Risks of Zinc Phosphide Uses to the Federally Threatened Alameda Whipsnake (*Masticophis lateralis euryxanthus)*

And Federally Endangered Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*)

Pesticide Effects Determinations
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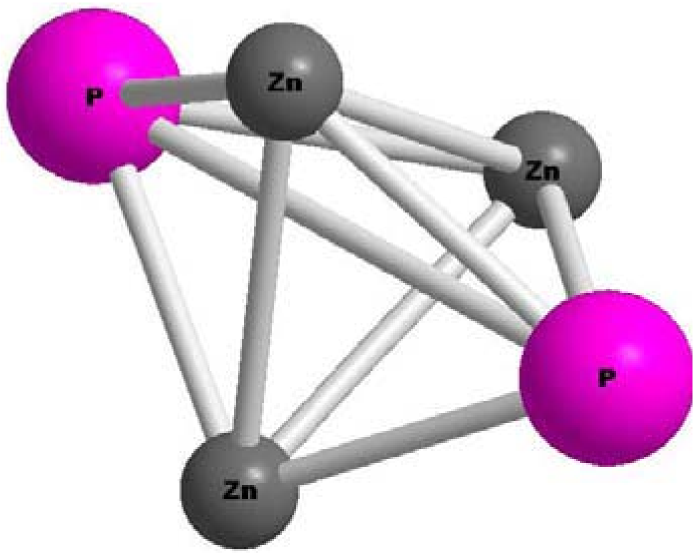

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Table of Contents

Appendices

Attachments

Attachment I: Supplemental Information on Standard Procedures for Threatened and Endangered Species Risk Assessments on the San Francisco Bay Species
Attachment II: Status and Life History for the San Francisco Bay Species
Attachment III: Baseline Status and Cumulative Effects for the San Francisco Bay Species

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
AW	Alameda Whipsnake
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
CBD	Center for Biological Diversity
CCR	California Clapper Rail
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CFWS	California Freshwater Shrimp
CI	Confidence Interval
CL	Confidence Limit
CTS	California Tiger Salamander
CTS-CC	California Tiger Salamander Central California Distinct Population Segment
CTS-SB	California Tiger Salamander Santa Barbara County Distinct Population Segment
CTS-SC	California Tiger Salamander Sonoma County Distinct Population Segment
DS	Delta Smelt
EC	Emulsifiable Concentrate
EC_{05}	5% Effect Concentration
EC_{25}	25% Effect Concentration
EC_{50}	50% (or Median) Effect Concentration

ECOTOX	EPA managed database of Ecotoxicology data
EEC	Estimated Environmental Concentration
EFED	Environmental Fate and Effects Division
e.g.	Latin *exempli gratia* ("for example")
EIM	Environmental Information Management System
EPI	Estimation Programs Interface
ESU	Evolutionarily significant unit
et al.	Latin *et alii* ("and others")
etc.	Latin *et cetera* ("and the rest" or "and so forth")
EXAMS	Exposure Analysis Modeling System
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FQPA	Food Quality Protection Act
ft	Feet
GENEEC	Generic Estimated Exposure Concentration model
HPLC	High Pressure Liquid Chromatography
IC_{05}	5% Inhibition Concentration
IC_{50}	50% (or median) Inhibition Concentration
i.e.	Latin for *id est* ("that is")
IECV1.1	Individual Effect Chance Model Version 1.1
KABAM	K_{OW} (based) Aquatic BioAccumulation Model
kg	Kilogram(s)
kJ/mole	Kilojoules per mole
km	Kilometer(s)
K_{AW}	Air-water Partition Coefficient
Kd	Solid-water Distribution Coefficient
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
pH	Symbol for the negative logarithm of the hydrogen ion activity in an aqueous solution, dimensionless
pKa	Symbol for the negative logarithm of the acid dissociation constant, dimensionless
ppb	Parts per Billion (equivalent to µg/L or µg/kg)

ppm	Parts per Million (equivalent to mg/L or mg/kg)
PRD	Pesticide Re-Evaluation Division
PRZM	Pesticide Root Zone Model
ROW	Right of Way
RQ	Risk Quotient
SFGS	San Francisco Garter Snake
SJKF	San 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 Alameda whipsnake (*Masticophis lateralis euryxanthus*, AW) and salt marsh harvest mouse (*Reithrodontomys raviventris*, SMHM) arising from Federal Insecticide Fungicide and Rodenticide Act (FIFRA) regulatory actions regarding use of zinc phosphide on all use sites. In addition, this assessment evaluates whether these uses can be expected to result in modification of designated critical habitat for the AW. Critical habitat has not been designated for the SMHM. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998), procedures outlined in the Agency's Overview Document (USEPA, 2004), and consistent with a suit in which zinc phosphide was alleged to be of concern to the AW and SMHM (*Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS)).

The AW was listed as threatened in 1997 by the USFWS. The species occurs in the Inner Coast Ranges in Contra Costa, Alameda, San Joaquin, and Santa Clara Counties in California. The SMHM was listed by the USFWS as an endangered species in 1970. The species is found in tidal and non-tidal salt marshes along the San Francisco, San Pablo, and Suisun Bays in California.

1.2. Scope of Assessment

Zinc phosphide is an inorganic rodenticide used to control gophers, mice, rats, lagomorphs (*e.g.*, jack rabbits), prairie dogs, and squirrels and was first registered as a pesticide in the U.S. by the U.S. Department of Agriculture (USDA) in 1947. Formulations include dusts intended for mixing into baits, solid baits, and tracking powders. Zinc phosphide baits are applied by hand, machine spreader, cyclone seeder, and aircraft. Currently, 28 zinc phosphide products are registered.

1.2.1. Uses Assessed

Zinc phosphide has indoor and outdoor uses. Indoor uses are classified as: **indoor food** (agricultural/farm structures/buildings and equipment; and storage areas-full); **indoor non-food** (commercial transportation facilities-nonfeed/nonfood; commercial/institutional/industrial premises/equip. (indoor); public buildings/structures (vert. pest control); and ships and boats); **indoor residential** (household/domestic dwellings; and household/domestic dwellings indoor premises). Outdoor uses are classified as: **forestry** (conifer release; forest plantings (reforestation programs)(tree farms, tree plantations, etc.); forest trees (all or unspecified); forest trees (hardwoods, broadleaf trees); forest trees (softwoods, conifers); and hybrid cottonwood/poplar plantations); **outdoor residential** (household/domestic dwellings outdoor premises; and residential lawns); **terrestrial feed crop** (alfalfa; grass forage/fodder/hay; pastures; rangeland; and timothy); **terrestrial food + feed crop** (agricultural crops/soils (unspecified); agricultural rights-of-way/fencerows/hedgerows; agricultural uncultivated areas; corn (unspecified); grapes; *Momordica* spp.; orchards (unspecified); sugar beet; sugarcane; and vegetables (unspecified)); **terrestrial food crop** (artichoke; blackberry; blueberry; bushberries; caneberries; chayote;

cucumber; cucurbit vegetables; currant; elderberry; gherkin; gooseberry; gourd (wax), Chinese; gourds; huckleberry; loganberry; macadamia nut (bushnut); melons, citron; melons, musk; melons, water; nursery stock; orchards (unspecified); pumpkin; raspberry (black, red); squash (summer); squash (winter) (hubbard); and strawberry); **terrestrial non-food + outdoor residential** (ornamental and/or shade trees; ornamental herbaceous plants; ornamental lawns and turf; ornamental nonflowering plants; and ornamental woody shrubs and vines); **terrestrial non-food crop** (agricultural crops/soils (unspecified); agricultural rights-of-way/fencerows/hedgerows; agricultural uncultivated areas; agricultural/farm structures/buildings and equipment; airports/landing fields; alfalfa; Christmas tree plantations; commercial/institutional/industrial premises/equipment (outdoor); deciduous fruit trees (unspecified); golf course turf; grapes; industrial / construction areas (outdoor); nonagricultural outdoor buildings/structures; nonagricultural rights-of-way/fencerows/hedgerows; nonagricultural uncultivated areas/soils; nursery stock; orchards (unspecified); ornamental and/or shade trees; ornamental herbaceous plants; ornamental lawns and turf; ornamental non-flowering plants; ornamental woody shrubs and vines; recreational areas; and utility poles/right-of-way) depending upon the application method and label restrictions. Additionally, zinc phosphide has uses that are listed as aquatic uses (agricultural drainage systems; drainage systems; and aquatic areas/water), but actually refers to use in rodent control near waterbodies and drainage ways.

Uses that occur strictly in indoor environments would not be expected to result in any direct or indirect exposure to the SMHM or AW, and therefore, pose no risk to the SMHM or AW. However, many label uses classified as "indoor" actually refer to uses that take place indoors and/or within 50 ft of residences or other structures. Therefore, all of the uses listed above (both indoor and outdoor) are considered as part of the federal action evaluated in this assessment. Only dust formulations that are reformulated and relabeled prior to application would be excluded from the federal action evaluated in this assessment.

The semantic confusion concerning uses classified as indoors actually referring to indoors and/or within 50 ft of residences and other structures has other important ramifications for this assessment. Because zinc phosphide was included in a 1993 biological opinion (U.S. FWS 1993), endangered species language excluding the use of zinc phosphide within 100 yds of SMHM habitat is included on the outdoor use labels. (The AW was not a listed species at the time of this biological opinion.) Potentially if such language were included on all of the zinc phosphide labels, the existing language might be sufficient to preclude exposure and risk to the SMHM. However, the indoor labels that actually refer to applications within 50 ft of residences and other structures do not contain this endangered species language.

1.2.2. Environmental Fate Properties of Zinc Phosphide

Similar to other (aluminum and magnesium) phosphide rodenticides, zinc phosphide produces its pesticidal action by a hydrolysis reaction to produce the toxic gas, phosphine (PH_3). However, the hydrolysis reaction for zinc phosphide is very slow under normal ambient environmental conditions (circum-neutral pH); whereas hydrolysis is rapid for aluminum and magnesium phosphides. Because of this difference in hydrolysis reaction rates, zinc phosphide's pesticidal action is achieved in a very different manner than that of aluminum and magnesium phosphide.

Aluminum and magnesium phosphide react with environmental moisture rapidly enough that sufficient phosphine gas concentrations are achieved for these compounds to be used as fumigants in rodent burrows. The rodents are killed through inhalation of the phosphine gas and subsequent absorption through the lining of the lungs.

In contrast, zinc phosphide is used with a bait material or as a tracking powder that only reacts after ingestion (tracking powder is ingested when the rodent cleans, *i.e.*, licks, the tracking powder from its feet and fur). The acid conditions of the digestive track cause the hydrolysis of zinc phosphide to occur much more rapidly, releasing phosphine gas in the digestive tract with subsequent adsorption through the lining of the digestive tract.

Zinc phosphide has several properties that make it relatively inert in the terrestrial environment. First, it is essentially insoluble in water which makes it largely immobile in soil. Second, hydrolysis occurs only very slowly under circum-neutral pHs. The binding agents used to attach the zinc phosphide to the bait material (*e.g.*, rolled oats) likely further protect the zinc phosphide from hydrolysis until the bait or binding agents degrade. Third, zinc phosphide has no chromophoric groups and, therefore, would not be expected to photodegrade. Terrestrial field dissipation studies typically produced half-lives of > 1 month (though, < 1 week in moist soils).

As phosphine is slowly produced through hydrolysis of zinc phosphide in the ambient terrestrial environment, the phosphine gas would be rapidly and strongly sorbed to the soil or diluted in the atmosphere (Hilton and Robison 1972). This slow release of phosphine is thought to be attractive to rodents because the smell is described as similar to garlic (MRID 43466302).

Attempts to use zinc phosphide as a fumigant for in burrow rodent control similar to the way that aluminum and magnesium phosphide are used proved to not be efficacious. Zinc phosphide does not react fast enough, even when wetted, to produce lethal concentrations of phosphine gas inside the confined space of a burrow. Therefore it is assumed to not produce sufficient concentrations of phosphine gas in the unconfined terrestrial areas in which it is applied (Krishnamurthy and Singh 1967).

In the aquatic environment, zinc phosphide degrades more rapidly than in the terrestrial environment because the principle degradation pathway, hydrolysis, would occur continuously rather than only when wetted or moist in the terrestrial environment. Because zinc phosphide is essentially insoluble, zinc phosphide would not disburse throughout a waterbody. Field observations of a zinc phosphide bait formulation that was accidentally applied over a stream indicated that the bait sank to bottom of the channel and slowly disappeared over the course of a week without apparent incident (Pank et al., 1975 as reported in MRID 43466302). In aquatic environments, the release of zinc ions may be the more ecologically harmful exposure rather than the generation of phosphine (MRID 43466302).

1.2.3. Evaluation of Degradates and Stressors of Concern

The major degradate of concern for zinc phosphide is phosphine gas. Essentially the zinc phosphide is a delivery agent for the biologically active degradate, phosphine. Other degradates are zinc hydrates and phosphate which are considered common in the environment. Given the small amounts used in a terrestrial application (maximum of 0.2 lbs ai/acre of phosphide bait), the amounts of phosphate and zinc ions are inconsequential. For example, Hilton et al. (1971) determined that the remaining zinc ions from use of zinc phosphide on sugarcane fields of Hawaii would contribute about 0.9 ppm zinc in the upper inch of soil during each 2-year crop cycle. This would not be a substantial addition compared to the 25-100 ppm already present as background in Hawaiian soils, which are largely of volcanic origin. In addition, the decomposition products in soil (phosphates and zinc ions) may be utilized by the plants as elemental zinc or phosphorus.

1.3. Assessment Procedures

This assessment includes quantitative estimates of exposure and effects that address the oral consumption of treated baits as a food source for mammals. No quantitative exposure estimates were made for the AW. Exposures for the snake are expected to be secondary from the consumption of recently dead or dying small prey that have consumed lethal doses of zinc phosphide. Owing to similar expectations of sensitivity to the pesticide, consumption of lethally intoxicated prey is assumed to be lethal to the AW as well. The intended use of zinc phosphide is as bait or tracking powder. Because of the properties of zinc phosphide and the bait formulations, it is assumed that the zinc phosphide remains almost exclusively with the bait and the bait does not move from the field of application. Tracking powders are also assumed to not be exported from the site of application in other than *de minimus* quantities because it is used in small quantities at specific sites where rodents are expected to travel (along walls, on rodent trails, or in the opening of rodent burrows).

In the case of the SMHM (a rodent), it is assumed that direct exposure to the zinc phosphide (a rodenticide) in the bait could result in consumption of a lethal dose of bait or consumption of a lethal dose through cleaning (licking) the tracking powder from the feet and fur. The results of a basic quantitative approach for oral exposure through diet suggests that an assumption that the risk of death for lethal effects is 100 percent appears supportable if the bait or tracking powder is applied within the area where the SMHM may scavenge for food or 0% (*de minimus* risk) if the bait or tracking powder is applied outside of the area where the SMHM may scavenge for food. Similarly for other effects (growth, reproduction, sublethal, etc.), it is assumed that the lethality assumption obviates the need to consider, in depth, these other effects if the bait or tracking powder is applied within the area where the SMHM may scavenge for food and that the risk is 0% for these other effects if the bait or tracking powder is applied outside of the area where the SMHM may scavenge for food. This logic is consistent with the USFWS rodenticide biological opinion (1993), which specifically addressed zinc phosphide in regards to the SMHM.

In the case of the AW, exposure would be through consumption of exposed prey items (small rodents and birds) (Attachment II). Because the phosphine gas produced in the digestive tract of the exposed prey items is rapidly degraded to non-toxic byproducts after adsorption through the lining of the digestive tract, only the zinc phosphide and phosphine gas remaining in the digestive tract is toxic. The prey's other tissues and organs are not toxic. In this assessment, it is assumed the AW consumes the entire prey item and that a recently exposed prey item would contain a sufficient dose of zinc phosphide in its digestive tract to kill an AW (see Johnson and Fagerstone 1994). Again, there is no quantitative evaluation of risk for the AW other than to assume that risk for lethal effects is 100 percent, if the bait or tracking powder is applied within the area where the AW hunts its prey, or 0% (*de minimus* risk) if the bait or tracking powder is applied outside of the area where the AW hunts its prey. Similarly for other effects (growth, reproduction, sublethal, etc.), it is assumed that the lethality assumption obviates the need to consider these other effects if the bait or tracking powder is applied within the area where the AW hunts its prey and that the risk is 0% for these other effects if the bait or tracking powder is applied outside of the area where the AW hunts its prey. Again, this logic is consistent with the USFWS rodenticide biological opinion (1993), although this document did not specifically address the AW.

1.3.1. Exposure Assessment

1.3.1.a. Aquatic Exposures

Aquatic exposure estimates for zinc phosphide were not evaluated for two reasons. First, the current labels for zinc phosphide do not allow application to water. Tracking powders would not be expected to contribute to zinc phosphide in a water body since tracking powders are used in relatively small quantities around buildings which would typically be located some distance from water. The most likely way for zinc phosphide to reach a water body would be through a bait application. However, baits are large objects that would not be easily transported through runoff or erosion of soil particles. The bait would not tend to be transported with water through crop stubble or planted or weedy fields. Second even if the bait made it to an aquatic environment, neither the AW nor the SMHM is an aquatic species or has obligate relationships with aquatic species. Analyses of plants exposed to zinc phosphide did not show measureable concentrations of zinc phosphide or phosphine in their tissues (SMHM are herbivorous). Although the SMHM lives in the upland portions of marshes and is able to swim, it seems unlikely that it would receive much exposure to an insoluble chemical through water contact or drinking.

1.3.1.b. Terrestrial Exposures

Oral exposures for the SMHM were assessed on the basis of direct consumption of treated bait at a zinc phosphide concentration of 2% (20g/kg-bait). Oral ingestion in the SMHM was estimated to be approximately 3.2 g of treated bait per day (the assumed TREX v1.4.1 model assumption for a similarly sized mammal (15 g) eating grain). The resultant daily oral dose of zinc phosphide from this approach is as follows:

(20g pesticide/kg-bait * 0.0032 kg food/day)/0.015 kg-bw = 4.27 g pesticide/kg-bw = 4270 mg pesticide/kg-bw.

Oral exposure for birds (indirect effects analysis appropriate for the SMHM) was constructed in a similar manner and made use of the medium size bird category in the TREX v 1.4.1 model. This involved an assumption of food intake for treated grain/bait at 65 g/day and a body weight of 100 g. The resultant daily oral dose of zinc phosphide from this approach is as follows:

(20g pesticide/kg-bait * 0.065 kg food/day)/0.1 kg-bw = 13 g pesticide/kg-bw = 13000 mg pesticide/kg-bw.

1.3.2. Toxicity Assessment

Orally ingested zinc phosphide is acutely and chronically toxic to mammals, and acutely toxic to birds as determined by direct empirical evidence. Available toxicity data allow for quantitative lethal and reproduction effects endpoints for mammals and a lethal effects endpoint for birds. There are no data to assess quantitatively the chronic reproduction toxicity to birds. However, because zinc phosphide produces adverse developmental and reproduction effects in mammals, this toxic potential in birds cannot be precluded. There are no direct empirical data to establish definitive lethal or reproduction endpoints in reptiles. Therefore avian lethal effects endpoint information will serve as a surrogate for a reptile lethal endpoint. Because of the absence of an avian reproduction endpoint reproduction risks for reptiles cannot be quantitatively assessed through consideration of either empirical reptile data or through surrogacy with birds and so reproduction toxicity is considered possible.

No empirical data are available for terrestrial invertebrate toxicity for the subject compound. However, because the compound is expected to liberate phosphine gas to the gut lumen upon ingestion, and because phosphine gas is a registered invertebrate pest control agent for fumigation of commodities, lethal toxicity for invertebrates upon consumption of zinc phosphide treated materials is assumed.

No laboratory toxicity data are available to quantitatively assess the effects of zinc phosphide on seedling emergence or vegetative vigor of terrestrial plant species. However, the material is routinely used in agricultural crop settings and available field data show no effects in at least one crop species. Therefore for the purposes of this risk assessment, terrestrial plant toxicity is considered to be insignificant.

1.3.3. Measures of Risk

This risk assessment uses quantitative methods for assessing acute and reproduction risks for small mammals, involving the calculation of a ratio of estimated exposure divided by the effects endpoint, as an indicator of risk. For other receptors, lethal risk is qualitatively assumed to occur within treatment areas for terrestrial animals consuming dead or dying animal prey intoxicated with zinc phosphide. Because available toxicity data for birds places acute lethal thresholds near those for small mammals, the same lethal response is expected in birds as in mammals following consumption of zinc phosphide treated baits and tracking powders. Because reproduction effects in mammals occur at exposure levels below those expected to induce lethality, that lethal risk assumption for mammals consuming bait is protective of possible reproduction effects as well. For chronic effects to birds and reptiles, no quantification of risk is possible because effects endpoints are unavailable. Similarly the absence of terrestrial invertebrate and plant effects measures precludes quantitative risk measures for these taxa. Other lines of evidence serve as qualitative indicators of risk or the absence of risk for terrestrial invertebrates and plants, respectively.

1.4. Summary of Conclusions

Based on the best available information, the Agency makes a May Affect, and Likely to Adversely Affect determination for all evaluated species from zinc phosphide's uses. Additionally, the Agency has determined that there is the potential for modification of designated critical habitat for the AW by virtue of effects on small mammal prey, invertebrate prey, bird prey and reducing available mammal burrows for shelter. A summary of the risk conclusions and effects determinations for each listed species assessed here and their designated critical habitat is presented in Table 1-1 and 1-2. Use-specific determinations are provided in Tables 1-3 and 1-4. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2. Given the LAA determination for the AW and SMHM and potential modification of designated critical habitat for AW a description of the baseline status and cumulative effects for these species is provided in Attachment III.

Table 1-1. Effects Determination Summary for Effects of Zinc Phosphide on AW and SMHM

Species	Effects Determination	Basis for Determination
Alameda Whipsnake (*Masticophis lateralis euryxanthus*)	May Affect, Likely to Adversely Affect (LAA)	Potential for Direct Effects
		Potential for direct acute effects uncertainty surrounding reproduction effects precludes a finding of NLAA
		Potential for Indirect Effects
		Animal prey items (invertebrate and small mammal) will be killed by exposure to treated baits
Salt Marsh Harvest Mouse (SMHM) (*Reithrodontomys raviventris*)	May Affect, Likely to Adversely Affect (LAA)	**Potential for Direct Effects**
		Direct lethal and reproduction effects are expected
		Potential for Indirect Effects
		Lethal effects on birds will reduce the availability of avian nests as shelter sites

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

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Alameda Whipsnake (*Masticophis lateralis euryxanthus*)	Habitat modification	Application of baits resulting in mortality of small mammal, bird, and insect prey will reduce food availability and possible sheltering availability (burrows) for the snake in critical habitat

Table 1-3. Use Specific Summary of The Potential for Adverse Effects to Aquatic Taxa

Uses	Potential for Effects to Identified Taxa Found in the Terrestrial Environment:						
	Fish		Amphibians		Invertebrates		Aquatic Plants
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute
All Uses	no	no	no	no	no	no	no

A finding of "no" in this table is predicated on the expectation of no complete exposure pathway to aquatic environments.

Table 1-4. Use Specific Summary of The Potential for Adverse Effects to Terrestrial Taxa

Uses	Potential for Effects to Identified Taxa Found in the Terrestrial Environment:								
	Small Mammals		Birds		Reptiles		Invertebrates (Acute)	Dicots	Monocots
	Acute	Chronic	Acute	Chronic	Acute	Chronic			
All Uses	yes	yes	yes	yes*	yes	yes*	yes	no	no

*- there is a complete exposure pathway and there is insufficient data to preclude reproduction risk.

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

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the listed species and its resources (*i.e*., food and habitat) are not expected to be uniform across the action area. In fact, 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 listed species 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 USEPA's *Guidance for Ecological Risk Assessment* (USEPA, 1998a), 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 assessment is to evaluate potential direct and indirect effects on the Alameda whipsnake (*Masticophis lateralis euryxanthus*, AW) and its critical habitat, and the salt marsh harvest mouse (*Reithrodontomys raviventris*, SMHM) arising from FIFRA regulatory actions regarding use of zinc phosphide on all use sites. This ecological risk assessment has been prepared consistent with a stipulated injunction settling the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

The AW was listed as threatened in 1997 by the USFWS. The species occurs in the Inner Coast Ranges in Contra Costa, Alameda, San Joaquin, and Santa Clara Counties in California. The PCEs for AW critical habitat are 1) scrub/shrub communities with a mosaic of open and closed canopy; 2) woodland or annual grassland plant communities contiguous to lands containing PCE 1, and 3) lands containing rock outcrops, talus, and small mammal burrows within or adjacent to PCE1 or PCE 2.

The SMHM was listed by the USFWS as an endangered species in 1970. The species is found in tidal and non-tidal salt marshes along the San Francisco, San Pablo, and Suisun Bays in California.

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook*, the assessment of effects associated with registration of zinc phosphide is based on an action area. The action area is the area directly or indirectly affected by the federal action, as indicated by the risk quotients that exceed the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of zinc phosphide may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the species previously listed in this section and their designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached separately for each of the assessed species in the lawsuits regarding the potential use of zinc phosphide in accordance with current labels:

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

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

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

Indoor uses of zinc phosphide include:

Indoor food - Agricultural/farm structures/buildings and equipment; and Storage areas-full
Indoor non-food - Commercial transportation facilities-nonfeed/nonfood; Commercial/institutional/industrial premises/equip. (indoor); Public buildings/structures (vert. Pest control); and Ships and boats
Indoor residential - Household/domestic dwellings; and Household/domestic dwellings indoor premises

Outdoor uses of zinc phosphide include:

Aquatic food crop - Agricultural drainage systems
Aquatic non-food industrial - Drainage systems
Aquatic non-food outdoor - Aquatic areas/water
Forestry - Conifer release; Forest plantings (reforestation programs) (tree farms, tree plantations, etc.); Forest trees (all or unspecified); Forest trees (hardwoods, broadleaf trees); Forest trees (softwoods, conifers); and Hybrid cottonwood/poplar plantations
Outdoor residential - Household/domestic dwellings outdoor premises; and Residential lawns
Terrestrial feed crop - Alfalfa; Grass forage/fodder/hay; Pastures; Rangeland; and Timothy
Terrestrial food + feed crop - Agricultural crops/soils (unspecified); Agricultural rights-of-way/fencerows/hedgerows; Agricultural uncultivated areas; Corn (unspecified); Grapes; *Momordica* spp.; Orchards (unspecified); Sugar beet; Sugarcane; and Vegetables (unspecified)
Terrestrial food crop - Artichoke; Blackberry; Blueberry; Bushberries; Caneberries; Chayote; Cucumber; Cucurbit vegetables; Currant; Elderberry; Gherkin; Gooseberry; Gourd (wax), Chinese; Gourds; Huckleberry; Loganberry; Macadamia nut (bushnut); Melons, citron; Melons, musk; Melons, water; Nursery stock; Orchards (unspecified); Pumpkin; Raspberry (black, red); Squash (summer); Squash (winter) (hubbard); and Strawberry

Terrestrial non-food + outdoor residential - Ornamental and/or shade trees; Ornamental herbaceous plants; Ornamental lawns and turf; Ornamental non-flowering plants; and Ornamental woody shrubs and vines

Terrestrial non-food crop - Agricultural crops/soils (unspecified); Agricultural rights-of-way/fencerows/hedgerows; Agricultural uncultivated areas; Agricultural/farm structures/buildings and equipment; Airports/landing fields; Alfalfa; Christmas tree plantations; Commercial/institutional/industrial premises/equipment (outdoor); Deciduous fruit trees (unspecified); Golf course turf; Grapes; Industrial / construction areas (outdoor); Nonagricultural outdoor buildings/structures; Nonagricultural rights-of-way/fencerows/hedgerows; Nonagricultural uncultivated areas/soils; Nursery stock; Orchards (unspecified); Ornamental and/or shade trees; Ornamental herbaceous plants; Ornamental lawns and turf; Ornamental non-flowering plants; Ornamental woody shrubs and vines; Recreational areas; and Utility poles/right-of-way

Site not specified – this rat bait product (Southland Pearson's Rat Poison: registration #322-8) does not specify any particular use site.

Although current registrations of zinc phosphide allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses in portions of the action area that are reasonably assumed to be biologically relevant to the species assessed herein and their designated critical habitat. Further discussion of the action area is provided in Section 2.8.

2.2.1. Evaluation of Degradates and Other Stressors of Concern

Upon ingestion, zinc phosphide produces phosphine gas through hydrolysis in the acidic environment of the gut. Phosphine is the pesticidal agent associated with the application of zinc phosphide and is the material expected to exert direct toxic effects on vertebrate and invertebrate animal taxa consuming treated bait materials. Phosphine further degrades to phosphate, which is a common chemical constituent in the environment and a major plant nutrient. The other product from the hydrolysis of zinc phosphide is zinc ions which are a minor plant nutrient and is also considered to be environmentally benign.

Zinc phosphide that is not ingested by target or non-target organisms would be slowly converted into phosphine gas by hydrolysis under the circum-neutral conditions in the environment where zinc phosphide is intended for application. This slow release of phosphine gas under the circum-neutral conditions is expected to dissipate in the atmosphere or adsorb to soils before it can reach levels of toxicological concern.

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).

Zinc phosphide does not have registered products that contain multiple active ingredients.

2.3. Previous Assessments

The history of zinc phosphide use has been described by Marsh (1988). It was first synthesized in 1740, and was first used as a rodenticide in Europe in 1911. Its first use in the U.S. occurred around 1939-40 for control of commensal rodents ("commensal" is used to mean "living with or in close association to humans" and typically refers to mice and rats). Use for control of field (non-commensal) rodents began in the early 1940's and expanded after World War II. Zinc phosphide was first registered as a pesticide in the U.S. in 1947. EPA issued a Registration Standard for zinc phosphide in June 1982 (PB85-102499). A Data Call-In Notice (DCI) was issued in 1987 and another in 1991 requiring further data for reregistration. Following the issuance of the 1991 DCI, the Zinc Phosphide Consortium was formed. The consortium is made up of technical, formulator, as well as end-use product registrants. The USDA APHIS (Animal and Plant Health Inspection Service) is the consortium leader.

U.S. Fish and Wildlife Service (U.S. FWS) Biological Opinion 1993
The U.S. FWS issued a Biological Opinion in March of 1993 entitled "Effects of 16 Vertebrate Control Agents on Threatened and Endangered Species". The effect of zinc phosphide use on the salt marsh harvest mouse was addressed in this opinion. (The AW was not classified as a listed species at this time.) The opinion found that the SMHM may be subject to zinc phosphide exposure because some uses for which this chemical is registered (*e.g.*, in and around buildings, lawns, recreational areas, golf courses, and rights-of-way) could occur within harvest mice habitats or areas adjacent to such habitats. SMHM occupy areas in which man-made structures or sites exist nearby (commercial and industrial buildings in the vicinity of San Francisco Bay salt marshes, municipal golf courses, and similar). Furthermore, adverse effects of zinc phosphide use on the SMHM could be significant because: 1) SMHM may be attracted to grain or pelletized zinc phosphide baits if applied in the vicinity of occupied habitats; 2) SMHM are highly susceptible to the toxic effects of this compound; and 3) the habitats of SMHM are highly restricted and fragmented. It is the Service's biological opinion that zinc phosphide use within the ranges of the SMHM is likely to jeopardize the continued existence of this species.

The biological opinion indicated that prohibiting use within 100 yards of occupied habitat of the SMHM would avoid jeopardy to the species and that an unquantifiable level of incidental take could occur as a result of zinc phosphide use.

The 1993 biological opinion also provided reasonable and prudent measures that EPA was to implement to minimize incidental take. These measures focused on EPA implementing a monitoring program that would include monitoring field applications to determine compliance with the label, compliance with reasonable and prudent alternatives, and effectiveness of the buffer zones recommended by the FWS for aerial and ground applications.

1998 Reregistration Eligibilty Decision (RED) and 2008 Risk Mitigation Decision (USEPA 1998b)

The RED for zinc phosphide was issued in July 1998. The Risk Mitigation Decision for Ten Rodenticides (RMD) that included zinc phosphide was issued in May 2008 and revised in June 2008. The 2008 RMD only considered, "non-restricted" commensal uses, in and around (within 50 feet) buildings. The 1998 RED excluded pocket gopher and mole uses in closed burrow systems around (within 50 feet) buildings if the companies added specific exclusionary text on their labels. All uses registered at the time (including field and orchard uses) were covered under the 1998 RED. No uses were cancelled and no application rate changes were required due to either the 1998 RED or the 2008 RMD.

There were four major consumer product mitigations required in the 2008 RMD. First, the bait form was required to be a block or other solid form only. Meal, treated whole-grain, or pelleted forms of bait were prohibited. Second, consumer products must contain 1 pound of bait or less. Third, bait must be sold and packaged in a bait station, including refills. And fourth, consumer products that are allowed to be placed outside of a structure must be placed within 50 ft. of a home or building (no wide area or whole field applications).

There were several major professional applicator product (Agricultural & PCO) mitigations required in the 2008 RMD. First, the bait form was required to be meal, pellet, block, or paste. Professional applicator products must be packaged to contain greater than four pounds of bait. The professional applicator product use sites include the consumer product use sites as well as inside of transport vehicles (ships, trains, or aircraft), and wide area (field-scale) applications. However, bait stations are mandatory for indoor and outdoor above-ground use.

The last day for rodenticide manufacturers to sell or distribute zinc phosphide products that do not include the mitigation listed above is June 4, 2011. Products sold by rodenticide manufacturers on or before June 4, 2011, may be sold until stocks are exhausted. All labels with similar uses will have similar endangered species text (this text includes the areas recommended for use exclusion from the 1993 biological opinion).

2.4. Environmental Fate Properties and Transport Mechanisms

The following discussion summarizes the properties and fate assessment as described in the science chapter for the 1998 RED and forms the basis for conclusions regarding the fate of zinc phosphide post application and the resulting phosphine gas produced. The environmental fate assessment for zinc phosphide is based on a review of data available in the open literature. The Agency reviewed these data and considers the studies submitted by USDA/APHIS (MRID 43466302, 43466303) adequate to define the environmental fate and transport of zinc phosphide for its current uses. The physical and chemical properties of zinc phosphide are presented in Table 2-1.

Table 2-1. Physical-chemical properties of zinc phosphide and phosphine.

Property	Zinc Phosphide		Phosphine	
	Value and units	MRID or Source	Value and units	MRID or Source
CAS #	1314-84-7	IUPAC	7803-51-2	IUPAC
Molecular Weight	258.1 g/mole	IUPAC	34.0 g/mole	IUPAC
Chemical Formula	Zn_3P_2	IUPAC	PH_3	IUPAC
Density/ Relative Density/ Bulk Density	--	--	1.512 g/ml	IUPAC
Vapor Pressure	4.88×10^{-11} torr @ 25°C	IUPAC	25.8 torr @ 25°C	IUPAC
Henry's Law Constant	--	--	328 atm-m^3/mole @ 25°C	IUPAC
Water Solubility	0.0014 mg/L @ 20°C	IUPAC	312 mg/L @ 20°C	IUPAC

IUPAC Agrochemical Information (http://sitem.herts.ac.uk/aeru/iupac/1730.htm).

2.4.1. Degradation

Hydrolysis: Hydrolysis is reported to be the major route of dissipation, resulting in the formation of volatile phosphine and Zinc ions. The rate of hydrolysis is believed to be pH dependent, with the fastest degradation rate occurring in acid solutions. The rate of hydrolysis of the degradation product, phosphine, appears to be pH and soil moisture dependent, with the rate increasing as the pH increases or decreases from neutrality. The hydrolysis reaction under acidic conditions can be written as follows:

$$Zn_3P_2 + 6H^+ \rightarrow 2PH_3 + 3Zn^{2+}$$

Figure 2-1 is a reproduction of the data provided in MRID 00005926 from the U.S. Department of the Interior's Denver Wildlife Research Center. Eight analyses were run, using solutions ranging in pH from about 0.2 through about 14. In each analysis, 100 ml. of water (adjusted to a given pH with buffers, acid, or base) was added to a reaction flask containing known amounts of zinc phosphide. The flask was maintained at 50ºC with a continuous N_2 sweep for 1 hour. At low pHs (as well as very high pHs), the conversion of zinc phosphide to phosphine is relatively rapid, while at circum-neutral pHs, the reaction occurs relatively slowly.

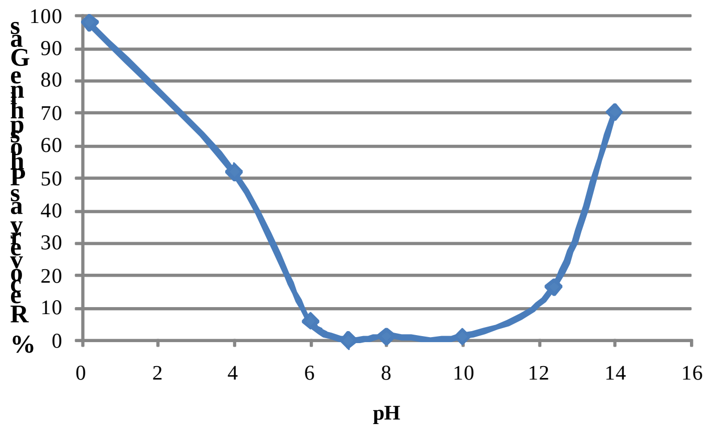

Figure 2-1. Percent recovery of zinc phosphide as phosphine gas after 1 hour at 50^{o}C as a function of pH.

Photodegradation in Water: The data indicate that zinc phosphide has no chromophoric groups (Occidental Chemical Corp. 1977). In addition, it is expected to degrade by hydrolysis prior to photolysis. Therefore, photolysis is not expected to be a route of dissipation for zinc phosphide.

Photodegradation on Soil: The data indicate that zinc phosphide does not degrade by photolysis at least prior to degrading by hydrolysis. However, zinc phosphide in bait formulations appears to decompose slowly when exposed to ambient soil moisture or dried soil. Bait formulations exhibited only 12 to 39% reduction of parent material due to climatic conditions during exposure periods of 21 to 27 days. It is likely that hydrolysis was the principal decomposition mechanism and that the sluggish decomposition rate was due to protection of zinc phosphide by formulation additives and packaging. In addition, experiments conducted with UV-C light wavelengths show photolysis of PH_3 to produce hydrogen and PH_2 or PH^{2-} radicals under oxygen deprived conditions or phosphates under oxygen enriched conditions. If soil photolysis occurs, such as through photo-sensitized hydrolysis, the reaction is expected to be minor compared to the extensive hydrolysis that occurs in wet soil without exposure to light. (MRID 43466303)

2.4.2. Metabolism

Aerobic and Anaerobic Soil Metabolism: The data indicate that zinc phosphide at high concentrations may affect the viability of algae and other soil organisms. Tarar and Salpekar (1978) studied the effects of three different zinc phosphide concentrations (0.2%, 0.4%, and 0.6%; equivalent to 8000, 16000, and 24000 ppm in soil) on twenty soil algae taxa: 15 from Cyanophyceae, 4 from Chlorophyceae, and 1 from Bacillariophyceae. Zinc phosphide suspensions were prepared at three concentrations in distilled water. The solutions were added in 20 ml aliquotes to flasks each containing 5 g of soil and 200 ml of nutritive culture media. All of the flasks were exposed to uniform, diffused sunlight from the north and the algal activity was observed periodically for up to 60 days. Four species remained active at all three concentrations and were presumed to be resistant: *Phormidium luridum*, *Chlorococcum humicolo*, *Protococcus viridis*, and *Closterium* sp. Four other species were present only at the lower concentrations; *Nostoc punctiforme*, *Anabaena spaerica*, *Chlorococcum vitosum*, and *Tabellaria* sp. Twelve other species were found to be highly susceptible to zinc phosphide at those concentrations; *Aphanothece* *stagnina*, *Aphanocapsa biformis*, *Lyngbya stagnina*, *Cylindrospermum musicola*, *Nostoc sphaericum*, *Anabaena attenuata*, *Anabaena spiroides*, *Anabaena oryzae*, *Calothrix bharadwajae*, *Calothrix elenkinii*, *Hapalosiphon welwitchii*, and *Westiellopsis prolifica*. The total algicidal effect was 60%, 75%, and 80% at 0.2%, 0.4%, and 0.6% concentrations, respectively (Tarar and Salpekar, 1978). However, plants should be able to utilize the decomposition products of zinc phosphide at the registered application rates, since they are essential micronutrients for plant life (Olsen 1972). In addition, the data indicate that parent zinc phosphide at low concentrations is relatively stable to aerobic soil metabolism. Zinc phosphide hydrolyzes prior to any degradation by biotic processes (MRID 43466303).

Aerobic Aquatic Metabolism: Although microbial mediated processes cannot be ruled out in the decomposition of zinc phosphide, a potential mechanism has not been described. Zinc phosphide degrades by hydrolysis, which appears to be dependent on pH (degrading under acid and alkaline pHs) and temperature. Since zinc phosphide is relatively stable at pH 7, it may not readily decompose in fresh or sea water. Degradation in natural circum-neutral waterbodies is believed to be mainly by decomposition in sediment.

In a Hawaiian field trial in which aerial broadcast baiting erroneously applied 1.88% zinc phosphide oat groats over a slow moving stream, bait (grain) was observed settling to the bottom (Pank et al., 1975). The bait was gone in seven days, presumably consumed by aquatic life, with no zinc phosphide residue (> 0.01 ppm) detected as phosphide in the bottom sediments (Hilton and Robison, 1972).

Investigators Janda and Bosseova (1970) submerged 2.5% zinc phosphide wheat bait in water for 4 days and conducted analyses on each day. They showed that 2.37%, 2.26%, 2.23%, and 2.04% zinc phosphide remained in the bait after each of those days, respectively - with an 18% total loss. Similarly, Janda (1972) submerged samples of Nera-grain (2.5% zinc phosphide on wheat grain), M-Koder klein (1.4% zinc phosphide preparation on 8 × 6 × 2 mm plates), Arrex E bait (3.8% zinc phosphide paste on sunflower grains inside cellophane bags) in water for 4 days, 10 days, and 10 days, respectively. He noted that decomposition occurred slowly, with 18%, 20%, and 15% decline in zinc phosphide, respectively; however, the nature of the adherents, solar exposure, or pH and quality of the water were not provided in the report.

These studies demonstrate that zinc phosphide on bait usually will decompose slowly in water. When in contact with bottom sediments under aerobic conditions, zinc phosphide will rapidly decompose to phosphoric acid and zinc ions (Hilton and Robison, 1972). (MRID 43466302)

2.4.3. Mobility

The most likely transport mechanism would be surface water runoff. Leaching, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems is not expected. The low solubility of zinc phosphide makes transport in runoff water in the dissolved phase unlikely.

The potential for transport entrained as particulates in surface water runoff probably varies with the properties of the formulation. Tracking powders, being composed of small particles, would be expected to be more subject to transport because lower water velocities are needed to keep the small particles entrained in the water (prevent the particles from settling). However, tracking powders are not widely broadcast or used in large quantities; rather these powders are placed at specific sites (along the base of walls or on rodent trails through vegetation) in small quantities where rodents are expected to traverse. Therefore, it is unlikely that such small quantities after being disbursed over the course of surface water runoff to offsite locations would be deposited in sufficient quantities to harm the SMHM or AW. Bait formulations, being composed of large particles, would be expected to be less subject to offsite transport because higher water velocities are needed to keep the particles entrained in the water and larger particles are more likely to be retained on their site of application due to filtration from the water by crop residue and weeds growing in the fields to which the zinc phosphide is applied.

Leaching/adsorption/desorption: While no data exist on the sorption of parent zinc phosphide, it is considered to be relatively non-mobile. In moist soils, zinc phosphide rapidly degrades to phosphine (PH_3) which absorbs to soil and oxidizes to phosphate ions and phosphorus. The sorption of degradation products appears to increase with temperature, but is not pH dependent (Hilton and Robison 1972). On dried soil, zinc phosphide appears to be moderately persistent (half-lives may be >1 month).

Volatility-Lab: The data indicate that in moist soils zinc phosphide degrades to a volatile product, phosphine (Hilton and Robison, 1972). The rate of volatility appears to be dependent on soil moisture and the pH of the system. Appreciable amounts of phosphine were shown to evolve from moist, acidic or basic soils. However, phosphine concentrations from bait use on dried soils or neutral waters appear negligible and are liberated too slowly to be discernible. Under normal use conditions bait formulations may be moderately persistent. Most of the phosphine released during incubation may be absorbed to soil and oxidized to phosphate ions.

2.4.4. Field Dissipation Studies

Terrestrial field dissipation: The field data agree with the laboratory data, with zinc phosphide dissipating with half-lives of <1 week in moist soils. In dry soils the half-lives were one month or longer. Therefore, the bait formulations may be moderately persistent under some environmental conditions. The data indicate that the application rate will generally be low enough that residues will not be detectable in plants or soil after a sufficient period of time (≈1 to 2 weeks). In addition, the phosphate and zinc ion decomposition products in soil may be utilized by plants as elemental zinc or phosphorus. (USEPA 1998b)

Aquatic field dissipation: Although the direct application of zinc phosphide to aquatic systems is not a labeled use, some research on the fate of zinc phosphide in water has been conducted because of the potential for contamination by surface water run-off or drift from aerial broadcasting near intermittent streams. In a field trial in which aerial broadcast baiting of 1.88% zinc phosphide oat groats was conducted at 6 lb/acre (6.7 kg/ha) in noncrop areas adjacent to Hawaiian sugarcane fields (Pank et al., 1975), three samples of bottom sediments from pools in both the treated and reference sections of a nearby stream were collected 22 days after baiting and analyzed for zinc phosphide and phosphine residues (Hilton and Robison, 1972). Direct bait contamination of the stream during the application was measured by placing thirty 5.5 ×8.5 inch (14 × 21.5 mm) sheets of adhesivecoated, waterproof paper every 30 ft. along the edge of the stream (Pank et al., 1975). Although a buffer area was established, it was determined that the stream was contaminated with 13.9 lbs. of bait per surface acre of water or 0.1 ppm zinc phosphide per cu. ft. of water during aerial application, with 0.1% of the zinc phosphide that reached the stream entering in the form of dislodged fines. Bait was observed settling in the slow moving sections of the stream following application, but was not present after 7 days (Pank et al. 1975). No zinc phosphide (determined by measuring phosphine) residues (>0.01 ppm) were detected in the bottom sediments (Hilton and Robison, 1972). (MRID 43466302)

2.5. Environmental Fate Assessment

Zinc Phosphide

The environmental fate assessment is based on the review of available literature and is not supported by guideline studies. The major route of degradation/dissipation of zinc phosphide is hydrolysis which results in the formation of volatile phosphine and zinc ions. Zinc Phosphide and its residues appear to be non-persistent (not detected ≤7 days post-treatment) under moist soil conditions and is relatively non-mobile (Zn ion and phosphine readily sorb onto soil) in laboratory and field data. However, when applied to dry soil environments, zinc phosphide may be moderately persistent (≈40% of applied remaining at 30 days post-treatment). The rates of hydrolysis and volatilization of the degradation product phosphine appear to be pH and soil moisture dependent with the hydrolysis rate increasing as the pH increases or decreases from neutrality. There are limited data available on the metabolism (microbial mediated processes) of zinc phosphide. It is believed that zinc phosphide hydrolyzes prior to biotic metabolism. However, a potential metabolic process has not been described. It has been noted that in the presence of oxygen, soil organisms utilize the decomposition products when present at low concentrations. Zinc phosphide degrades rapidly to Zn^{2+} and PH_3 which sorb strongly to soil and are common nutrients in soil. Zinc phosphide and its degradation products have low potential for contamination of ground water or surface water.

Phosphine

Under normal environmental conditions phosphine exists as a gas. The solubility of phosphine in water at normal atmospheric pressure is approximately 340 ppm (WHO 1988) and the Ostwald solubility constant (the ratio of the concentration in solution to the concentration in the gas phase at equilibrium) is 0.201 (Fluck 1973). Because of its high vapor pressure (40 mm Hg at -129.4 ºC) and Henry's Law Constant (0.1 atm m^3/mol), phosphine at the soil surface is expected to rapidly dissipate into the atmosphere (WHO 1988).

Phosphine in the atmosphere is rapidly degraded (WHO 1988). The half-life in air was 5 hours with the mechanism of degradation being photoreaction with hydroxy radicals. The dark half-life was 28 hours. The expected reaction products of phosphine in air are oxyacids of phosphorus and inorganic phosphate which are nonvolatile.

Several published laboratory studies suggest that phosphine is quickly adsorbed and degraded at the soil surface. Gaseous phosphine added to soil headspace at 1000 mg/kg dry soil in closed containers degrades 50% after approximately 5 days with air dried soil and 11 days in water saturated soil (Hilton and Robinson 1972). Smaller quantities of phosphine may be removed by soil through a faster mechanism because phosphine added at a lower concentration (0.35 μg/kg) was undetectable in 50 minutes (Eiseman et al. 1997). Diffusion through the soil environment is expected to be slow as phosphine is sorbed in seconds when pushed through several types of soil in a nitrogen carrier (Berck and Gunther 1970). The interaction of phosphine with soil appears to be mixed chemisorption (irreversible) and physisorption (reversible) with the extent of each dependent on soil type.

2.5.1. Mechanism of Action

When zinc phosphide (Zn_3P_2) is consumed by a target species, acids in the digestive tract react with the zinc phosphide to form phosphine (PH_3) (Chitty and Southern, 1954; Curry et al., 1959). Research by Chefurka et al. (1976) indicates that phosphine's toxicity results from inhibition of cytochrome oxidase in certain mitochondria of insects and mice. Also, phosphine is believed to be quickly oxidized in the body to yield hypophosphorus, phosphorus, and phosphoric acids (Klimmer, 1968).

Residual zinc in the body from zinc phosphide ingestion is generally not considered to be toxic (Chitty and Southern, 1954), but it is distributed through an animal's blood stream to all organs and tissues (Banks et al., 1950; Venugopa1 and Luckey, 1978). Bai et al. (1980) postulates that when zinc phosphide reacts with hydrochloric acid (HCl) in the stomach, zinc chloride ($ZnCl_2$) and phosphine are formed. The zinc chloride may then be hydrolyzed to Zn^{2+} and $C1^-$ ions in the presence of water. When zinc phosphide was 1abe1ed with both ^{32}P and ^{65}Zn and was given to rats in lethal and sublethal doses, both ions were found in various ratios in all the organs examined by Andreev et al. (1959).

In addition to rodent efficacy, zinc phosphide has qualities that make it suitable for use in grain baits. Zinc phosphide induces an emetic reflex in many species, which results in a degree of protection to nontarget animals from its toxicity (Hill and Carpenter, 1982). Also, zinc phosphide emits a garlic-like or phosphorus odor when it decomposes that is disagreeable to most animals, but may be attractive to rodents. In contrast to other metal phosphides that are known to rapidly decompose in contact with water to phosphine (*i.e.*, aluminum and magnesium phosphide), zinc phosphide decomposes slowly enough to allow target animals time to consume bait before the bait loses toxicity (von Oettingen, 1947). Also, zinc phosphide decomposes relatively slowly when subjected to ambient or soil moisture (Robison, 1971).

2.5.2. Use Characterization

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

The majority of labeled uses for zinc phosphide are bait applications. Indoor applications are expected to potentially affect listed species because they can be applied within 50 ft of a structure for many "indoor" uses. The highest application rate is 0.2 lb ai/a for several bait applications. Many of the maximum application rates are listed as “not directly convertible” (NDC) for all tracking powder applications and many bait applications because these applications are by hand at specific sites (along walls, on rodent trails under vegetation, etc.) and therefore cannot be directly converted to a per acre application basis. Table 2-1 presents the uses and corresponding application rates and methods of application considered in this assessment.

Table 2-2. Zinc Phosphide Uses Assessed for California

Use	App. Method	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)
Indoor Food					
Agricultural/Farm Structures/Buildings And Equipment	Bait App.	NDC	NS	NS	NS
Storage Areas-Full		NDC	NS	NS	NS
Agricultural/Farm Structures/Buildings And Equipment	Tracking powder	NDC	NS	NS	30 d
Indoor Non-Food					
Commercial Transportation Facilities-Nonfeed/Nonfood	Bait App.	NDC	NS	NS	30 d
Commercial/Institutional/Industrial Premises/Equip. (Indoor)		NDC	NS	30 / day	NS
Public Buildings/Structures (Vert. Pest Control)		NDC	NS	NS	30 d
Ships And Boats		NDC	NS	NS	30 d
Commercial/Institutional/Industrial Premises/Equip. (Indoor)	Tracking powder	NDC	NS	NS	30 d
Public Buildings/Structures (Vert. Pest Control)		NDC	NS	NS	30 d
Indoor Residential					
Household/Domestic Dwellings	Bait App.	NDC	NS	30 / day	30 d
Household/Domestic Dwellings Indoor Premises		NDC	NS	NS	30 d
Household/Domestic Dwellings	Tracking powder	NDC	NS	NS	30 d
Aquatic Food Crop					
Agricultural Drainage Systems	Bait App.	.2	NS	NS	NS
Aquatic Non-Food Industrial					
Drainage Systems	Bait App.	.2	NS	NS	30 d
Aquatic Non-Food Outdoor					
Aquatic Areas/Water	Bait App.	NDC	NS	NS	30 d
Forestry					
Conifer Release	Bait App.	.18	NS	NS	NS
Forest Plantings (Reforestation Programs)(Tree Farms, Tree Plantations, Etc.)		.2	NS	NS	NS
Forest Trees (All Or Unspecified)		.2	NS	NS	NS
Forest Trees (Hardwoods, Broadleaf Trees)		.18	NS	NS	NS
Forest Trees (Softwoods, Conifers)		.18	NS	NS	NS
Hybrid Cottonwood/Poplar Plantations		.2	NS	NS	NS

Use	App. Method	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)
Outdoor Residential					
Household/Domestic Dwellings Outdoor Premises	Bait App.	NDC	NS	NS	30 d
Residential Lawns		NDC	NS	NS	NS
Terrestrial Feed Crop					
Alfalfa	Bait App.	.2	.4	2/yr	10 d
Grass Forage/Fodder/Hay		NDC	NS	NS	NS
Pastures		.2	NS	1/yr	NS
Rangeland		.2	NS	1/yr	NS
Timothy		.2	NS	2/yr	NS
Terrestrial Food + Feed Crop					
Agricultural Crops/Soils (Unspecified)	Bait App.	NDC	NS	NS	NS
Agricultural Rights-Of-Way/Fencerows/Hedgerows		.2	NS	NS	NS
Agricultural Uncultivated Areas		.2	NS	NS	30 d
Corn (Unspecified)		.12	NS	NS	NS
Grapes		.2	NS	NS	NS
Momordica Spp.		.12	NS	NS	NS
Orchards (Unspecified)		.2	NS	NS	NS
Sugar Beet		.2	.4	2/yr	NS
Sugarcane		.2	NS	NS	30 d
Vegetables (Unspecified)		NDC	NS	NS	NS
Terrestrial Food Crop					
Artichoke	Bait App.	.2	NS	1/yr	NS
Blackberry		.2	NS	2	21 d
Blueberry		.2	NS	2	21 d
Bushberries		.2	NS	NS	21 d
Caneberries		.2	NS	NS	21 d
Chayote		.12	NS	NS	NS
Cucumber		.12	NS	NS	NS
Cucurbit Vegetables		.12	NS	NS	NS
Currant		.2	NS	2	21 d
Elderberry		.2	NS	2	21 d
Gherkin		.12	NS	NS	NS
Gooseberry		.2	NS	2	21 d
Gourd (Wax), Chinese		.12	NS	NS	NS
Gourds		.12	NS	NS	NS
Huckleberry		.2	NS	2	21 d
Loganberry		.2	NS	2	21 d
Macadamia Nut (Bushnut)		.1	.4	4/yr	NS
Melons, Citron		.12	NS	NS	NS
Melons, Musk		.12	NS	NS	NS
Melons, Water		.12	NS	NS	NS
Nursery Stock		.182	NS	NS	NS
Orchards (Unspecified)		.2	NS	NS	NS
Pumpkin		.12	NS	NS	NS
Raspberry (Black, Red)		.2	NS	2	21 d
Squash (Summer)		.12	NS	NS	NS

Use	App. Method	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)
Squash (Winter) (Hubbard)		.12	NS	NS	NS
Strawberry		.2	NS	NS	21 d
Terrestrial Non-Food + Outdoor Residential					
Ornamental And/Or Shade Trees	Bait App.	.2	NS	NS	NS
Ornamental Herbaceous Plants		.2	NS	NS	NS
Ornamental Lawns And Turf		.2	NS	NS	NS
Ornamental Nonflowering Plants		.2	NS	NS	NS
Ornamental Woody Shrubs And Vines		.2	NS	NS	NS
Terrestrial Non-Food Crop					
Agricultural Crops/Soils (Unspecified)	Bait App.	.06	NS	NS	NS
Agricultural Uncultivated Areas		.2	NS	NS	NS
Agricultural/Farm Structures/Buildings And Equipment		NDC	NS	30/day	30 d
Agricultural Rights-Of-Way/Fencerows/Hedgerows		.12	NS	NS	NS
Airports/Landing Fields		.2	NS	NS	NS
Alfalfa		.06	NS	NS	NS
Christmas Tree Plantations		.2	NS	NS	NS
Commercial/Institutional/Industrial Premises/Equipment (Outdoor)		NDC	NS	NS	30 d
Deciduous Fruit Trees (Unspecified)		.2	NS	NS	NS
Golf Course Turf		.2	NS	NS	30 d
Grapes		.2	NS	NS	30 d
Industrial/Construction Areas (Outdoor)		.182	NS	NS	NS
Nonagricultural Outdoor Buildings/Structures		NDC	NS	NS	30 d
Nonagricultural Rights-Of-Way/Fencerows/Hedgerows		.2	NS	NS	NS
Nonagricultural Uncultivated Areas/Soils		NDC	NS	NS	30 d
Nursery Stock		.2	NS	NS	NS
Orchards (Unspecified)		.2	NS	NS	NS
Ornamental And/Or Shade Trees		.2	NS	NS	NS
Ornamental Herbaceous Plants		.2	NS	NS	NS
Ornamental Lawns And Turf		.2	NS	NS	30 d
Ornamental Nonflowering Plants		.2	NS	NS	NS
Ornamental Woody Shrubs And Vines		.2	NS	NS	NS
Recreational Areas		.2	NS	NS	NS
Utility Poles/Right-Of-Way		.2	NS	NS	NS
Use Group For Site 00000					
Site Not Specified	Bait App.	.2	NS	NS	NS

Abbreviations: App. = applications; NS = Not specified. NDC = Not directly convertible.

The United States Geological Survey's (USGS) national pesticide usage data (http://water.usgs.gov/nawqa/pnsp/usage/maps/compound_listing.php?year=02) does not present data for zinc phoshide.

The state of California collects data on pesticide applications within the state and provides public access to this data through its Pesticide Use Reporting (PUR) database. Large-scale pesticide applications are typically referred to as production uses (*e.g.*, agricultural pesticide applications to large fields) and have spatial location data available for mapping these pesticide applications. Small-scale pesticide applications are typically referred to as non-production uses (*e.g.*, residential treatments) and do not have spatial location data available for mapping these applications.

Zinc phosphide production uses from 2000-2008 PUR data totals 13,703 lbs ai out of which only 8574 lbs could be mapped. **Figure 2-2** only shows those sections immediately surrounding the habitat of AW and the SMHM. Only one section (shown in red) has concurrent zinc phosphide use and species occurrence records or critical habitat. Non-production chemicals total 4327 lbs ai (no spatial location data available and, therefore, is not mapped in this figure) over the same reporting period. The total pounds of ai used between 1999 and 2008, reported as total use (production and non-production PUR data), in the counties in the vicinity of the SMHM and AW occurrence locations and critical habitat are Alameda 157, Contra Costa 217, Marin 3.54, Napa 21.4, Sacramento 1262, San Francisco 524, San Joaquin 3269, San Mateo 59.7, Santa Clara 101, Solano 788, and Sonoma 28.4.

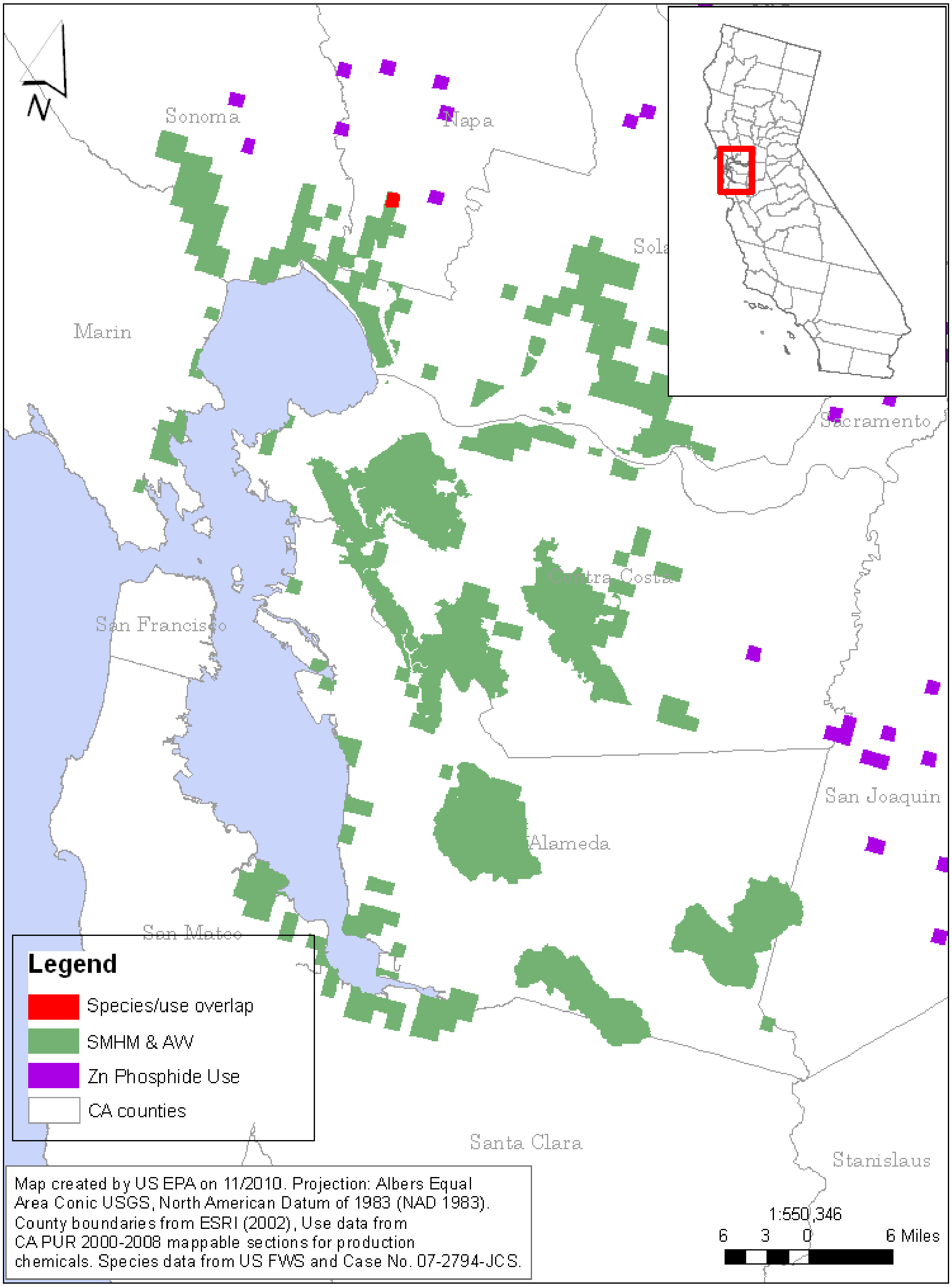

Figure 2-2. Map depicting zinc phosphide use (known 2000 – 2008 PUR locations only) in relation to the AW critical habitat and SMHM CNDB occurrence sections (http://www.dfg.ca.gov/bdb/html/cnddb.html).

2.6. Assessed Species

Table 2-3 provides a summary of the current distribution, habitat requirements, and life history parameters for the listed species being assessed. More detailed life-history and distribution information can be found in Attachment II. See Figures 2-3 and 4 for maps of the current range and designated critical habitat, if applicable, of the assessed listed species. The AW (Figure 2-3) was listed as threatened in 1997 by the USFWS. The species occurs in the Inner Coast Ranges in Contra Costa, Alameda, San Joaquin, and Santa Clara Counties in California. The SMHM (Figure 2-4) was listed by the USFWS as an endangered species in 1970. The species is found in tidal and non-tidal salt marshes along the San Francisco, San Pablo, and Suisun Bays in California.

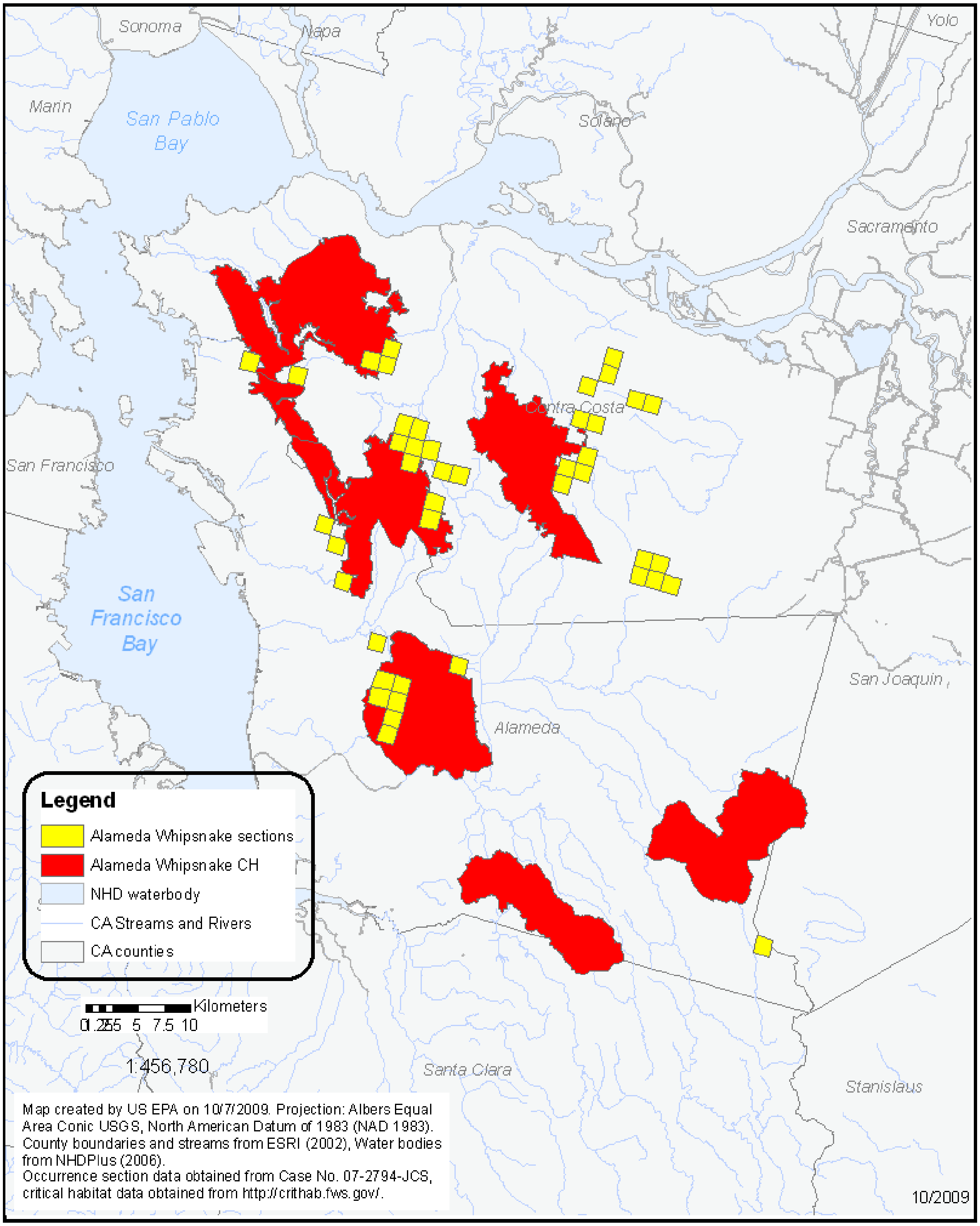

Figure 2-3. Map of Alameda whipsnake (AW) current range based on the California Natural Diversity Database (CNDDB) occurrence sections http://www.dfg.ca.gov/bdb/html/cnddb.html and AW designated critical habitat (CH).

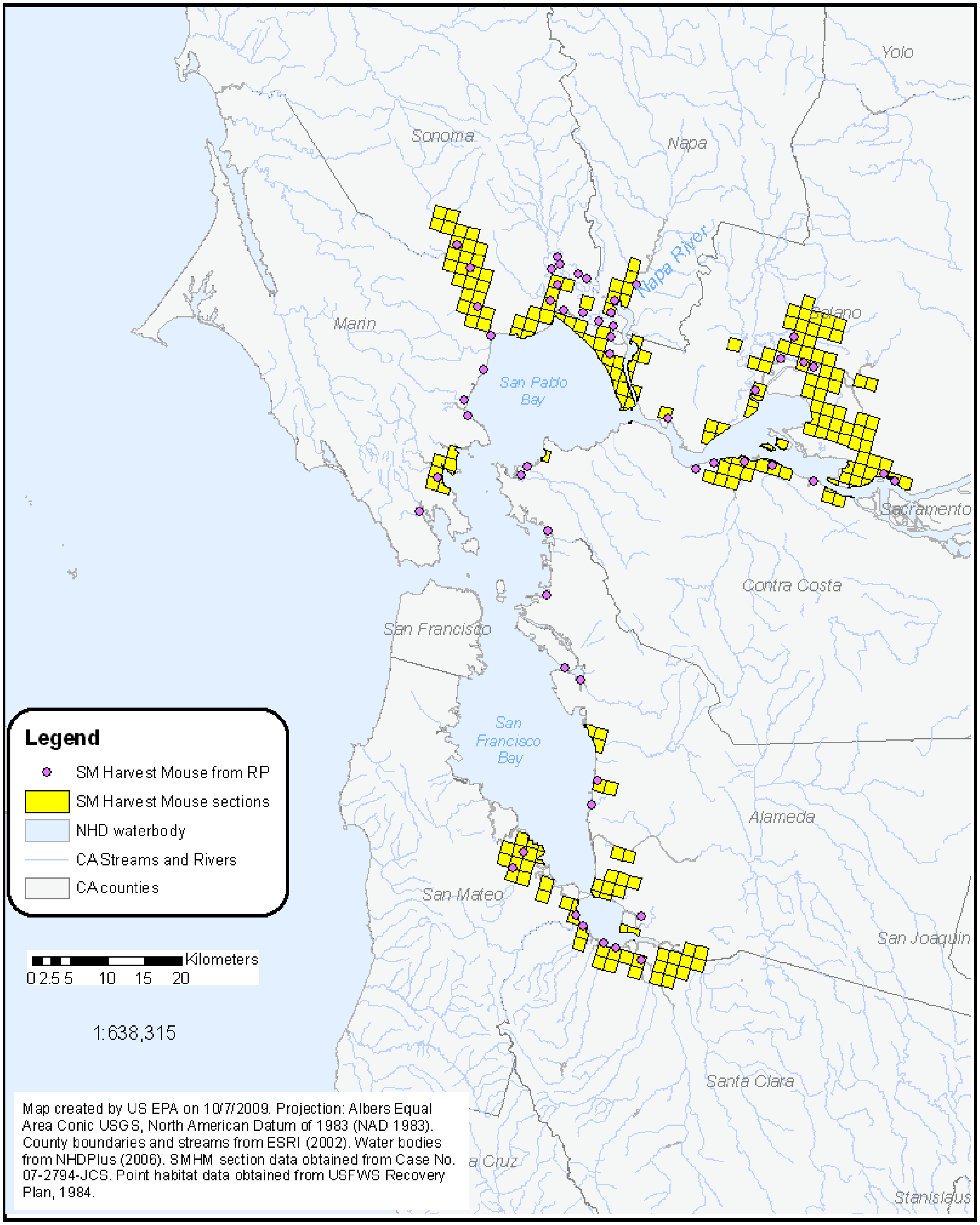

Figure 2-4. Map of salt marsh harvest mouse (SMHM) current range based on the recovery plan (RP) (Salt Marsh Harvest Mouse Recovery Plan, 1984. (ecos.fws.gov) and California Natural Diversity Database (CNDDB) occurrence sections http://www.dfg.ca.gov/bdb/html/cnddb.html.

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Table 2-3. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]

Assessed Species	Size	Current Range	Habitat Type	Designated Critical Habitat?	Reproductive Cycle	Diet
Alameda Whipsnake (AW) (*Masticophis lateralis euryxanthus*)	3 – 5 ft	Contra Costa and Alameda Counties in California (additional occurrences in San Joaquin and Santa Clara Counties)	Primarily, scrub and chaparral communities. Also found in grassland, oak savanna, oak-bay woodland, and riparian areas. Lands containing rock outcrops, talus, and small mammal burrows.	Yes	Emerge from hibernation and begin mating from late March through mid-June. Females lay eggs in May through July. Eggs hatch from August through November. Hibernate during the winter months.	Lizards, small mammals, nesting birds, other snakes including rattlesnakes
Salt Marsh Harvest Mouse (SMHM) (*Reithrodontomys raviventris*)	Adult 8 – 14 g	Northern subspecies can be found in Marin, Sonoma, Napa, Solano, and northern Contra Costa counties. The southern subspecies occurs in San Mateo, Alameda, and Santa Clara counties with some isolation populations in Marin and Contra Costa counties.	Dense, perennial cover with preference for habitat in the middle and upper parts of the marsh dominated by pickleweed and peripheral halophytes as well as similar vegetation in diked wetlands adjacent to the Bay	No	Breeding: March – November Gestation period: 21 – 24 days	Leaves, seeds, and plant stems; may eat insects; prefers "fresh green grasses" in the winter and pickleweed and saltgrass during the rest of the year; drinks both salt and fresh water

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

2.7. Designated Critical Habitat

Critical habitat has been designated for the AW. Risk to critical habitat is evaluated separately from risk of effects on the species. 'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species'. Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). Table 2-4 describes the PCEs for the critical habitats designated for the aforementioned species.

Table 2-4. Designated Critical Habitat PCEs for the AW[1].

Species	PCEs	Reference
Alameda whipsnake	Scrub/shrub communities with a mosaic of open and closed canopy	71 FR 58175 58231, 2006
	Woodland or annual grassland plant communities contiguous to lands containing PCE 1	
	Lands containing rock outcrops, talus, and small mammal burrows within or adjacent to PCE 1 and or PCE 2	

[1] These PCEs are in addition to more general requirements for habitat areas that provide essential life cycle needs of the species such as, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

More detail on the designated critical habitat applicable to this assessment can be found in Attachment III. Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of zinc phosphide that may alter the PCEs of the designated critical habitat for the AW form the basis of the critical habitat impact analysis.

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

2.8. Action Area and LAA Effects Determination Area

2.8.1. 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 toxic effect to the assessed species and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature.

It is recognized that the overall action area for the national registration of zinc phosphide is likely to encompass considerable portions of the United States based on the diffuse nature of the target pests and varied sites of use. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the assessed species 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 San Francisco Bay Species. Additionally, the concept of a state-wide action area takes into account the potential for direct and indirect effects and any potential modification to critical habitat based on ecological effect measures associated with reduction in survival, growth, and reproduction, as well as the full suite of sublethal effects available in the effects literature.

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

2.8.2. LAA Effects Determination Area

A stepwise approach is used to define the Likely to Adversely Affect (LAA) Effects Determination Area. An LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the species and/or modify its designated critical habitat using EFED's standard assessment procedures (see Attachment I) and effects endpoints related to survival, growth, and reproduction. This is the area where the "Potential Area of LAA Effects" (initial area of concern + drift distance or downstream dilution distance) overlaps with the range and/or designated critical habitat for the species being assessed. If there is no overlap between the potential area of LAA effects and the habitat or occurrence areas, a no effect determination is made. The first step in defining the LAA Effects Determination Area is to understand the federal action. The federal action is defined by the currently labeled uses for zinc phosphide. An analysis of labeled uses and review of available product labels was completed. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the assessed species, the analysis indicates that, for zinc phosphide the following uses are considered as part of the federal action evaluated in this assessment:

1. Indoor uses:

Indoor food - Agricultural/farm structures/buildings and equipment; and Storage areas-full
Indoor non-food - Commercial transportation facilities-nonfeed/nonfood; Commercial/institutional/industrial premises/equip. (indoor); Public buildings/structures (vertebrate pest control); and Ships and boats
Indoor residential - Household/domestic dwellings; and Household/domestic dwellings indoor premises

2. Outdoor uses:

Aquatic food crop - Agricultural drainage systems
Aquatic non-food industrial - Drainage systems
Aquatic non-food outdoor - Aquatic areas/water
Forestry - Conifer release; Forest plantings (reforestation programs) (tree farms, tree plantations, etc.); Forest trees (all or unspecified); Forest trees (hardwoods, broadleaf trees); Forest trees (softwoods, conifers); and Hybrid cottonwood/poplar plantations
Outdoor residential - Household/domestic dwellings outdoor premises; and Residential lawns
Terrestrial feed crop - Alfalfa; Grass forage/fodder/hay; Pastures; Rangeland; and Timothy
Terrestrial food + feed crop - Agricultural crops/soils (unspecified); Agricultural rights-of-way/fencerows/hedgerows; Agricultural uncultivated areas; Corn (unspecified); Grapes; *Momordica* spp.; Orchards (unspecified); Sugar beet; Sugarcane; and Vegetables (unspecified)
Terrestrial food crop - Artichoke; Blackberry; Blueberry; Bushberries; Caneberries; Chayote; Cucumber; Cucurbit vegetables; Currant; Elderberry; Gherkin; Gooseberry; Gourd (wax), Chinese; Gourds; Huckleberry; Loganberry; Macadamia nut (bushnut); Melons, citron; Melons, musk; Melons, water; Nursery stock; Orchards (unspecified); Pumpkin; Raspberry (black, red); Squash (summer); Squash (winter) (hubbard); and Strawberry
Terrestrial non-food + outdoor residential - Ornamental and/or shade trees; Ornamental herbaceous plants; Ornamental lawns and turf; Ornamental nonflowering plants; and Ornamental woody shrubs and vines
Terrestrial non-food crop - Agricultural crops/soils (unspecified); Agricultural rights-of-way/fencerows/hedgerows; Agricultural uncultivated areas; Agricultural/farm structures/buildings and equipment; Airports/landing fields; Alfalfa; Christmas tree plantations; Commercial/institutional/industrial premises/equipment (outdoor); Deciduous fruit trees (unspecified); Golf course turf; Grapes; Industrial / construction areas (outdoor); Nonagricultural outdoor buildings/structures; Nonagricultural rights-of-way/fencerows/hedgerows; Nonagricultural uncultivated areas/soils; Nursery stock; Orchards (unspecified); Ornamental and/or shade trees; Ornamental herbaceous plants; Ornamental lawns and turf; Ornamental nonflowering plants; Ornamental woody shrubs and vines; Recreational areas; and Utility poles / right-of-way
Site not specified – this rat bait product (Southland Pearson's Rat Poison: registration #322-8) does not specify any particular use site.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of zinc phosphide use patterns (*i.e*., the area where pesticide application may occur) is determined. This "footprint" represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. For zinc phosphide uses assessed herein, these land cover types encompass the majority of the state of California and further refinement of the initial footprint will not provide meaningful additional spatial resolution.

Once the initial area of concern is defined, the next step is to define the potential boundaries of the Potential Area of LAA 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 listed species LOCs. There are no drift or run-off pathways identified for the uses of zinc phosphide nor is there an available quantitative risk analysis for LOC comparison purposes. Therefore the application sites are assumed to comprise the Potential Area of LAA.

2.9. Assessment Endpoints and Measures of Ecological Effect

2.9.1. Assessment Endpoints

Table 2-5 identifies the taxa used to assess the potential for direct and indirect effects from the uses of zinc phosphide for each listed species assessed here.

Table 2-5. Taxa Used in the Analyses of Direct and Indirect Effects for the Assessed Listed Species.

Listed Species	Birds	Mammals	Terr. Plants	Terr. Inverts.	FW Fish	FW Inverts.	Estuarine/ Marine Fish	Estuarine/ Marine Inverts.	Aquatic Plants
California Alameda whipsnake	Direct Indirect (prey)	Indirect (prey/habitat)	Indirect (habitat)	Indirect (prey)	n/a	n/a	n/a	n/a	n/a
Salt marsh harvest mouse	Indirect (rearing sites)	Direct Indirect (rearing sites)	Indirect (food, habitat)	Indirect (prey)	n/a	n/a	n/a	n/a	n/a

Abbreviations: n/a = Not applicable as no listed species resource requirement for the taxa or complete exposure pathway to these taxa are evident

2.9.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of zinc phosphide that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species were previously described in Section 2.7. Actions that may modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the assessed species. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (*i.e*., the biological resource requirements for the listed species associated with the critical habitat).

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

2.10. Conceptual Model

2.10.1. 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, 1998a). For this assessment, the risk is stressor-linked, where the stressor is the release of zinc phosphide to the environment and subsequent release of phosphine gas. The following risk hypotheses are presumed in this assessment.

The labeled use of zinc phosphide within the action area may:

- directly affect AW and SMHM by causing mortality or reducing reproduction;
- indirectly affect AW and SMHM and/or modify any designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect AW and SMHM and/or modify any designated critical habitat by reducing or changing terrestrial habitat in their current range (via reduction in small mammals required biologically derived sheltering opportunities leading to reduction in underground refugia/cover).

2.10.2. Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the zinc phosphide release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for AW and SMHM and the conceptual models for the terrestrial PCE components of critical habitat are shown in 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. The conceptual models only deal with terrestrial exposures as there is no expected complete exposure pathway to surface waters.

Though not a controlled lab study, Krishnamurthy and Singh (1967) demonstrated the volatility of phosphine from zinc phosphide treated soil. These researchers investigated the use of zinc phosphide in rodent burrows to determine whether the phosphine produced may be an effective fumigant. They tried zinc phosphide alone and in combination with sulfuric acid-impregnated (20 %) clay (1:6 ratio of zinc phosphide to clay). Krishnamurthy and Singh found that zinc phosphide alone did not produce enough phosphine gas to kill a rat. The zinc phosphide-acid-clay mixture was only slightly more successful, because gas production was still dependent upon the acidified moisture sorbed by the clay in the soil. Because the soil moisture could not be controlled in the field, the researchers proposed the use of aluminum phosphide for burrow fumigation rather than zinc phosphide.

Under environmental conditions, an appreciable amount of phosphine may evolve from moist, acidic or basic soils; however, amounts are too small and liberated too slowly under normal bait use to be a fumigant (toxicant) due to dilution in the atmosphere. Negligible amounts would likely evolve from dry soil. Therefore, inhalation pathways are not considered in the conceptual model.

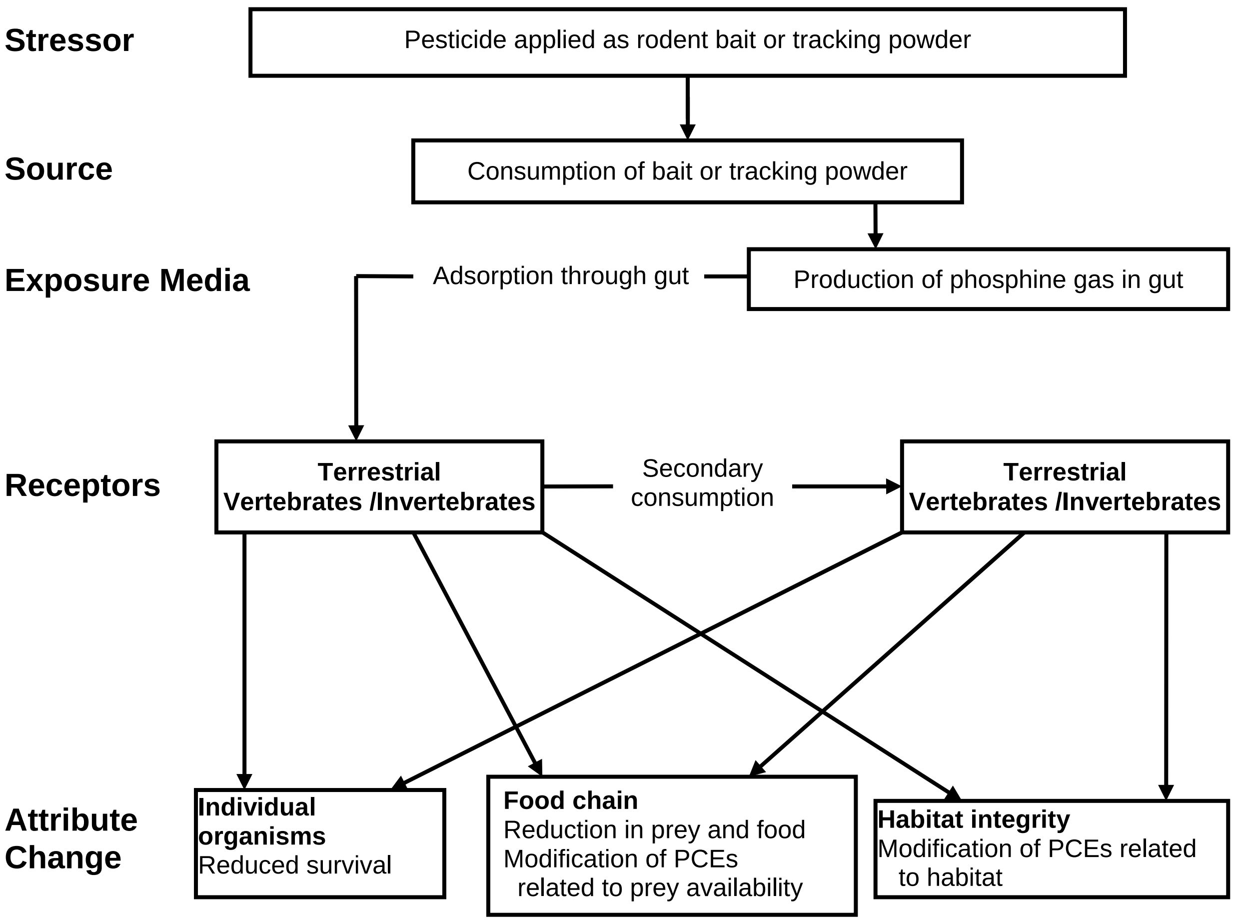

Figure 2-5. Conceptual model depicting stressors, exposure pathways, and potential effects to terrestrial organisms from the use of zinc phosphide.

2.11. Analysis Plan

This assessment includes quantitative estimates of exposure for terrestrial vertebrates and effects in terrestrial vertebrates when data allow. Concerning the SMHM (a rodent), the intended pesticidal use of zinc phosphide is to kill rodents. The zinc phosphide efficacy data indicates that the pesticide, used as intended, does kill rodents. Therefore it is assumed that if zinc phosphide is applied to an area, SMHM will be exposed to the pesticide and will receive (consume) an acutely lethal dose.

The uncertainties with this assumption are: 1) the SMHM may not be directly exposed to zinc phosphide even in treated areas because the SMHM may not be attracted to the bait or may not visit those areas that would be treated with tracking powder; and 2) exposure may not be lethal because many species are able to regurgitate zinc phosphide prior to be receiving a lethal dose. No studies were identified that addressed either of these issues specifically for the SMHM.

The 1993 zinc phosphide biological opinion (USFWS 1993) used this same assumption regarding the SMHM to recommend that zinc phosphide labels provide a description of the location of SMHM habitat and not allow applications within 100 yards of that habitat. Therefore regarding the SMHM, the current risk assessment addresses 1) whether the language contained on current zinc phosphide labels that prohibit use of zinc phosphide in SMHM habitat which was based on the 1993 biolgical opinion precludes all potential exposure in the SMHM habitat as it is currently understood today; and 2) whether there is the potential for harm to the SMHM from applications beyond the 100 yds. exclusion zone around SMHM habitat.

Concerning the AW (a snake that consumes rodents), the intended pesticidal use of zinc phosphide involves rodents consuming a dose sufficient to kill the rodent. If an AW were to consume an exposed rodent, there is the possibility that it would receive a lethal dose because snakes consume the entire rodent including the rodent's digestive track. (Animals that avoid consuming the digestive tract are not susceptible to secondary poisoning by zinc phosphide.) Therefore it is assumed that if zinc phosphide is applied to an area, AW will be exposed to the pesticide and will receive (secondarily consume) an acutely lethal dose.

The major uncertainty with this assumption is that exposure may not be lethal because many species are able to regurgitate zinc phosphide prior to adsorbing a lethal dose. Potentially, the AW may be able to regurgitate exposed prey prior to being lethally dosed (or the exposed prey item may regurgitate prior to consumption by an AW). No studies were identified that addressed this issue that were specific to AW exposure through secondary consumption of zinc phosphide exposed rodents. The 1993 zinc phosphide biological opinion (USFWS 1993) does not address the AW because the AW was not recognized as a listed species until after that opinion. Therefore, in the absence of data confirming emetic behavior in the AW, it is assumed that secondary poisoning is possible for this species.

2.11.1. Measures of Exposure

Oral exposures for the SMHM were assessed on the basis of direct consumption of treated bait at a zinc phosphide concentration of 2% (20g/kg-bait). Oral ingestion in the SMHM was estimated to be approximately 3.2 g of treated bait per day (the assumed TREX v1.4.1 model assumption for a similarly sized mammal (15 g) eating grain). The resultant daily oral dose of zinc phosphide from this approach is as follows:

(20g pesticide/kg-bait * 0.0032 kg food/day)/0.015 kg-bw = 4.27 g pesticide/kg-bw = 4270 mg pesticide/kg-bw.

Oral exposure for birds (indirect effects analysis appropriate for the SMHM) was constructed in a similar manner and made use of the medium size bird category in the TREX v 1.4.1 model. The equations include an assumption of food intake for treated grain/bait at 65 g/day and a body weight of 100 g. The resultant daily oral dose of zinc phosphide from this approach is as follows:

(20g pesticide/kg-bait * 0.065 kg food/day)/0.1 kg-bw = 13 g pesticide/kg-bw = 13000 mg pesticide/kg-bw.

2.11.2. Measures of Effect

No quantitative measures of effect are used to establish thresholds of effect for quantitative risk assessment. Available ecotoxicological data is summarized in this document to provide rationale for extending risk assumptions in targeted small mammals to non-target birds and reptiles. Consumption of treated bait is assumed to induce lethality in target and nontarget terrestrial vertebrates and any invertebrates consuming the bait.

2.11.2.a. Integration of Exposure and Effects

In this risk assessment, no numerical integration of exposure and effects is made. The assessment assumes that effects occur within the confines of treatment areas and results in complete morality in vertebrates and invertebrates residing therein and consuming zinc phosphide baits and tracking powders directly. Secondary intoxication, with mortality, is assumed to occur for those organisms consuming the gastrointestinal tract of intoxicated target organisms.

2.11.3. Data Gaps

Several guideline studies were satisfied through literature searches and summary reports provided by the Phosphides Consortium. Effects data limitations are obviated in a conservative manner by assuming that exposure to phosphide-derived phosphine gas is completely lethal for all SMHM consuming zinc phosphide and all AW consuming zinc phosphide exposed rodents.

3. Exposure Assessment

Zinc phosphide is formulated as a bait or tracking powder. Tracking powders are typically used in and around buildings or some other specific feature that is attractive to rodents, but would not be used for wide area treatments. Baits can be used in the same settings that tracking powders would be used as well as in wide area treatments such as entire farm fields.

3.1. Label Application Rates and Intervals

The formulated product labels legally limit zinc phosphide potential use to only those sites that are specified on the labels. Currently registered uses of zinc phosphide within California include those summarized in Table 2-2.

3.2. Aquatic Exposure Assessment

For several reasons, there does not appear to be a complete aquatic exposure pathway from an application that is consistent with any label use of zinc phosphide to the AW or SMHM. First, neither the AW nor SMHM are aquatic species. Second, neither has a known obligate relationship to any aquatic species. Third, the zinc phosphide would tend to stay in the bait material since zinc phosphide is not soluble in water. Therefore, surface water levels of zinc phosphide from labeled uses are expected to be negligible. Since zinc phosphate hydrolyzed very slowly under circum-neutral pH environment as well as the vapor pressure and HLC are phosphine gas are very high, expected exposure would be negligible.

3.2.1. Existing Monitoring Data

No monitoring data for zinc phosphide or phosphine gas are available in air, groundwater, or surface water in California.

3.3. Terrestrial Animal Exposure Assessment

3.3.1. Exposure to Residues in Terrestrial Food Items

Oral exposures for the SMHM were assessed on the basis of direct consumption of treated bait at a zinc phosphide concentration of 2% (20g/kg-bait). Oral ingestion in the SMHM was estimated to be approximately 3.2 g of treated bait per day (the assumed TREX v1.4.1 model assumption for a similarly sized mammal (15 g) eating grain). The resultant daily oral dose of zinc phosphide from this approach is as follows:

(20g pesticide/kg-bait * 0.0032 kg food/day)/0.015 kg-bw = 4.27 g pesticide/kg-bw = 4270 mg pesticide/kg-bw.

Oral exposure for birds (indirect effects analysis appropriate for the SMHM) was constructed in a similar manner and made use of the medium size bird category in the TREX v 1.4.1 model. This involved an assumption of food intake for grain at 65 g/day and a body weight of 100 g. The resultant daily oral dose of zinc phosphide from this approach is as follows:

(20g pesticide/kg-bait * 0.065 kg food/day)/0.1 kg-bw = 13 g pesticide/kg-bw = 13000 mg pesticide/kg-bw.

Secondary consumption of zinc phosphide may also occur through consumption of residual zinc phosphide in the gut lumen of morbid prey. Available field studies and secondary exposure studies confirm that organisms feeding on the gastrointestinal tract of intoxicated target organisms are also subject to lethal exposure levels.

3.4. Terrestrial Plant Exposure Assessment

Because no terrestrial plant effects are anticipated, no zinc phosphide exposure analysis was conducted. Available field data, albeit limited to a single treated crop species, suggested that zinc phosphide exerts no discernible effects at field applied rates in excess of currently labeled rates.

4. Effects Assessment

4.1. Toxicity of Zinc Phosphide to Aquatic Organisms

The lack of complete exposure pathways to aquatic systems precludes risk to aquatic organisms and aquatic organisms are not material to this assessment. Therefore no reporting of aquatic toxicity information is made in this assessment.

4.2. Toxicity of Zinc Phosphide to Terrestrial Organisms

Avian Toxicity Data

Two acute oral toxicity studies are available from Agency data evaluation records. The endpoints for these studies include a single oral dose LD50 of 12.9 mg/kg-bw for technical zinc phosphide in bobwhite quail (*Colinus virginianus*) and an LD50 of 67.4 mg/kg-bw for the mallard duck (*Anas platyrhynchos*). There is a study from ECOTOX for mallards establishing an LD50 of 33.56 mg/kg-bw. A study is available from the ECOTOX search in bantam chickens (*Gallus domesticus*) with an LD50 of 21.75 mg/kg-bw for 87 percent zinc phosphide.LD50s are also available from the ECOTOX literature for horned larks (*Eremophila alpestris*, 39.65 mg/kg-bw) and ring-necked pheasants (*Phasianus colchicus*, 13.78 mg/kg-bw).

Table 4-1. Avian Acute Oral Toxicity

Species	% ai	LD50 (mg/kg-bw)	Accession No.	Study Classification
Northern bobwhite quail (*Colinus virginianus*)	TG (94%)	12.9 (12.0-13.9) * Slope not reported	404999	Acceptable
Mallard duck (*Anas platyrhynchos*)	TG (94%)	67.4 (56.3-80.9) Slope not reported	404999	Acceptable
	84%	33.56 Slope not reported	ECOTOX 50386	Supplemental
Bantam chickens (*Gallus domesticus*)	87%	21.75 Slope not reported	ECOTOX 38760	Supplemental
Horned lark (*Eremophila alpestris*)	84%	39.65 Slope not reported	ECOTOX 50386	Supplemental
Ring-necked pheasant (*Phasianus colchicus*)	84%	13.78 Slope not reported	ECOTOX 50386	Supplemental

*lowest acute value available for this taxonomic group.

A sub-acute oral LC50 is available or bobwhite quail showing an LC50 of 468.5 mg/kg-diet with some evidence of reduced feed consumption at doses near the LC50 and above. A mallard sub – acute LC50 of 2855 mg/kg-diet is also available, again with feed consumption rates at doses near the LC50. A second mallard duck study is available from the ECOTOX search that places the LC50 for zinc phosphide lower than the registrant submitted study (LC50 1285 mg/kg-diet) the bobwhite quail again provides the lowest sub-acute lethal endpoint for this taxon.

Table 4-2. Avian Sub-acute Dietary Toxicty

Species	% ai	5-Day LC50 (mg/kg-diet)	Accession no	Study Classification
Northern bobwhite quail	TG (94%)	468.5 (355.6-545.8)* Slope 2.5	404999	Acceptable
Mallard duck	TG (94%)	2,885 (1,970-4,329) Slope 3.6	404999	Acceptable
Mallard duck	100 %	1285	ECOTOX 35243	Supplemental

*lowest acute value available for this taxonomic group.

Avian Chronic Toxicity Data

No reproduction effects study meeting Agency guideline requirements is available for zinc phosphide. However, supplemental data are available from a 10-day repeated daily capsule gavage study using Japanese quail (*Coturnix coturnix japonica*). No effects level was determined in this study. The lowest dose (0.7 mg/kg/day) produced significant drops in egg-laying and fertilization. This value is over one order of magnitude lower than the lowest quantitatively suitable acute avian endpoint available.

Reptile Acute Toxicity Data

One literature study (ECOTOX 150403) reports an acute LD50 of 17.4 mg/kg-bw (a.i. corrected) for 63.7 % zinc phosphide administered to American alligators (*Alligator mississippiensis*). The study is **not classified as suitable for quantitative** use because the LD50 was calculated by pooling experimental data from more than one dosing experiment. Nevertheless, the endpoint was close to but not as low as the lowest acute toxicity endpoint for birds (12.9 mg/kg-bw), which would serve as a surrogate endpoint for reptiles in this risk assessment.

Mammalian Toxicity Data

The health Effects Division data evaluation records report a Norway rat (Rattus norwegicus) acute LD50 of 21 mg/kg-bw.

Table 4-3. Mammalian Acute Toxicity

Species	% ai	Test Type	Toxicity Value	Accession Number	Study Classifi-cation
Laboratory rat (*Rattus norwegicus*)	89%	Acute oral by gavage	21 mg/kg-bw	245763	core

Mammalian Reproduction Toxicity

No reproduction study for mammals is available from the HED data review process. However, there is a developmental study (MRID 43083501). In this rat gavage developmental toxicity study (Guideline 83-3a), mated female Crl:CDBR VAF/Plus rats (25/group) were administered single daily doses at levels of 1.0, 2.0 or 4.0 mg Zn_3P_2/kg in propylene glycol (2 ml/kg) on days 6 through 15 of gestation by oral gavage. A propylene glycol control group of animals were also included. Nine maternal animals from the 4.0 mg/kg group were found dead between days 10 and 16 of gestation. The cause of death was not apparent from a gross examination. Mean body weight and food intake reductions in the 4.0 mg/kg group females were significantly lower for gestation days 6-10 but not altered by the end of the treatment period. The maternal findings in the 1.0 and 2.0 mg/kg test groups were not remarkable. Developmental fetal variations in the treatment groups were comparable to the controls. The maternal NOEL was 2.0 mg/kg; LEL = 4.0 mg/kg based on mortality. The NOEL for developmental toxicity was at or above 4.0 mg/kg (high dose group).

Secondary Poisoning Toxicity Data

The Registration Eligibility Document and subsequent risk assessments performed for Section 18 and 24C registrations of zinc phosphide have all concluded from available secondary effects studies that the use of zinc phosphide enhances the potential to produce secondary toxic effects on animals that consume whole carcasses of treated target organisms, including the gastrointestinal tract of moribund treated organisms, and in those secondary consumers with a low capability for an emetic response to consuming contaminated prey. These conclusions were based on the consideration of the following information.

Zinc phosphide killed prairie dogs (whole or their extracted stomach/liver/intestines) were fed to 5 male and 5 female domestic ferrets. No ferrets died post feeding (MRID 40998001).

Zinc phosphide poisoned black-tailed prairie dog stomach/live/intestines were fed to two domestic ferrets at each of 7 effective zinc phosphide doses (6.23, 12.46, 24.92, 49.84, and 99.70 mg/kg-bw). Mortality was observed in all doses except the lowest dose. Regurgitation observations precluded definitive determination of an LD50. (MRID 41507401)

Zinc phosphide contaminated voles (*Microtus arvalis*) were fed to two specimens each of domestic cats, kestrels and weasels (MRID 42034001). Chemical analysis of treated vole carcasses showed that the predominant compartment for zinc phosphide residues was in the gastrointestinal tract (mean residues of 1,031 mg/kg). One cat received a total of 37 mg/kg-bw zinc phosphide in five entirely consumed vole carcasses and subsequently died. A second cat consumed 60 mg/kg-bw of zinc phosphide in nine vole carcasses. There was an emetic response but no mortality. Kestrels offered vole carcasses ate the somatic flesh and heads but did not eat the gastrointestinal tract of the carcasses (behavior observed in the presence or absence of zinc-phosphide) and all survived. Weasels did not consume the gastrointestinal tracts and again survived the feeding experiment.

A secondary toxicity study submitted in support of reregistration showed evidence of acute intoxication of Siberian ferrets fed zinc phosphide-poisoned rats (MRID 151407). Overt evidence of acute intoxication was emesis by the ferrets. Subacute zinc phosphide toxicity in the ferrets was indicated by significant decreases in hemoglobin, cholesterol, and triglycerides. The study shows the potential secondary exposure of nontarget animals.

Terrestrial Invertebrate Toxicity

There are no data on the effects of zinc phosphide to terrestrial invertebrates. However, there is reasonable expectation for release of phosphine gas in the invertebrate gut following oral consumption of zinc-phosphide treated materials. Because phosphine is used as a fumigant for the elimination of invertebrate pests in a variety of stored commodities, an acute toxic effect of zinc phosphide in invertebrates orally exposed to the material cannot be dismissed.

Plant Toxicity

No laboratory toxicity data are available for plants. However, a study of the effects of zinc phosphide application for rodent control on corn (*Zea mays*) showed no effects on corn at an application rate of 0.373 lb/acre (ECOTOX 86197).

Field Studies

The Registration Eligibility Document and subsequent risk assessments performed for Section 18 and 24C registrations of zinc phosphide have all concluded from available primary effects field studies that the use of zinc phosphide in agricultural fields will kill non-target birds and mammals that consume zinc phosphide treated baits. These conclusions were based on the consideration of the following information.

A review article submitted by the Zinc phosphide Reregistration Consortium states that instances of mortality of many species of nontarget rodents associated with prairie dog and ground squirrel colonies from zinc phosphide applications have been documented (MRID 423062). Baiting orchards produced mortality in cottontails, gallinaceous birds, and granivorous passerines. Six of a group of 24 birds (of seven species) from a sugar cane field that was treated with zinc phosphide were found to have eaten the bait. Mortality from zinc phosphide applications has been documented for deer, chickens, upland game birds, and waterfowl. Canada geese were killed in baited alfalfa enclosures.

Ramey, Sterner, Wolff, and Edge (1994) observed the nontarget hazards to ring-necked pheasants and California quail of hand broadcasting of 2% zinc phosphide oat groats bait for control of gray-tailed voles in alfalfa in experimental plots. Ring-necked pheasants, but not California quail, were killed. The study did not address nontarget hazards to voles, but it implies that voles would be killed as a nontarget species if they were in the treated areas (MRID 43586602).

An “intensive ground search” of an orchard that had been treated with 2% zinc phosphide bait by air and ground equipment at a rate of five to ten pounds per acre was conducted for 1 to 14 days post treatment. Carcasses recovered from the treatment area included a ring-necked pheasant, four cottontail rabbits, three deer mice, and one blue jay all found to contain zinc phosphide residues (MRID 232996).

4.3. Toxicity of Chemical Mixtures

No chemical mixture data are available. Zinc phosphide is not formulated with any other active ingredients.

4.4. Incident Database Review

4.4.1. Terrestrial Incidents

There are 44 terrestrial organism incidents reported in the EIIS incident database. Thirty-two of these incidents have been evaluated to be highly probable in their association with zinc phosphide applications. Eleven of these incidents are listed as probable associations with zinc phosphide. One is listed as possibly linked to zinc phosphide. Thirty-seven incidents involved avian mortalities, and the types of birds involved included anseriforms (duck and geese), galliforms (primarily wild turkeys) passeriforms (horned lark). Eight involved mammals, predominantly including rodents, lagomorphs, canids, and procyonadids. A table of EIIS Incidents is included at the end of this document as Appendix B.

4.4.2. Plant Incidents

No plant incidents have been reported for zinc phosphide.

4.4.3. Aquatic Incidents

Aquatic incidents are not pertinent to this risk assessment and are not summarized herein.

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

Probit dose analysis was not performed for this risk assessment. Acute lethal risk was assumed to be 100 % in any terrestrial animal receiving direct or secondary exposure to zinc phosphide.

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 AW and SMHM or for modification to AW designated critical habitat from the use of zinc phosphide in CA. This risk characterization does not employ quantification techniques, such as risk quotient calculations, as employed in other assessments.

5.1. Risk Estimation

The oral exposure of a small mammal the size of a SMHM is 4270 mg/kg bw for consumption of treated bait on a daily basis as a grain food. This exposure is over two orders of magnitude above the acute lethal dose (21 mg/kg-bw) with an associated RQ of 203. Similarly the mammal reproduction endpoint of 4 mg/kg-bw is exceeded by three orders of magnitude for the assumed daily dose. Both of these exceed Agency listed species and non-listed species levels of concern (0.1 and 0.5 for acute, and 1 for chronic).

Oral exposure for birds (indirect effects analysis appropriate for the SMHM) was estimated to be 13000 mg/kg-bw each day bait is consumed as a daily food source. This value is three orders of magnitude above the lowest avian acute oral dose estimate (12.9 mg/kg-bw) and many orders of magnitude above the reproduction toxicity threshold and the frank reproduction effects endpoint of 0.7 mg/kg-bw. Moreover the dietary concentration of zinc phosphide in bait (20000 mg/kg-bait) is many orders of magnitude above the lowest bird dietary sub acute LC50 (468.5 mg/kg) RQs for these comparisons of exposure to effects endpoints are far in excess of the Agency listed species and non-listed species levels of concern (0.1 and 0.5 for acute, and 1 for chronic).

The conclusions of this risk assessment are both quantitatively determined through the comparison of risk quotients to Agency established levels of concern and by virtue of consideration of other lines of evidence showing adverse effects to terrestrial wildlife taxa. This assessment presents evidence and rationale for asserting that there is a complete exposure pathway for non-target terrestrial animals through direct consumption of zinc phosphide treated bait or powders and that secondary exposure through consumption of the gastrointestinal tract of moribund prey is a viable exposure route as well. Exposure of terrestrial animals directly or secondarily is quantitatively and qualitatively judged to be sufficient to produce lethality in exposure animals residing in the treatment area.

No laboratory toxicity data are available for plants. However, a study of the effects of zinc phosphide application for rodent control on corn (*Zea mays*) showed no effects on corn at an application rate of 0.373 lb active/acre (ECOTOX 86197) this is in excess of the highest zinc phosphide labeled application rate of 0.2 lb active/acre.

5.1.1. Primary Constituent Elements of Designated Critical Habitat

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

5.2. Risk Description

The risk description synthesizes overall conclusions regarding the likelihood of adverse impacts leading to a preliminary effects determination (*i.e.*, "no effect," "may affect, but not likely to adversely affect," or "likely to adversely affect") for the assessed species and the potential for modification of their designated critical habitat based on a non-quantitative analysis of exposure and hazard. The final No Effect/May Affect determination is made after the spatial analysis is completed at the end of the risk description, Section 5.2.3. In Section 5.2.3, a discussion of any potential overlap between areas where potential usage may result in LAA effects and areas where species are expected to occur (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

A summary of the risk concerns based on non-quantitative assessment are provided in Table 5-1 for direct and indirect effects to the listed species assessed here and in Table 5-2 for the PCEs of their designated critical habitat.

Table 5-1. Risk Estimation Summary for Zinc Phosphide - Direct and Indirect Effects

Taxa	Risk Concerns	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Birds, and Reptiles	Non-listed Species yes	Acute lethal effects for any all organisms consuming treated bait. Or the gastrointestinal tract of intoxicated target organisms.	Indirect Effects: AW,SMHM
	Listed Species yes		Direct Effects: AW
Mammals	Non-listed Species yes		Indirect Effects: AW
	Listed Species yes		Direct Effects: SMHM
Terrestrial Invertebrates	Non listed Species yes		Direct/Indirect Effects: AW

Table 5-2. Risk Estimation Summary for Zinc Phosphide – Effects to Designated Critical Habitat. (PCEs)

Taxa	Risk Concerns	Description of Results of Risk Estimation	Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action
Birds, Reptiles, and Terrestrial-Phase Amphibians	Non-listed Species yes	Reductions in prey base and or burrow availability	AW
	Listed Species yes	Toxic levels of pesticide in potential rodent burrows	
Mammals	Non-listed Species yes	Reductions in prey base, reductions in burrows for sheltering	AW

Taxa	Risk Concerns	Description of Results of Risk Estimation	Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action
	Listed Species yes	Toxic levels of pesticide in potential rodent burrows	
Terrestrial Invertebrates	Listed Species yes	Reductions in prey base	AW

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

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the assessed species or modify its designated critical habitat include the following:

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

A description of the risk and effects determination for each of the established assessment endpoints for the assessed species and their designated critical habitat is provided in Sections 5.2.1 and 5.2.2. The effects determination section for each listed species assessed will follow a similar pattern. Each will start with a discussion of the potential for direct effects, followed by a discussion of the potential for indirect effects. These discussions do not consider the spatial analysis. For those listed species that have designated critical habitat, the section will end with a discussion on the potential for modification to the critical habitat from the use of zinc phosphide. Finally, in Section 5.2.3, a discussion of any potential overlap between areas of concern and the species (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

5.2.1. Effects Determinations

Application of zinc phosphide to treatment areas can be expected to result in acute mortality to those organisms exposed. The direct toxic effects to those organisms present in treated fields are expected to include lethality and reproduction impairment for the AW and SMHM.

Indirect effects on the AW would include reductions in prey base, through lethal effects on vertebrate and invertebrate prey items within treated areas. The lethal effects on small mammals in treatment areas will reduce the availability of animal burrows for AW and lethal effects on birds will reduce SMHM sheltering opportunities.

5.2.2. Modification of Designated Critical Habitat

Treatment of areas with zinc phosphide products will result in intoxicated small mammals and terrestrial invertebrates that my pose a toxic risk to the AW if consumed combined with lethal effects on prey base, and an expected reduction in small animal burrowing opportunities lead to a finding of modification of critical habitat for the AW.

5.2.3. Spatial Extent of Potential Effects

The diffuse use site characteristics suggest that adverse effects to the species and modification of critical habitat may occur throughout the geographical extent of species and critical habitat. Figure 2-1 presents the association of California PUR use data for the years 2000 through 2008 and the associated locations of the species assessed in this document.

5.2.3.a. Spray Drift

No drift events are expected to occur from application of zinc phosphide bait or tracking powder. The tracking powder is applied to discrete locations (along walls or on rodent trails through vegetation) by hand. The bait material can be applied by a wider range of application methods including aerially, but is applied as a pelleted form (very large particles), which would not be expected to drift in air currents. EFED’s policy is to assume no spray drift for granular applications.

5.2.3.b. Downstream Dilution Analysis

No downstream effects are considered because complete exposure pathways to aquatic systems are not expected.

5.3. Effects Determinations

For all species assessed, zinc phosphide use as a vertebrate control agent presents an acute lethal risk to any individual consuming the treatment materials directly or indirectly via the gut contents of intoxicated organisms. This represents a lethal effect directly to all assessed species, to animal prey, small mammals constructing burrows (sheltering sites for the AW and birds constructing nests (sheltering sites for SMHM). Lethal effects to animal prey and to those animals constructing sheltering sites represent indirect effects to all species assessed as well as representing habitat modification for the AW. The widespread nature of the potential application sites for zinc phosphide suggests that there is considerable overlap potential between the use of the pesticide and the areas inhabited by the listed species assessed and the critical habitat designated for the AW.

Therefore, the Agency makes a may affect, and likely to adversely affect determination for the AW and SMHM and a habitat modification determination for the designated critical habitat for the AW based on the potential for direct and indirect effects and effects to the PCEs of critical habitat.

5.3.1. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined earlier in this document. Based on the conclusions of this assessment, none of the hypotheses can be rejected, meaning that the stated hypotheses represent concerns in terms of direct and indirect effects of zinc phosphide on the AW, the SMHM and designated critical habitat for AW.

The labeled uses of zinc phosphide may:

- directly affect AW and SMHM by causing mortality;
- indirectly affect AW and SMHM and/or modify their designated critical habitat by reducing or changing the composition of food supply; and
- indirectly affect AW and SMHM and/or modify their designated critical habitat by reducing or changing terrestrial habitat in their current range (via reduction in small burrowing mammals or bird nesting sites leading to reduction in refugia/cover).

6. Uncertainties

6.1. Exposure Uncertainties

It is assumed that if zinc phosphide is applied to a SMHM occupied area, SMHM will be exposed to the pesticide and will receive (consume) an acutely lethal dose. The uncertainties with this assumption are: 1) the SMHM may not be directly exposed to zinc phosphide even in treated areas because the SMHM may not be attracted to the bait or may not visit those areas that would be treated with tracking powder; and 2) exposure may not be lethal because many species are able to regurgitate zinc phosphide prior to be receiving a lethal dose.

Similarly, it is assumed that if zinc phosphide is applied to an AW occupied area, AW will be exposed to the pesticide and will receive (secondarily consume) an acutely lethal dose. The major uncertainty with this assumption is that exposure may not be lethal because many species are able to regurgitate zinc phosphide prior to adsorbing a lethal dose. Potentially, the AW may be able to regurgitate exposed prey prior to being lethally dosed (or the exposed prey item may regurgitate prior to consumption by an AW).

6.1. Effects Uncertainties

6.1.1. Reproduction and Sublethal Effects

While there may be potential for reproduction and sublethal risks associated with zinc phosphide exposure, the assumption in this assessment is that exposures readily rise to the point of lethality within the confines of the treated site. This is a conservative approach expected to be protective of the species assessed and the prey resources upon which they may rely. The reproduction endpoint informing the quantitative assessment of such risks to birds (indirect effects to the AW and SMHM) is uncertain given the gavage nature of exposure and the short duration of the exposure period. In addition, the species tested is not typically considered an acceptable species under Agency review criteria. However, given the extreme nature of acute lethal risks, it is likely that the uncertainties associated with a reproduction risk assessment centering on the use of available avian reproduction toxicity data is moot to making an effects determination for the species considered in this assessment.

6.1.2. Plant Effects

The lack of plant effects laboratory data remains an uncertainty in this risk assessment. However available field data suggests that such effects are not anticipated.

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 zinc phosphide to the AW and SMHM and the designated critical habitat for AW.

Based on the best available information, the Agency makes a May Affect, and Likely to Adversely Affect determination for all evaluated species from the use of zinc phosphide. Additionally, the Agency has determined that there is the potential for modification of designated critical habitat for the AW by virtue of elimination of small mammals that construct burrows. A summary of the risk conclusions and effects determinations for each listed species assessed here and their designated critical habitat is presented in Table 7-1 and 7-2. Use-specific determinations are provided in Tables 7-3 and 7-4. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2. Given the LAA determination for the AW and SMHM and potential modification of designated critical habitat for AW a description of the baseline status and cumulative effects for these species is provided in Attachment III.

Table 7-1. Effects Determination Summary for Effects of Zinc Phosphide on AW and SMHM

Species	Effects Determination	Basis for Determination
Alameda Whipsnake (*Masticophis lateralis euryxanthus*)	May Affect, Likely to Adversely Affect (LAA)	Potential for Direct Effects
		Potential for direct acute effects uncertainty surrounding reproduction effects precludes a finding of NLAA
		Potential for Indirect Effects
		Animal prey items (invertebrate and small mammal) will be killed by exposure to treated baits
Salt Marsh Harvest Mouse (SMHM) (*<u>Reithrodontomys raviventris</u>*)	May Affect, Likely to Adversely Affect (LAA)	**Potential for Direct Effects**
		Direct lethal and reproduction effects are expected
		Potential for Indirect Effects
		Lethal effects on birds will reduce the availability of avian nests as shelter sites

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

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Alameda Whipsnake (*Masticophis lateralis euryxanthus*)	Habitat modification	Application of baits resulting in mortality of small mammal, bird, and insect prey will reduce food availability and possible sheltering availability (burrows) for the snake in critical habitat

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

Uses	Potential for Effects to Identified Taxa Found in the Terrestrial Environment:						
	Fish		Amphibians		Invertebrates		Aquatic Plants
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute
All Uses	no	no	no	no	no	no	no

A finding of "no" in this table is predicated on the expectation of no complete exposure pathway to aquatic environments.

Table 7-4. Use Specific Summary of the Potential for Adverse Effects to Terrestrial Taxa

Uses	Potential for Effects to Identified Taxa Found in the Terrestrial Environment:								
	Small Mammals		Birds		Reptiles		Invertebrates (Acute)	Dicots	Monocots
	Acute	Chronic	Acute	Chronic	Acute	Chronic			
All Uses	yes	yes	yes	yes*	yes	yes*	yes	no	no

*- there is a complete exposure pathway and there is insufficient data to preclude reproduction risk.

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

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the 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 AW and SMHM 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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