phosmet uses range from 2.08 to 245 µg/L. The maximum concentration of phosmet reported by NAWQA for California surface waters with agricultural watersheds is ≤ 0.21 µg/L. This value is approximately 1,000 times less than the maximum model-estimated environmental concentration. The maximum concentration of phosmet reported by the California Department of Pesticide Regulation surface water database (0.63 µg/L) is roughly 415 times lower than the highest peak model-estimated environmental concentration. However, it should be noted that the modeled estimated exposure concentrations for phosmet were based on conservative input parameters (*e.g.*, assumed stable to aquatic degradation, increased the aerobic half-life by three times) and PRZM/EXAMS scenarios which were designed to be conservative. As a result, the PRZM/EXAMS EECs provide a conservative measure of exposure for the CTS.

6.1.4. Terrestrial Exposure Modeling of Phosmet

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

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

Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods do not account for a potentially important aspect of food requirements. Depending upon the species and dietary matrix, avian assimilation of wild diet energy ranges from 23 – 80%, and mammalian assimilation ranges from 41 – 85% (USEPA, 1993). Assuming that laboratory chow is formulated to maximize assimilative efficiency (e.g., a value of 85%), an assumption that consumption of food in the wild is comparable with consumption during laboratory testing may underestimate exposure in the wild because metabolic rates are not equivalent to food consumption.

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

T-REX

Although many amphibians are unlikely to consume plant material, the small bird (20 g) consuming short grass is used as a screen for risk to amphibians in T-REX because it is more conservative than modeling an alternative amphibian diet. Therefore, in the case of phosmet, the short grass screen is estimated to be more protective of the CTS. Where RQ values for the small bird consuming short grass do not exceed the Agency's LOCs, adverse effects to the CTS are unlikely to occur. If RQ values exceed the LOC, refined RQ values for amphibians are calculated using T-HERPS.

T-HERPS

For foliar applications of liquid formulations, T-HERPS estimates exposure for the following groups of dietary items: broadleaf plants and small insects; fruits, pods, seeds, and large insects; smal herbivore mammals; small insectivore mammals; and small amphibians. Amphibians may consume items from all of these dietary classes. The default size classes of amphibians represented in T-HERPS are small (2 g), medium (20 g), and large (200 g). The medium (20 g) amphibian in T-HERPS is most representative of the terrestrial-phase CTS (14 g – 80 g; Trenham *et al*., 2000). The default vertebrate prey sizes that medium and large amphibians can consume are 13.3 g and 133 g, respectively; small (2 g) amphibians are not expected to consume vertebrate prey. EECs and RQs are calculated for the most sensitive ecologically relevant dietary and size classes in T-HERPS. In the case of phosmet, EECs and RQs for the CTS are calculated for the medium amphibian (20 g) consuming small (13.3 g) herbivorous mammals

The lack of information regarding foraging strategies for amphibians, specifically for CTS, results in some uncertainty regarding estimates of exposure and risk. The most sensitive values result from the inclusion of small herbivorous mammals as prey (T-HERPS). However, with regard to frequency of consumption, it is likely that mammals (and amphibians) comprise a smaller portion of the CTS diet than do invertebrates. Therefore, the estimates of exposure and risk associated with the consumption of small mammals reflect an upper bound estimate of peak exposure. Additional information on the feeding ecology of CTS, including but not limited to encounter rates for specific prey items, relative proportions of prey in stomach contents, and seasonal foraging patterns, would better inform future assessments of risk.

Table 6.1 shows values for EECs and RQs for various size and dietary classes of amphibians in T-HERPS, as percentages of the EECs and RQs presented for the most sensitive size and dietary class (*i.e.*, 20 g amphibians consuming 13.3 g herbivorous mammals). This information can be used to further characterize potential risk specific to the diet of amphibians. As with birds and mammals in T-REX, not enough data are available to conclude that amphibians exclude or exclusively rely upon a particular dietary class. RQs for the most sensitive size and dietary class are expected to overestimate risk to amphibians that consume a variety of dietary items. For example, if the RQ is 100 for a 20 g amphibian consuming small herbivorous mammals, then the RQ for a 20 g amphibian that only consumes broadleaf plants and small insects is 3 (100 x 3%).

Table 6-1. Relationship Between EECs and RQs for Different Sizes and Dietary Classes of Amphibians in T-HERPS, as Percentages of Values for the Most Sensitive Size and Dietary Class for the CTS (*i.e.*, 20 g amphibian consuming small herbivorous mammals).

Dietary Items	**Percentage of EECs and RQs for Most Sensitive Size and Dietary Class (20 g amphibian consuming small herbivorous mammals)**		
	Dose-Based EECs and RQs		
	2 g Amphibian[1]	20 g Amphibian	200 g Amphibian[2]
Broadleaf plants/sm insects	5%	3%	2%
Fruits/pods/seeds/lg insects	0.5%	0.3%	0.2%
Small herbivore mammals[3]	N/A	**100%**	37%
Small insectivore mammals[3]	N/A	6%	2%
Small amphibians[3]	N/A	2%	1%
	Dietary-Based EECs and RQs		
Broadleaf plants/sm insects	56%		
Fruits/pods/seeds/lg insects	6%		
Small herbivore mammals	**100%**		
Small insectivore mammals	6%		
Small amphibians	2%		

Bolded values represent values for the most sensitive size and dietary class of amphibians used in the assessment of potential risks to terrestrial-phase CTS from phosmet exposure.
N/A Not applicable.
[1] EECs and RQs for the 2 g amphibian are relevant to the terrestrial-phase CTS only for the assessment of indirect effects via effects on amphibian prey items.
2 Values for the 200 g amphibian are presented to illustrate that dose-based EECs and RQs are expected to decline as the size of the amphibian increases. The upper bound of the size range for terrestrial-phase CTS is approximately 80 g (Trenham *et al*., 2000).
[3] Small (2 g) amphibians are not expected to consume vertebrate prey items.

6.2. Effects Assessment Uncertainties

6.2.1. Data Gaps and Uncertainties

Aerobic and anaerobic aquatic metabolism studies, used to describe the fate of phosmet in surface water bodies, have not been submitted. As such, conservative estimates (assuming stability) were used in lieu of the missing data. Such data are used to reliably estimate the concentrations to which fish and invertebrates may be exposed. Additionally, the studies could potentially identify any transformation products that may occur.

Further, additional information is needed to better quantify the exposure of the phosmet oxon under environmental conditions. Oxon degradates of other organophosphate (OP) pesticides have been reported equally or more toxic than parent, although fate and relevant ecotoxicity data for the phosmet oxon remain unavailable. As a result, the EECs and associated risk conclusions in this assessment could be underestimated.

The ecological effects data set for phosmet is largely complete, though the endpoints used in this assessment are from studies that lack dose response curve data and have limited discussion of sublethal effects. The phosmet studies cited in this assessment met the requirements for inclusion in the ECOTOX database and the OPP criteria for qualitative and/or quantitative use in risk assessments.

There are no studies assessing the potential for phosmet to impact nontarget terrestrial plants. Given the breadth of crop species for which phosmet is labeled, the mode of action and the lack of plant incident data, the potential for injury to nontarget plants is uncertain. However, label restrictions state that sweet cherry (*Prunus* spp.) crops should not be treated with phosmet. Phosmet is known to cause premature leaf drop, particularly in some sweet cherry cultivars. This suggests some plant species may be sensitive to phosmet exposure. Given that other *Prunus* species and crops in the same family (Rosaceae) are labeled uses, sensitivity may be highly species-specific. Nonetheless, the chemically-related organothiophosphate insecticide profenofos is also known to have phytotoxic effects. The lack of phytotoxicity data for phosmet is a source of uncertainty in assessing the potential for direct and indirect adverse effects on non-target organisms.

As with terrestrial plants, there are no studies assessing the potential for phosmet to impact nontarget aquatic plants. For the reasons given above, aquatic plant toxicity endpoints for the organophosphate pesticides naled are used, as they represent the most sensitive available endpoints for the class of organophosphate insecticides. The lack of data specific to phosmet represents another important uncertainty in this assessment.

Finally, no studies are available that evaluate the toxicity of currently registered formulated products to non-target organisms. Previous assessments (*e.g.*, USEPA, 2008) reported results of tests with Imidan 50WP and Imidan 3E, which were in some cases (*e.g.*, bluegill) more toxic than the TGAI. However, these products were cancelled, and it is unknown whether currently registered formulations are similar in toxicity.

6.2.2. Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on phosmet are not available for aquatic-phase amphibians; therefore, freshwater fish are used as surrogate species for aquatic-phase amphibians and the CTS. Endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase amphibians including the CTS. Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. To account for these uncertainties, the Agency's LOCs are intentionally set low, and deliberately conservative assumptions are made in the screening level risk assessment.

As previously noted, the avian effects assessment is based on dietary endpoints only. There is an acute dose-based endpoint available, but it is greater than the Agency's limit dose for testing (> 2,000 mg a.i./kg bw). The endpoint is based on the mallard duck and is the only available LD_{50} value. The mallard duck also has a nondefinitive subacute dietary toxicity endpoint, also greater than the Agency's limit dose (> 5,000 mg a.i./kg diet). It is not known if a dose-based study with the bobwhite quail or a passerine species would result in a definitive endpoint, so there is uncertainty in the assessment because only the dietary endpoint is used to derive RQs.

Toxicity data for non-target plants exposed to phosmet have not been submitted by the registrant and are unavailable in the ECOTOX open literature. In the absence of data, risk to aquatic and terrestrial plants cannot be precluded. The potential for risk to non-target plants is discussed in the Risk Description and is characterized based upon the lowest toxicity endpoints for the available tests with organophosphate insecticides. Specifically, endpoints for the pesticide naled are used to characterize risk to aquatic plants, and endpoints for profenofos are used to characterize risk to terrestrial plants. However, even though these endpoints represent the lowest toxicity thresholds from the available organophosphate data, it is not known whether phosmet is more or less phytotoxic than these surrogates. Phosmet exposure is known to cause premature leaf drop in certain sweet cherry varieties, but current labels permit application to tart cherries. Adverse effects on other plant species have not been reported. Therefore, it is uncertain to what extent the potential for phytotoxicity is specific to a given plant variety, species, or class (*i.e.*, monocots, dicots).

6.2.3. Sublethal Effects

When assessing acute risk, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the 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.

No additional data are available on the sublethal effects of phosmet beyond the effects described in Sections 4.2 and 4.3 on reproduction, growth, and body weight for freshwater fish and invertebrates, birds, and mammals. However, the absence of data cannot be construed as the absence of effects. To the extent to which other sublethal effects are not considered in this assessment, the potential direct and indirect effects of phosmet on CTS may be underestimated.

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 phosmet to CTS and their designated critical habitat.

Based on the best available information, the Agency makes a "likely to adversely affect" determination for CTS in the Central California, Santa Barbara County, and Sonoma County DPSs. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the Central California and Santa Barbara County CTS DPSs associated with the use of phosmet. Given the LAA determination and potential modification of designated critical habitat for CTS, a description of the baseline status and cumulative effects is provided in Attachment 3.

A summary of the risk conclusions and effects determinations for the CTS and their critical habitat, given the uncertainties discussed in Section 6 and Attachment 1, 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 Phosmet on CTS in the Central California, Santa Barbara County, and Sonoma County Distinct Populations Segments

DPS	Effects Determination	Potential for Direct Effects
Central California Santa Barbara County Sonoma County	May affect/ LAA	***Aquatic-phase (Eggs, Larvae, and Adults):*** RQ values based on mortality and reduced number of offspring in freshwater fish (a surrogate for aquatic-phase amphibians) exceed the listed species and chronic LOCs, respectively. ***Terrestrial-phase (Juveniles and Adults)***: Acute and chronic dietary-based RQ values based on mortality and reduced reproduction (*i.e.*, number of eggs) in birds (a surrogate for terrestrial-phase amphibians) exceed the LOCs.
DPS	**Effects Determination**	**Potential for Indirect Effects**
Central California Santa Barbara County Sonoma County	May affect/ LAA	***Aquatic prey items, aquatic habitat, cover and/or primary productivity*** The LOCs are exceeded for aquatic prey items with respect to (1) acute effects (*i.e.*, mortality) in freshwater fish (*eg.*, amphibians) and invertebrates and (2) chronic effects in freshwater fish (*eg.*, amphibians) and freshwater invertebrates based on reduced numbers of offspring., Risk to aquatic and terrestrial plants is presumed in the absence of phytotoxicity data specific to phosmet; this indicates a potential for indirect effects via direct effects on prey (aquatic non-vascular plants), aquatic habitat (aquatic vascular plants and terrestrial/semi-aquatic plants), and primary productivity (aquatic vascular plants and terrestrial/semi-aquatic plants).

DPS	Effects Determination	Potential for Direct Effects
		Terrestrial prey items, riparian habitat In the absence of phytotoxicity data for phosmet, the potential for reductions in riparian habitat and primary productivity resulting from risk to terrestrial plants cannot be precluded. Additional reductions in habitat are expected based on exceedances of acute and chronic LOCs for small mammals. The small mammal exceedances, joined with acute and chronic exceedances for birds (*i.e.*, terrestrial-phase amphibians) and terrestrial invertebrates, also contribute to a potential reduction in the prey base.

[LAA] Likely to adversely affect.

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

DPS	Effects Determination	Basis for Determination
Central California Santa Barbara County	Habitat modification	PCEs are expected to be modified for aquatic habitat (PCE1), terrestrial habitat (PCE2), and corridors for migration and dispersal (PCE3) based upon LOC exceedances for small mammals and an asusmption of risk for to aquatic and terrestrial plants, in the absence of phytotoxicity data for phosmet. Phosmet use also may modify critical habitat by reducing the prey base as a result of direct effects on aquatic-nonvascular plants (presumed in the absence of phytotoxicity data), amphibians, mammals, and invertebrates.

Table 7-3. Phosmet Use-specific Risk Summary for CTS

Use(s)	Species Effects Determ.	Critical Habitat Mod.	Potential for Effects Taxon (Acute and/or Chronic Effects)			
			Aquatic Phase		*Terrestrial Phase*	
			Direct	**Indirect**	**Direct**	**Indirect**
Alfalfa	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (C) Mamm. (A, C) Invert. (A) Plants
Almonds, filberts, pecans, pistachios, walnuts, other tree nuts	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Apples, crabapples	LAA	Yes	Fish (A,C)	Fish (C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Apricots, cherries (tart), nectarines, peaches, plums, prunes	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Blueberries	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Christmas trees, pine trees, conifer and	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C)

Use(s)	Species Effects Determ.	Critical Habitat Mod.	Potential for Effects Taxon (Acute and/or Chronic Effects)			
			Aquatic Phase		*Terrestrial Phase*	
			Direct	**Indirect**	**Direct**	**Indirect**
deciduous trees						Invert. (A) Plants
Citrus	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Grapes	LAA	Yes	N/A	Invert. (A) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Ornamentals	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Pears	LAA	Yes	Fish (A,C)	Fish (A,C) Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Peas	LAA	Yes	Fish (A,C)	Invert. (A,C) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants
Potatoes, sweet potatoes	LAA	Yes	N/A	Invert. (A) Plants	Birds (A,C)	Birds (A,C) Mamm. (A, C) Invert. (A) Plants

Abbreviations: Determ. = Determination, Mod. = Modification, LAA = Likely to adversely affect, A = acute effects, C = chronic effects, Fish = freshwater fish (and aquatic-phase amphibians), Invert. = invertebrates, Birds = birds (*i.e.*, terrestrial-phase amphibians), Mamm. = mammals, N/A = not applicable

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

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

- Enhanced information on the density and distribution of CTS life stages within the action area and/or applicable designated critical habitat. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the assessed species.

- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual species and potential modification to critical habitat.

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