Risks of Mancozeb Use to Federally Threatened California Tiger Salamander (*Ambystoma californiense*), Central California Distinct Population Segment and Federally Endangered California Tiger Salamander, Sonoma County and Santa Barbara County Distinct Population Segments

Pesticide Effects Determinations

PC Codes: 014504
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List of Commonly Used Abbreviations and Nomenclature

µg/kg	Symbol for "micrograms per kilogram"
µg/L	Symbol for "micrograms per liter"
ºC	Symbol for "degrees Celsius"
AAPCO	Association of American Pesticide Control Officials
a.i. or ai	Active Ingredient
AIMS	Avian Monitoring Information System
Acc#	Accession Number
Amu	Atomic Mass Unit
BCB	Bay Checkerspot Butterfly
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
Bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
CAW	California Alameda Whipsnake
CBD	Center for Biological Diversity
CCR	California Clapper Rail
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CFWS	California Freshwater Shrimp
CI	Confidence Interval
CL	Confidence Limit
CTS	California Tiger Salamander
CTS-CC	California Tiger Salamander Central California Distinct Population Segment
CTS-SB	California Tiger Salamander Santa Barbara County Distinct Population Segment
CTS-SC	California Tiger Salamander Sonoma County Distinct Population Segment
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
OCSPP	Office of Chemical Safety and Pollution Prevention
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 of mancozeb (PC code: 014504) and its principle degradate ethylenethiourea (ETU) (PC code: 600016) on the California tiger salamander (*Ambystoma californiense)* (referred to hereafter as CTS) in its terrestrial and aquatic habitats arising from FIFRA regulatory actions regarding use of mancozeb. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitat for CTS. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998), procedures outlined in the Agency's Overview Document (USEPA, 2004), and consistent with a stipulated injunction ordered by the Federal District Court for the Northern District of California in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

There are currently three CTS Distinct Population Segments (DPSs): the Sonoma County (SC) DPS, the Santa Barbara (SB) DPS, and the Central California (CC) DPS. Each DPS is considered separately in this risk assessment as they occupy different geographic areas. The CTS-SB and CTS-SC were down listed from endangered to threatened in 2004 by the USFWS; however, the down listing was vacated by the U.S. District Court. Therefore, the SC and SB DPSs are currently listed as endangered while the CC DPS is listed as threatened. The CTS utilizes vernal pools, semi-permanent ponds, and permanent ponds, and the terrestrial environment in California. The aquatic environment is essential for breeding and reproduction and mammal burrows are also important habitat for aestivation.

1.2. Scope of Assessment

Mancozeb is a member of the ethylene-bis-dithio-carbamate (EBDCs) group of fungicides. The chemical is a polymer or highly coordinated salt complex, in which the EBDC ligand is present in coordination with zinc (ZN+2) and manganese (Mn+2) ions. The parent mancozeb is expected to be hydrolytically unstable in the natural environment as it is applied under moist conditions. Therefore, this risk assessment is based on estimates of exposure to the mancozeb hydrolytic residue; referred to hereafter as the mancozeb complex. As discussed later, the mancozeb complex consists of multi-chemical species including the major degradate ethylenethiourea (ETU). In the risk assessment process, both acute and chronic exposure concentrations will be estimated for the total toxic residue or mancozeb complex. It is noted, however that the chemical species present in the "fresh" mancozeb complex at the short-term, which are believed to be those chemical species responsible for observed acute toxicity of mancozeb, include ETU. In contrast, the "aged: mancozeb complex is expected to be enriched with ETU. Use of the total toxic residue procedure in the risk assessment process was necessary due to the unique hydrolytic instability of mancozeb and the formation of mancozeb complex. Details of the short- and long-term exposure estimation procedures and justification for relating them to measured acute and chronic effects are presented in the analysis plan in the document (**Section 2.10**). In this assessment, the stressor of concern is the total toxic residue (or the mancozeb complex) which includes all of the chemicals resulting from the rapid hydrolysis of mancozeb (parent). More details are provided in **Section 2.4**

Uses Assessed

In this ecological risk assessment for mancozeb, the following uses are included: apples (including crab apple, pear, and quince), asparagus, cereal grains, corn (field , seed crop, sweet and pop), cotton, cucurbits, fennel, forestry (Douglas fir), garlic, ginseng, grapes (table & wine), onion (dry), ornamentals (in nursery, residential including turf, pachysandra), papayas, potatoes, shallot, sugar beet, tomatoes, tropical (selected), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms), and X-mass tree plantations.

1.3. Assessment Procedures

Fate and Transport Characteristics

Parent mancozeb is applied under moist conditions (rain and/or irrigation-fed growing plants). Under such conditions, the chemical reaching the soil system is expected to be short lived due to its hydrolytic instability (hydrolysis half-life is several hours). Therefore environmental exposure will result from chemical species produced by hydrolysis of mancozeb, which is the referred to as the "mancozeb complex" in this document. Given these factors, the total toxic residue procedure was implemented to arrive at the mancozeb complex acute and chronic aquatic exposure estimates. The process is called the total toxic residue method and is presented in detail in Section 2.4 Environmental Fate and Transport Properties. Specifically, the referenced process is based on estimations chemicals present in the mancozeb total toxic residue or the "mancozeb complex" in the short-term (for the potential acute exposure) and for chemicals present in the "mancozeb complex" in the long-term (for the potential chronic exposure). Terrestrial exposure from the mancozeb complex is evaluated using the T-REX model. The environmental fate properties of mancozeb indicate that spray drift and run-off represent potential transport mechanisms of parent and resultant mancozeb complex into the aquatic and terrestrial habitats of the CTS. In this assessment, transport of parent mancozeb from initial application sites through spray drift and runoff are considered in deriving quantitative estimates of exposure to the CTS, its prey and its habitats.

Assessment Endpoints

The assessment endpoints for the CTS include direct toxic effects on the survival, reproduction, and growth of the CTS itself, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. In the absence of toxicity data for amphibians, direct effects to the CTS in the aquatic habitat are based on toxicity information for freshwater fish, which are generally used as a surrogate for aquatic-phase amphibians. In the terrestrial habitat, direct effects are based on toxicity information for birds, which are used as a surrogate for terrestrial-phase amphibians in the absence of toxicity data for terrestrial phase amphibians. Given that the CTS's prey items and designated critical habitat requirements in the aquatic habitat are dependent on the availability of freshwater aquatic invertebrates in the water column and in sediment, fish and aquatic plants, toxicity information for these taxonomic groups is also discussed. In the terrestrial habitat, indirect effects due to depletion of prey are assessed by considering effects to terrestrial insects and birds as surrogates for frogs. Indirect effects due to modification of the terrestrial habitat are characterized by available data for terrestrial monocots and dicots. Federally-designated critical habitat has been established for the CTS. Primary constituent elements (PCEs) are used to evaluate whether mancozeb has the potential to modify designated critical habitat.

Available toxicity studies indicate that mancozeb is highly toxic for acute exposure to freshwater fish and aquatic invertebrates. Toxicity studies reviewed indicate that mancozeb is practically nontoxic for acute exposure to birds, mammals and terrestrial invertebrates. **Section 4** summarizes the ecotoxicity data available on mancozeb parent, mancozeb complex and the main degradate ETU.

Models

Since the CTS exists within aquatic and terrestrial habitats, exposure of the CTS, its prey and its habitats to mancozeb complex is assessed separately for the two kinds of habitat. Tier-II aquatic exposure models (PRZM/EXAMS) are used to estimate high-end exposures to the mancozeb complex in aquatic habitats resulting from runoff and spray drift from different uses. To estimate mancozeb complex exposures to the terrestrial-phase CTS, and its potential prey, the T-REX model is used. Input parameters for application rate, toxicity and foliar dissipation half-life represent the mancozeb complex. The resulting RQ also represents the mancozeb complex. The T-HERPS model is used to allow for further characterization of dietary exposures of terrestrial-phase amphibians relative to birds.

AgDRIFT is used to estimate potential deposition of the mancozeb complex on terrestrial habitats from spray drift. The TerrPlant model is routinely used to estimate exposures to terrestrial-phase habitat, including plants inhabiting semi-aquatic and dry areas, resulting from foliar application, however, due to nondefinitive endpoints from the toxicity study the TerrPlant model will not be used in this assessment.

Consistent with the process described in the Overview Document (US EPA 2004), this risk assessment uses a surrogate species approach in its evaluation of the use of mancozeb. The Agency evaluated toxicological data generated from surrogate test species and open literature, which are intended to be representative of broad taxonomic groups, to extrapolate the potential effects on a variety of species (receptors) included under these taxonomic groupings. Based on this approach, birds serve as surrogates for terrestrial-phase amphibians and reptiles and freshwater fish serve as surrogates for aquatic-phase amphibians. The most sensitive toxicity value available from acceptable or supplemental studies for each taxon relevant for estimating potential risks to the assessed species and/or their designated critical habitat was used.
Risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. Acute and chronic RQs are compared to the Agency's levels of concern (LOCs) to identify instances where mancozeb complex use within the action area has the potential to adversely affect the CTS and its designated critical habitat via direct toxicity or indirectly based on direct effects to its food supply (i.e., freshwater invertebrates in the water column and in sediment, algae, fish, frogs represented by birds and terrestrial invertebrates) or habitat (i.e., mammal burrows, aquatic

plants and terrestrial upland and riparian vegetation). When RQs for a particular type of effect are below LOCs, the pesticide is determined to have "no effect" on the subject species. Where RQs exceed LOCs, a potential to cause adverse effects is identified, leading to a conclusion of "may affect." If a determination is made that a use pattern, within the action area, "may affect" the CTS and its designated critical habitat, additional information is considered to refine the potential for exposure and effects, and the best available information is used to distinguish those actions that "may affect, but are not likely to adversely affect" (NLAA) from those actions that are "likely to adversely affect" (LAA) the CTS and its critical habitat.

1.4. Assessment Results and Conclusions

Based on the best available information and the procedures summarized above, the Agency makes a May Affect, and Likely to Adversely Affect (LAA) determination for CTS (all 3 DPSs) from the currently registered uses of mancozeb (**Table 1-1**). Additionally, the Agency has determined that there is the potential for modification of designated critical habitat for CTS (all 3 DPSs) from the currently registered uses of mancozeb (**Table 1-2)**. Further information on the results of the effects determination is included as part of the Risk Description in **Section 5.2**. Given the LAA determination for the CTS (all 3 DPSs) and potential modification of designated critical habitat for CTS (all 3 DPSs), a description of the baseline status and cumulative effects for CTS is provided in **Attachment 2**.

The overall mancozeb complex LAA determination for the CTS assessment is consistent with the CRLF LAA determination (USEPA, 2007) for all application methods, although taxa-specific determinations differ. For non-seed treatment uses, the LAA determination is based on the likelihood of direct aquatic effects using the fish as a surrogate for the aquatic-phase CTS (in absence of data for aquatic-phase amphibians) and terrestrial effects to CTS using the bird as a surrogate for terrestrial phase CTS (in absence of data for terrestrial-phase amphibians). The LAA determination for nonseed treatment applications used to evaluate indirect effects include reduction in prey for fish (used as a surrogate for aquatic-phase amphibian prey), aquatic invertebrates, aquatic plants, and a "Habitat Modification" determination based on effects on aquatic plants. There is also an LAA determination for indirect effects for reduction in terrestrial prey for birds (representing terrestrial-phase amphibians), mammals and terrestrial invertebrates. A " Habitat Modification" determination in the terrestrial habitat was based on the uncertainty due to the submitted terrestrial plant toxicity studies not being tested to the highest application rate and reported plant incidents involving mancozeb. An additional factor in the Habitat Modification" determination was based on the CTS' use of mammal burrows for shelter and the RQs indicating a reduction in the number of mammal burrows available for shelter. There is a "No Effect" (NE) determination for seed treatments from the use of mancozeb due to aquatic and terrestrial EECs being below levels of concern for listed CTS.

Species specific differences between the CTS and CRLF determinations are based on updates to the PRZM/EXAMS aquatic model and additional information form ecotoxicity studies received and reviewed. The aquatic EECs were modeled from the updated PRZM/ EXAMS version PE_5. Information from the additional ecotoxicity studies indicated that the degradate ETU was not as toxic as the parent mancozeb. Therefore, mancozeb toxicity values were used to estimate aquatic

RQs for the CTS rather than the ETU toxicity values used to estimate aquatic RQs in the CRLF assessment.

Table 1-1 Effects determination summary for effects of mancozeb complex on the CTS (all 3 DPSs).

Species	Effects Determination	Basis for Determination
		POTENTIAL FOR DIRECT EFFECTS
California tiger salamander (CTS)	LAA	***Aquatic-phase CTS (Eggs, Larvae, and Adults)***: *Freshwater Fish RQ* - Based on freshwater fish endpoints as surrogate for the aquatic-phase CTS, acute RQs for non-seed treatment uses exceeded the listed species risk LOC for cereal grains, corn (field), corn (sweet/Pop), cucurbits, forestry, garlic, ornamentals (residential turf), papayas, tropical fruit (Atemoya, cherimoya, custard apple, sugar apple and sweet sop), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farm) sod farms, and Christmas tree plantations mancozeb uses. Acute RQs ranged from <0.01for ornamentals (residential) to 0.41for turf (sod farms). - Based on freshwater fish, chronic RQs exceeded the chronic LOC for non-seed treatment uses with apple, asparagus, cereal grains, corn (field), corn (sweet/Pop), cotton, cucurbits, fennel, forestry, garlic, grapes, onion, ornamentals (nursery, pachysandra, residential turf), papayas, potatoes, sugar beets, tomatoes, turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farm), turf/ sod farms, and Christmas tree plantations mancozeb uses. Chronic RQs ranged from 0.06 for tropical fruit to 27.19 for turf (sod farms). *Likelihood of Individual Mortality* - The probit analysis suggested that the probability of an individual effect is ~1 in 4.18E+08 at LOC. The probability at the RQ indicated a high probability of risk. The probabilities ranged from ~1 in 27.3 to ~1 in 5.25E+26. Therefore, based on the refined probit analysis, direct effects to aquatic-phase CTS (all 3 DPSs) are likely for all uses resulting in an LAA determination from mancozeb complex exposures.
		Terrestrial-phase CTS (Juveniles and Adults): *Direct Deposition on Forage Items: Avian RQ* - - Chronic RQs for the small birds (used as a surrogate for the terrestrial-phase CTS) exceed the Agency LOC for all 10 crop exposure scenarios. Chronic RQs range from 5.53 for ornamental use to 105.73 for turf use. *Direct Deposition on Forage Items: Refined Herpetofauna Modeling* - Refined modeling was performed with chronic dietary-based toxicity values. Chronic RQs ranged from 5.55 to 96.67 for the CTS consuming small mammals. *Likelihood of Individual Mortality* The chance of individual effects (*i.e.*, mortality) for birds (surrogate for terrestrial -phase CTS) and herpetofauna based on direct deposition onto food items is as high as ~1 in 1.

Species	Effects Determination	Basis for Determination
		<u>Temporal and Spatial Overlap for both Aquatic and Terrestrial Phase CTS</u> There is spatial overlap between areas of potential pesticide application and all three distinct populations of the CTS occurrence/critical habitat based on the use patterns of mancozeb and the location of the CTS.
		POTENTIAL FOR INDIRECT EFFECTS
		CTS Aquatic Prey Items, Aquatic Habitat, Cover and/or Primary Productivity *<u>Freshwater fish and aquatic-phase amphibians</u>*: - Acute RQs exceed the listed species acute LOCs and there is a high likelihood of individual mortality (see above for direct effects to freshwater fish). ***.Freshwater Invertebrates-Water Column*:** -Acute RQs for freshwater invertebrates exceed the listed species LOC for cereal grains, corn (field), corn (sweet/Pop), cucurbits, forestry, garlic, ornamentals (nursery), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweet sop) turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farm), turf/ sod farms, and Christmas tree plantations mancozeb uses. Acute RQs ranged from 0.03for ornamentals (residential) to 0.32 for turf (sod farms). -Chronic RQs exceed the chronic LOC for cereal grains, corn (field), corn (sweet/Pop), cucurbits, forestry, garlic, ginseng, onion, ornamentals (nursery, pachysandra, residential turf), papayas, potatoes, turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farm), turf/ sod farms, and Christmas tree plantations mancozeb uses. RQs ranged from 0.05for tropical fruit to 12.98 for turf (sod farms). *<u>Likelihood of Individual Mortality</u>* -The chance of individual effects (*i.e*., mortality) for freshwater invertebrates is as high as ~1 in 66.1. The probabilities range from ~1 in 2.79E+29 to ~1 in 66.1. ***Freshwater Invertebrates-Benthic*:** -The only use resulting in an endangered species LOC exceedence was for turf/sod farms. The acute RQ for freshwater invertebrates exceeded the listed species for turf/ sod farms mancozeb uses, with an acute RQ=0.05. Turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms) use had the next highest RQ, (acute RQ=0.02). *<u>Likelihood of Individual Mortality</u>* -The chance of individual effects (*i.e*., mortality) for benthic invertebrates is ~1 in 4.18E+08 at the LOC as well for the turf (sod farm) RQ. ***Freshwater Plants*** Due to the absence of toxicity studies for vascular plants, the algal data will be used as a surrogate to represent indirect effects for both vascular and nonvascular aquatic plants. RQs for freshwater plants exceed the listed species LOC for asparagus, cereal grains, corn (field), corn (sweet/Pop), cucurbits, fennel, forestry, garlic, ginseng, grapes, ornamentals (nursery, pachysandra and residential turf), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweet sop), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms), turf/ sod farms, and Christmas tree plantations mancozeb uses. (RQs ranged from 0.13 to 13.87)

Species	Effects Determination	Basis for Determination
		CTS Terrestrial Prey Items, Riparian Habitat *Terrestrial-phase Amphibians*: - Exceedence of acute endangered species LOCs for terrestrial-phase amphibians as described above for CTS (see **"***Potential Direct Effects; Terrestrial Phase CTS [juveniles and adults])*" *Terrestrial Invertebrates*: - There is potential concern for bees representing terrestrial invertebrates based on the uncertainty due to the nondefinitive endpoint from the toxicity study. The bee toxicity study reported an LD50>179µg a.i./bee. For small insects, the EECs for all uses are above the reported LD50 value. For large insects, the turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms) use EEC is the EEC above the LD50 value. In addition, a 7 day toxicity study on the mite resulted in a residual toxicity LR50=0.1 lbs/A. The LR50 value is below application rates for all uses. The study also reported an adverse reproductive effect with an endpoint of eggs laid per female. The 14 day LOAEC= 0.02 lbs/a.i./A. Use rate ranges from ornamentals (1.2 lbs/A) to turf (19.1 lbs/A) *Small Mammals: Direct Deposition on Forage Items* - Chronic diet-based RQs for small mammals foraging on food items receiving direct deposition of applied mancozeb complex exceed the chronic LOC for mammals in all of the 10 crop scenarios modeled. RQs range from 0.36for ornamental use to 110.14 for turf use. *Small Mammals: Reduction in Burrows* -Based on chronic RQ exceedence of the LOC for all 10 crop scenarios indicating a potential reduction in mammals, there is the potential for fewer mammal burrows. Therefore, there is also an LAA for mancozeb complex indirect effects. ***Terrestrial Plants*** The highest tested mancozeb concentration for the terrestrial plant toxicity studies was 1.38 lbs a.i./A. The highest application rate for mancozeb is 19.1 lbs/A. For seedling emergence, soybean and tomato are the most sensitive dicots with 4% plant dry weight inhibition; onion is the most sensitive monocot with 12% dry weight inhibition when compared to controls at the application rate of 1.38 and 0.02 lb a.i. /A for mancozeb and dimethomorph, respectively. For vegetative vigor, tomato is the most sensitive dicot with a 6% plant dry weight inhibition; corn and onion are the most sensitive monocots with 2% plant dry weight inhibition when compared to the controls at the application rate. *Plant Incidents* Five mancozeb plant incidents were reported in the United States from the Ecological Incident Information System (EIIS)[1]. Four of the five reported

[1] http://www.epa.gov/oppefed1/general/databasesdescription.htm#eiis)

Species	Effects Determination	Basis for Determination
		incidents involved the application of mancozeb mixed with other pesticides. All four of those reported incidents were classified as possible using the certainty index. The fifth incident reported an application of mancozeb and resulted in a probable classification using the certainty index. Therefore, there is an LAA based on the uncertainty due to the highest tested concentration in the toxicity test and reported plant incidents.

Table 1-2 Effects determination summary for the mancozeb complex critical habitat impact analyses.

Assessment Endpoint	Effects Determination	Basis for Determination
Aquatic Phase PCEs (Aquatic Breeding Habitat)		
Standing bodies of fresh water, including natural and man-made (e.g., stock) ponds, vernal pools, dune pools and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (i.e., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle. FR Vol 69 No. 226 CTS, 68584, 2004	*Vascular Plants* **Habitat Modification**	Due to the absence of toxicity studies for vascular plants, the algal data is used as a surrogate to represent indirect effects for both vascular and nonvascular aquatic plants.
	Non-vascular Plants **Habitat Modification** <u>Mancozeb uses</u> Asparagus, cereal grains, corn (field and sweet/Pop), cucurbits, fennel, forestry, garlic, ginseng, grapes (wine), ornamentals (nursery, pachysandra, residential), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweet sop), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms), turf (sod farms) and christmas tree plantations	Using aquatic plant toxicity data (EC50) the RQ exceeds the listed species LOC of 1.0. RQs ranged from 0.13 for ornamentals (residential) to 13.87 for sod farms.
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		

Assessment Endpoint	Effects Determination	Basis for Determination
Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend on for food, shelter and protection from the elements and predation.	**Habitat Modification** Mancozeb use All non-seed and dip uses	Chronic RQs for mammals exceed the chronic LOC = 1 for all non-seed uses. RQs range from 0.36 to 100.33.
Upland areas between breeding locations (PCE 1) and areas with small mammal burrow (PCE 2) that allow for dispersal among sites.	*Terrestrial plant (protection from predators)* **Habitat Modification** All mancozeb nonseed or dip uses	Although a toxicity study was submitted evaluating the effect of mancozeb on terrestrial plants, the highest tested rate (1.38 lbs a.i./A) was below the highest application rate for turf (19.1 lbs/A). *Plant Incidents* The five reported plant incidents for mancozeb are described in Table 1-1. Therefore, there is a habitat modification determination for upland areas based on the uncertainty due to the highest tested concentration in the toxicity test and reported plant incidents.

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

2. Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA, 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA, 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS/NOAA, 2004).

2.1. Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the California tiger salamander (*Ambystoma californiense*) arising from FIFRA regulatory actions based on mancozeb uses on Douglas Fir, christmas tree plantations, asparagus, atemoya, Cherimoya, custard apple, sugar apple, sweetsop, cereal grains, corn, cotton, cucurbits, fennel, canistel, mamey, sapote, mango, crab apple, pear, quince, walnuts, ornamentals (pachysandra, turf and others),turf (commercial, industrial, recreational, golf course, ornamental and sod farm) and sod farm.

As detailed in the EPA verification memo dated April 4, 2011 (Appendix A) additional food uses for mancozeb have been proposed. The rule establishing tolerances for almonds, broccoli, cabbage, lettuce and peppers was published in April 2011 with comments ending June 2011. There are no signed labels to evaluate the risk to the CTS from those mancozeb uses at the time of this risk assessment. Therefore, these new food uses will not be included in this assessment because the labels will not be completed by June 30, 2011, the due date for the Mancozeb SFB assessment.

In this assessment, direct and indirect effects to the CTS and potential modification to designated critical habitat for the CTS are evaluated in accordance with the methods described in the Agency's Overview Document (USEPA, 2004b). The Santa Barbara and Sonoma County Distinct Population Segments (DPS) of the California tiger salamander [CTS] (*Ambystoma californiense*) are listed as endangered and the central population of the CTS is listed as threatened. The Santa Barbara County DPS of the CTS was listed as endangered on September 21, 2000 (65 FR 57241). The Sonoma County DPS of the CTS was listed as endangered on March 19, 2003 (68 FR 13497). On August 4, 2004, the CTS was listed as threatened throughout its range thereby down listing the Sonoma and Santa Barbara County DPS of the CTS from endangered to threatened (69 FR 47212). Also on this date, lUSFWS finalized the 4(d) rule, which exempts existing routine ranching activities, for this species throughout its range. On August 19, 2005, the special rule exemption for existing routine ranching activities was upheld, but the downgrading of the Santa Barbara and Sonoma County DPS was vacated. As a result, the endangered species status for the Santa Barbara and Sonoma County DPS of the CTS was reinstated. The CTS is restricted to vernal pools and seasonal ponds in grassland and oak savannah plant communities in central California.

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook*, the assessment of effects associated with registrations of mancozeb is based on an action area. The action area is the area directly or indirectly affected by the federal action, as indicated by the exceedance of the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of mancozeb 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 CTS and its designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached separately for each of the assessed species regarding the potential use of mancozeb in accordance with current labels:

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

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

A description of routine procedures for evaluating risk to the San Francisco Bay Species is provided in **Attachment 1**.

2.2. Scope

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

Mancozeb is a non-systematic preventive fungicide with wide use patterns including a variety of row crops, orchards and vines, ornamentals, turf, and forestry in addition to seed or dip treatment for seed and seed pieces. The total number of federally registered products applicable to uses in CA is 55 for mancozeb. The California Department of Pesticide Regulation (CDPR) registers pesticides for use within California as well. Of the 55 registered products for mancozeb, California has registered only thirty-nine for mancozeb[2]. However, this assessment is based on the federal action and therefore, considers the current federally registered labels. Instructions on these labels indicate that mancozeb can be used interchangeably in about one third of the use patterns.

Although current registrations of mancozeb allow for nationwide use, this ecological risk assessment and effects determination addresses currently registered uses of mancozeb in portions

[2] http://www.cdpr.ca.gov/cgi-bin/label/labq.pl?p_chem=211&activeonly=on

of the action area that are reasonably assumed to be biologically relevant to the CTS and its designated critical habitat. Further discussion of the action area for the CTS and its critical habitat is provided in **Section 2.7**. Mancozeb uses include asparagus, atemoya, cherimoya, custard apple, sugar apple, sweetsop, cereal grains, corn, cotton, cucurbits, ginseng, fennel, shallot, Christmas tree plantations, canistel, mamey, sapote, mango, crab apple, pear, quince, walnuts, Douglas Fir, ornamental (Pachysandra), ornamental (turf), ornamental (other), turf (commercial/industrial/recreational area lawns, golf course, ornamental sod farm) and turf (sod farms).

Mancozeb ((1,2-Ethanediylbis (carbamodithioato))(2-)) manganese and zinc mixture, is a member of the ethylene-*bis*-dithiocarbamate group of fungicides (EBDCs). The parent mancozeb is expected to be hydrolytically unstable in the natural environment as it is applied under moist conditions. Therefore, this risk assessment is based on estimates of exposure to the mancozeb hydrolytic residue; referred to hereinafter as the mancozeb complex. As discussed later, the mancozeb complex consists of multi-chemical species including the major degradate ethylenethiourea (ETU). In the risk assessment process, acute exposure concentrations will be estimated for chemical species present in the "fresh" mancozeb complex at the short-term, which are believed to be those chemical species responsible for observed acute toxicity of mancozeb, including some ETU. The chronic exposure concentrations will also be estimated for all chemical species, including ETU; however exposure concentrations reflect an "aged" mancozeb complex which is enriched with ETU. ETU is the constituent believed to be most responsible for observed chronic toxicity of mancozeb. Use of this procedure in the risk assessment process was necessary due to the unique hydrolytic instability of mancozeb and the formation of the mancozeb complex. Details of the short and long-term exposure estimation procedures and justification for relating them to measured acute and chronic effects are presented elsewhere in this document (see **Section 2.10 Analysis Plan**).

Evaluation of Degradates

Based on laboratory fate studies, the complete polymeric chains of parent mancozeb (the active ingredient "a.i." in mancozeb) are expected to be non-persistent in most natural environments (hydrolysis t ½= <1 day). Hydrolytic decomposition appears to be a complex process as it involves breakdown of the polymers into a fresh mancozeb complex consisting of variable/low molecular weight polymeric chains (i.e., polymer fragments), monomeric species, transient species, and EBDC ligand in association with metal ions other than Mn^{+2} or Zn^{+2}. Aging of the complex results in enrichment with ETU and ETU degradates. The rate of hydrolytic degradation appears to increase with particle size reduction of the applied parent, availability of moisture, oxygen, and high acidic and neutral conditions. The product of hydrolytic decomposition of mancozeb is a multi-chemical species complex hereinafter referred to as the "mancozeb complex" or the "total toxic residue".

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[3,4].

Acute oral toxicity data (i.e., LD50 values) from mammalian studies for formulated products that contain mancozeb and one or more additional active ingredients are summarized in Appendix B.

Currently, the Agency's guidance for assessing the potential risk of chemical mixtures is limited to human health applications (USEPA, 2000). However, the guidance includes principles for evaluating mixtures to assess potential interactive effects that are generally applicable. Consistent with EPA's Overview Document (USEPA, 2004), the Agency's mixture guidance (USEPA, 2000) discusses limitations in quantifying the risk of specified mixtures when there is differential degradation, transport and fate of chemical components following environmental release or application. The LD50 values are potentially useful only to the extent that a wild mammal would consume plants or animals immediately after these dietary items were directly sprayed by the product. Increasing time post application, the differential rates of degradation, transport, etc. for the active ingredients in the formulation only permit a qualitative discussion of potential acute risk (USEPA, 2004).

As discussed in USEPA (2000) a quantitative component-based evaluation of mixture toxicity requires data of appropriate quality for each component of a mixture. In this mixture evaluation, LD50s, with associated 95% confidence intervals, are needed for the formulated products. The same quality of data is also required for each component of the mixture. Most of the formulated products containing mancozeb have LD50 values greater than the limit dose (>5000 mg/kg) with no associated 95% confidence intervals. Of the formulated products, only five products (EPA Reg. Nos. 241-00383, 241-00395, 241-00411, 352-00690 and 67690-00035) have definitive LD50 values and associated confidence intervals. Since there are no confidence intervals associated with mancozeb, it is not possible to undertake a quantitative or qualitative analysis for potential interactive effects. However, because the active ingredients are not expected to have similar mechanisms of action, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would be inappropriate. Consequently, an assessment based on the toxicity of mancozeb is the only reasonable approach that employs the available data to address the potential acute risks of the formulated products.

2.3. Previous Assessments

Mancozeb was first registered in 1948 as a broad-spectrum fungicide for use in agriculture, professional turf management and horticulture. Degradation of this chemical and other EBDCs

[3] Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, Environmental Protection Agency (January 2004) (Overview Document).

[4] Memorandum to Office of Prevention, Pesticides and Toxic Substance, US EPA conveying an evaluation by the U.S. Fish and Wildlife Service and National Marine Fisheries Service of an approach to assessing the ecological risks of pesticide products (January 2004).

results in the formation of the common metabolite ethylenethiourea (ETU). Between 1986 and 1995, the registration standards for mancozeb were issued (1986-1987) and updated (1992) and Special Reviews for EBDCs, including mancozeb, were conducted requiring risk reduction measures, submission of additional data, and cancellation of EBDC use on 11 food/feed crops. During this period, EPA issued data call-ins (DCIs) requiring data to complete re-registration (1986-1987) and to evaluate worker exposure (October, 1995). In 2005, the Environmental Fate and Effects Division (EFED) completed the environmental fate and ecological risk assessments in support of the re-registration eligibility decisions (REDs) on mancozeb, and its major degradate ETU (U.S. EPA, 2005a, and b). In these RED, EPA determined that most uses of mancozeb are eligible for re-registration provided specific risk mitigation measures are adopted. These risk mitigation measures include: reduction of the application rates, limitation of the number of applications per year and cancellation of certain use patterns.

In the ecological risk assessment completed to support the RED for mancozeb, endangered species chronic risk levels of concern (LOCs) were exceeded for birds, terrestrial-phase amphibians, reptiles and mammals for all mancozeb uses. Also, acute and chronic risks to endangered species LOCs were exceeded for freshwater fish, aquatic-phase amphibians and freshwater invertebrates for all modeled uses of mancozeb. At that time, potential risk to terrestrial invertebrates was not assessed. Due to lack of data, risks to terrestrial plants or vascular aquatic plants were not assessed. Based on data for nonvascular plants, mancozeb's uses exceeded the endangered species acute risk LOC for nonvascular aquatic plants.

In the ecological risk assessment completed for ETU, the chronic risk LOC was exceeded for mammals across all uses of the parent compounds. Due to lack of data, potential acute and chronic risks to birds, terrestrial-phase amphibians and reptiles, chronic risks to freshwater fish, aquatic-phase amphibians and aquatic invertebrates, or potential acute risks to aquatic vascular plants were not assessed.

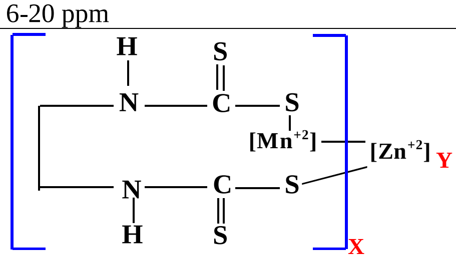
An evaluation of the effects of mancozeb on the CRLF [Case No: 02-1580-JSW(JL)] was completed in 2007. The assessment suggested that the use of mancozeb may affect, and is likely to adversely affect the CRLF, based on indirect effects (habitat modification to terrestrial plants) and that these same effects constitute adverse modification to critical habitat. The CRLF assessment evaluated mancozeb uses on Christmas tree plantations, cotton, cucurbits, fennel, forestry, garlic and onion, grapes, ornamentals (pachysandra and other), papayas, plantains, potatoes, shallot, sugar beets, tomatoes and turf.

It is important to note that the findings from the current assessment differ from the most recent CRLF assessment due differences in the type of crops considered, application rates, and formulations for mancozeb. In addition, label changes that took place after the CRLF assessment resulted in new uses and use rates. The total toxic residue was modeled for both acute and chronic EECs for this CTS assessment instead of modeling the residue minus ETU for acute EECs and ETU for chronic EECs as was done for the CRLF assessment. In addition, the aquatic model PRZM/EXAMs was updated from version PE4 to PE5. Changes to the aquatic EECs were also based on recently submitted toxicity studies using ETU for fish and *Daphnia,* indicating that mancozeb is more toxic than the degradate ETU. Therefore, the ETU component of the mancozeb complex has less effect on exposed species.

2.4. Environmental Fate and Transport Properties

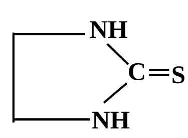
Mancozeb is a polymer or highly coordinated salt complex, in which the EBDC ligand is present in coordination with zinc (Zn^{+2}) and manganese (Mn^{+2}) ions. **Table 2-1** specifies the identity of the parent and **Table 2-2** specifies the degradate ETU along with a summary of laboratory measured physiochemical and abiotic fate properties (U.S. EPA, 2005 a, and b).

Table 2-1 Chemical identity and laboratory measured physiochemical and abiotic fate properties for mancozeb.

Parameters	***Value***
CAS name	((1,2-ethanediylbis (carbamodithioato)) (2-) Mn mixture with ((1,2-ethandiylbis (carbamodithioate)) (2-)) zinc
CAS registry number	8018-01-7
PC code	014504
Molecular weight This MWt is for the monomer just only the repeated unit of the polymer.	271
Vapor pressure (torr)	1.003×10^{-7}
Water solubility*	6-20 ppm
Chemical structure	 Mancozeb X:Y= 10:1
Hydrolysis	t ½ at pH 7= 0.7 day (17 hours)
Aqueous & soil photolysis	Stable

* Note that when mancozeb is dissolved in water up to 20 ppm, the polymeric mancozeb hydrolyzes completely into the mancozeb complex.

Table 2-2 Chemical identity and laboratory measured physiochemcial and abiotic fate properties for ETU.

Parameters	***ETU***	***Structure***
CAS name	2-Imidazolidinethione	 ETU

Based on laboratory fate studies, the complete polymeric chains of parent mancozeb (the active ingredient "a.i." in mancozeb) are expected to be non-persistent in most natural environments (hydrolysis t ½= <1 day). Hydrolytic decomposition appears to be a complex process as it involves breakdown of the polymers into what we refer to as the mancozeb complex consisting of variable/low molecular weight polymeric chains (i.e. polymer fragments), monomeric species, transient species, ETU, bound residue (in soil/sediment systems) and EBDC ligand in association with metal ions other than Mn^{+2} or Zn^{+2}. Aging of the complex results in enrichment with ETU and ETU degradates. The rate of hydrolytic degradation appears to increase with particle size reduction of the applied parent, availability of moisture, oxygen, and high acidic and neutral conditions. Therefore, the product of hydrolytic decomposition of mancozeb is a multi-chemical species complex hereinafter referred to as the "mancozeb complex".

For the aged mancozeb complex (at the long-term), fate and transport data are available for only one of its major constituents, ETU. ETU data were obtained from studies in which ETU was the experimental material. In contrast to ETU, bound residues forming in soil/sediment systems were poorly characterized. However, in the absence of a complete characterization of the bound residues, the screening-level RED assessments (U.S. EPA 2005a and 2005b) included bound residues as part of the total residue complex. Inclusion of bound residues in estimated half-lives resulted in conservative half-life estimates for the total mancozeb complex in soil and water/sediment systems. In this refined assessment, exposure to bound species will be covered by the total toxic residue.

The constituents of the mancozeb complex depend on the characteristics of the system and aging. For example, bound residue is expected to form late and persist only in systems containing soil or sediment particles. Furthermore, the maximum formation of the important ETU metabolite was shown to vary from approximately 10-36% depending on the test system and the parent EBDC (**Table 2-3**).

Table 2-3 Maximum ETU produced in laboratory fate studies for parent EBDCs.

Type of Study	*Parent EBDCs Used as a Test Substance (Number of Studies)*	*Maximum ETU Formed*	
		As % Parent Equivalent	*As % ETU**
Aqueous Hydrolysis	Maneb (1); Metiram (1)	93.0%	35.8%
Aerobic/Anaerobic Aquatic	Metiram (2); Maneb (1)	61.4%	23.6%
Aerobic Soil	Metiram (4); Mancozeb (3); Maneb (3)	24.8%	9.6%

* % ETU= % Parent Equivalent multiplied by Molar ratio of Parent to ETU of 38.5%; for example, the maximum for hydrolysis studies= 93% x 0.385 = 35.8%.

Potential transport mechanisms for pesticides include surface water runoff, spray drift, and secondary drift of volatilized or soil bound residues leading to deposition onto nearby or more distant ecosystems. The magnitude of transport via secondary drift depends on the mancozeb's ability to be mobilized into air and its eventual removal through wet and dry deposition of gases/particles and photochemical reactions in the atmosphere. Therefore, physicochemical properties of the chemical that describe its potential to enter the air from water or soil (*e.g.*, Henry's Law constant and vapor pressure), pesticide use data and modeled estimated concentrations in water and air are considered in evaluating the potential for atmospheric transport of mancozeb and to locations where it could impact the CTS.

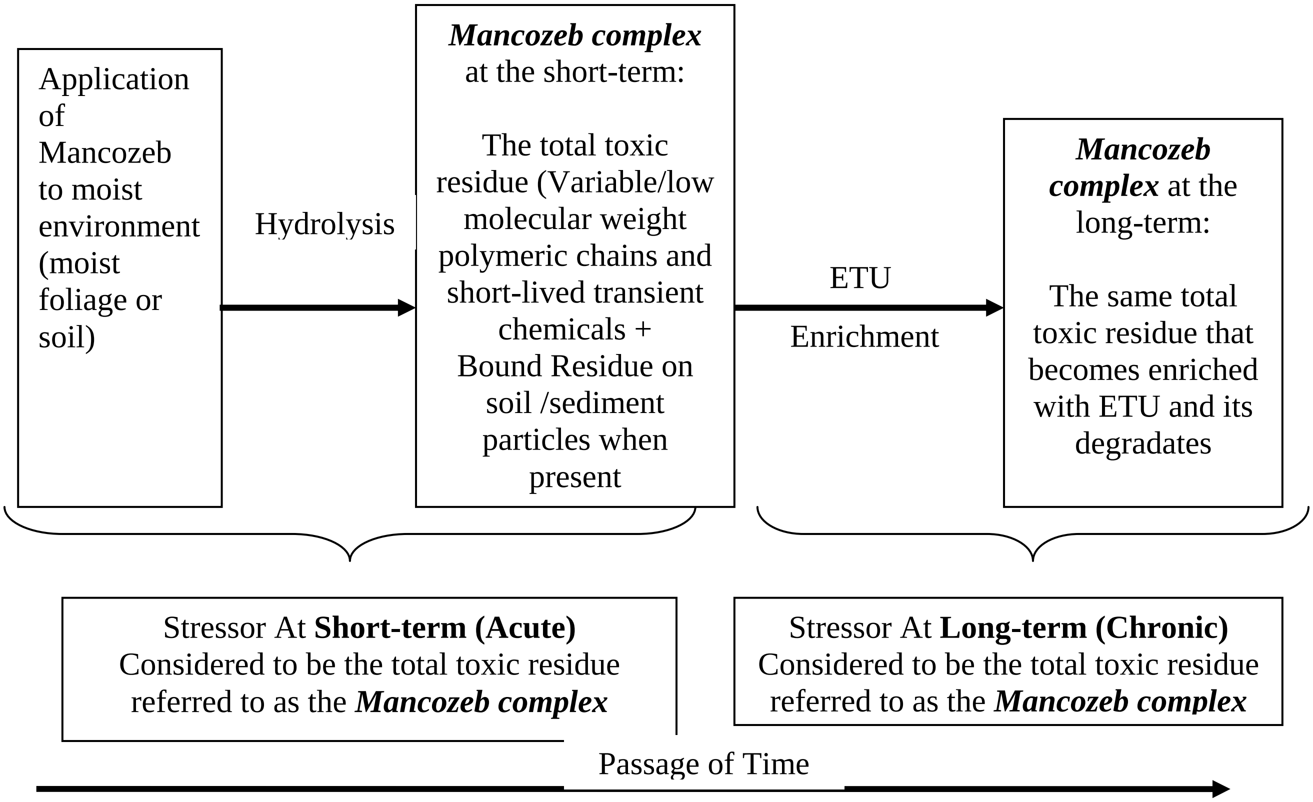
For mancozeb parent, the principal route of transport from application sites is expected to be spray drift. Secondary drift (atmospheric transport) of volatilized parent and the degradates leading to deposition onto nearby or more distant ecosystems is not expected based on the reported low vapor pressures and Henry's law constants (1 x 10^{-7} torr and 5.5 x 10^{-9} atm. m^3 $mole^{-1}$).

In contrast to the movement of parent mancozeb by spray drift, run-off/erosion is the principal route of transport for constituents of the mancozeb complex from application sites to nearby terrestrial and/or aquatic systems. This is due to rapid hydrolysis of the parents and relative high affinity of significant portions of the mancozeb complex to soil particles as well as in solution (the highly soluble ETU portion of the residue).

Based on laboratory studies, the whole freshly formed mancozeb complex, resulting from mancozeb, can be characterized by low mobility in accordance to FAO classification (FAO, 1998). Calculated K_{oc} values were in the range of 860-1,642 L kg^{-1}. Aged mancozeb complex is enriched with the ETU degradate, which is highly soluble (water solubility= 20,000 ppm) and very mobile (Average K_{oc}= 288 L kg^{-1}). In surface water, sources of ETU are formation from parent mancozeb deposited by drift, transported by runoff in dissolved form, and the possible continuous, slow formation from bound species transported on soil particles by runoff or erosion. Quantities of ETU that reach or form in natural surface water are expected to be stable to hydrolysis and direct photolysis; however, ETU can be removed rather quickly from these waters by indirect photolysis (half-lives of 1-4 days) in the presence of photosensitizers.

In an agricultural setting, foliar application of mancozeb is expected to reach plant/soil surfaces directly and air/water bodies by drift. In the air, either chemical will eventually be deposited onto soil/plant/water surfaces with minimal change. On plant surfaces, it is affected by physical wash-off and abiotic hydrolytic decomposition into the mancozeb complex given water availability and time. Based on fate data, the mancozeb complex consists of multiple chemicals that result from hydrolysis of parent mancozeb. The complex that forms from mancozeb and its constituents depend on the media of formation (i.e. the compartment of the environment). The suite of chemicals includes the following two categories: (1) chemicals associated with the short-term acute exposure potential which include variable/low molecular weight polymeric chains, ETU, and short-lived transient chemicals; and (2) chemicals associated with the long-term chronic exposure potential which is the same suite of chemicals that becomes enriched with ETU and ETU degradates. In the presence of soil or sediment particles, part of the chemical species partitions into the solid phase and are referred to as bound species. In this case, these bound species are considered part of the mancozeb complex in both short and long-term noting that these bound species becomes more important with time and that it also expected to slowly degrade into ETU and its degradates (**Figure 2-1**).

Figure 2-1 A flow diagram for degradation of mancozeb showing the multiple and temporally separated degradation products that constitute the total toxic residue, the stressor of concern.



Based on the unique nature of the degradation process for mancozeb, the stressor of concern is considered to be the total toxic residue (refered to in this document as the total toxic residue= the residue of concern= the mancozeb complex). As shown in **Figure 2.1,** the constituents of the stressor at the short and long-terms are the mancozeb complex which equivalent to the total toxic residue that becomes enriched with ETU and ETU-degradates.

Giving the unique degradation process for mancozeb, aquatic modeling for the exposure EECs can be obtained in two procedures, namely:

(1) The total toxic residue procedure where the residue of concern for mancozeb (total toxic residue= mancozeb complex) is considered in totality in modeling. In this case the total mancozeb complex is modeled in only one simulation for each crop/scenario giving the short and long term exposures (acute and chronic); or

(2) The total toxic residue of mancozeb is divided into two parts: one part is dominated by parent and the other chemical species (excluding ETU) and the other part is dominated by ETU only. This requires two modeling runs in which the first considers the fate parameters after deducting ETU contribution while the second run considers the residue to be ETU only modeled from the observed rate of conversion of mancozeb to ETU. The first run would give the short-term (acute) while the second run gives the long-term chronic exposure.

It is important to note that the second procedure was used in the CRLF assessment while the first procedure (i.e. the total toxic residue procedure) is used in this assessment.

The first procedure for aquatic modeling is used here because it generally gives more conservative estimates of exposure EECs than the second procedure and because it is believed to be more environmentally relevant. The relevance comes from the fact that repeated application of mancozeb is expected to result in less enrichment of ETU at the long term than that expected in one application in laboratory experiments.

As shown later in **Table 4-5,** the aquatic toxicity data for ETU are 2-3 orders of magnitude less toxic compared to the parent. Therefore, selected runs were executed for the total toxic residue parameters after subtracting ETU (**Figure 2-2** for peak values**, Figure 2-3** for 21-day values, and **Figure 2-4** for 60-day values). The results indicated that acute and chronic exposure EECs are generally less than EECs from modeling runs where ETU is included. With the exception of two crops, corn and cucurbits, the difference is minimal. Therefore, on the assumption ETU contributes only negligibly to acute and chronic toxicity, most RQ values are minimally affected, except for cucurbits and corn, which would be appreciably lower.

Figure 2-2 Peak EECs used in this assessment, the total toxic residue including ETU (+ETU) compared to EECs resulting from subtracting ETU from the total toxic residue (-ETU).

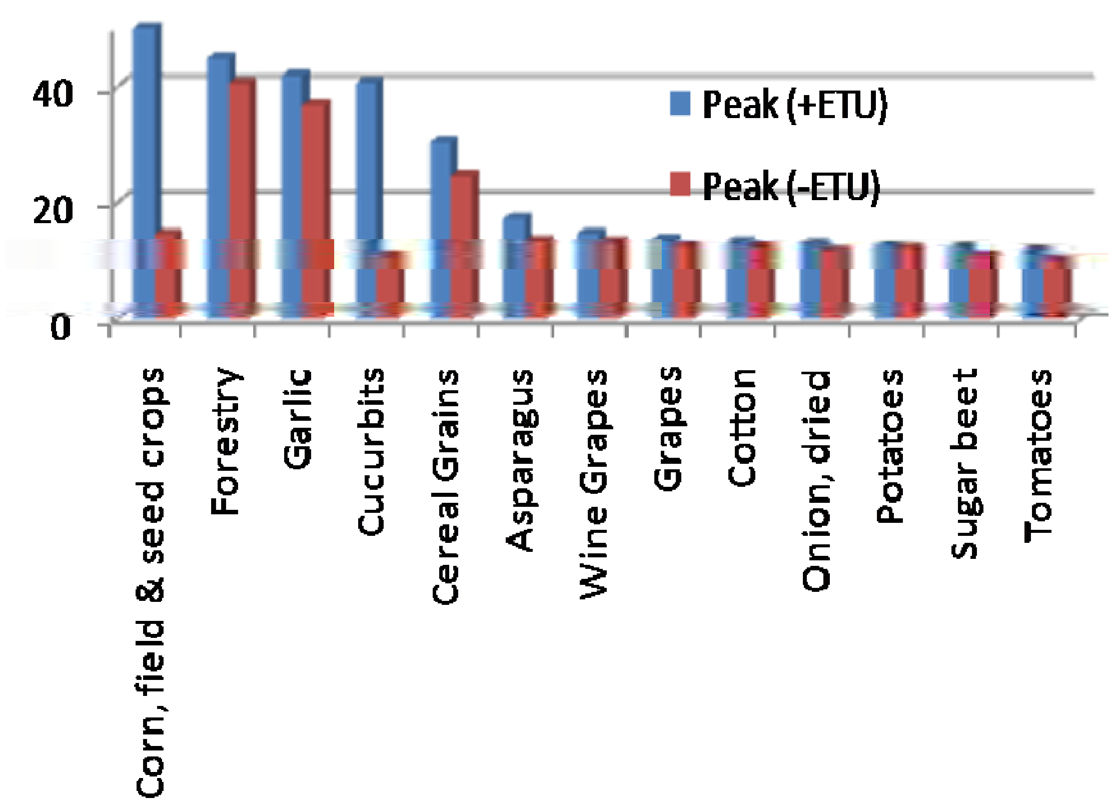


Figure 2-3 Peak EECs used in this assessment, the total toxic residue including ETU (+ETU) compared to EECs resulting from subtracting ETU from the total toxic residue (-ETU).

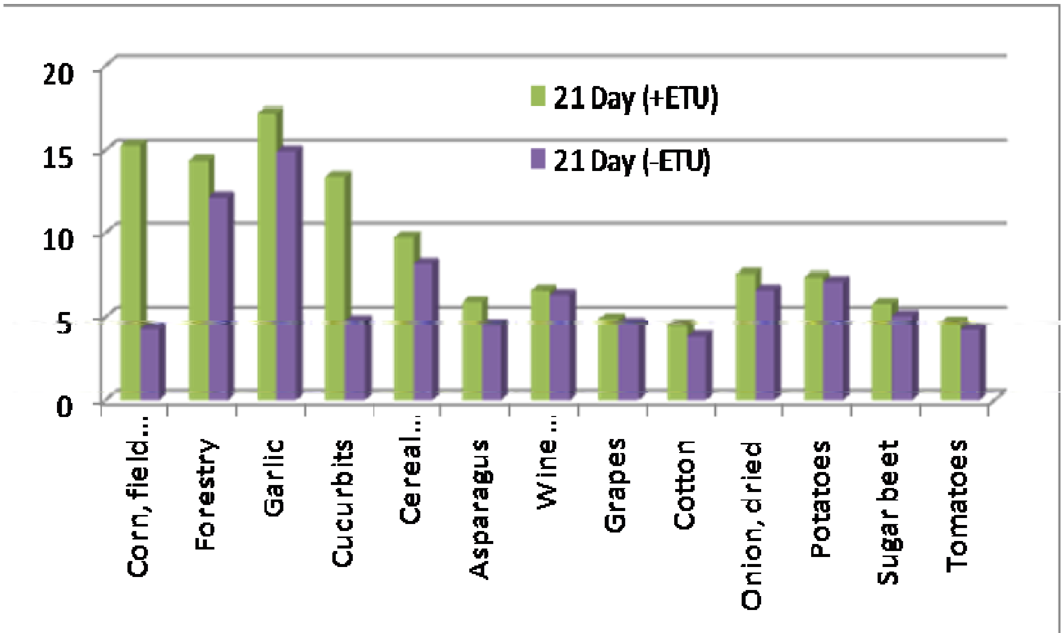
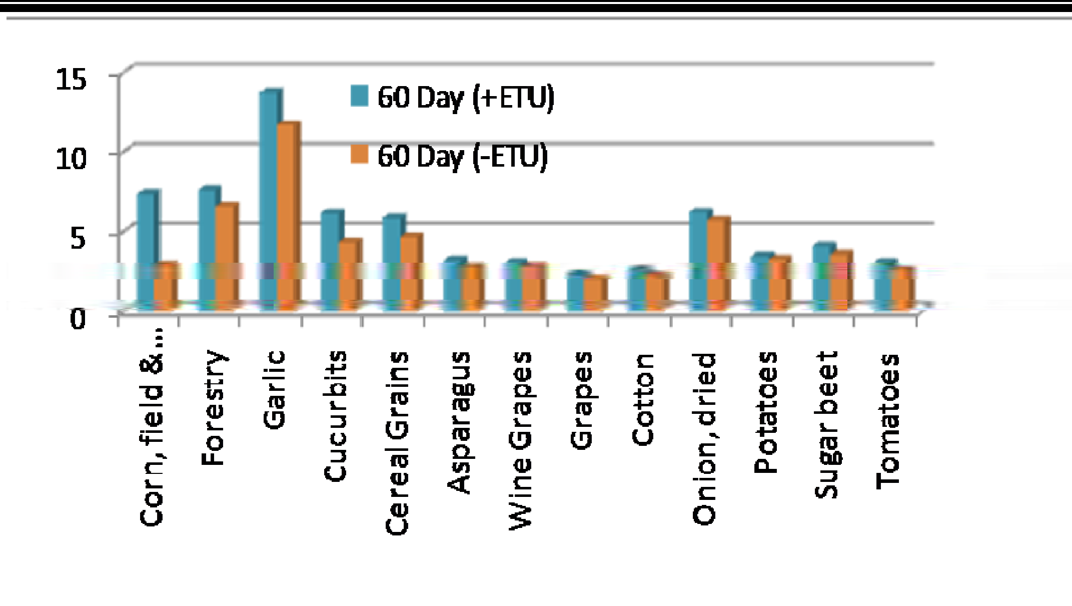


Figure 2-4 Peak EECs used in this assessment, the total toxic residue including ETU (+ETU) compared to EECs resulting from subtracting ETU from the total toxic residue (-ETU).



As shown in **Figures 2-2** through **2-4** above, the residue exposure EECs for the stressor were calculated for the total toxic residue that is the mancozeb complex. For this mancozeb complex, laboratory fate parameters were obtained using radioactivity as a surrogate for concentration. Based on this radio-labeled fate data, it appears that the fate of the complex is controlled by further hydrolytic decomposition, soil/sediment adsorption and to a lesser extent biotic mineralization into CO_2.

The T-REX model routinely used in EFED risk assessments estimated terrestrial EECs for the mancozeb complex. The input parameters, application rate, toxicity values and foliar dissipation values, represent the mancozeb complex, as well as the RQ value.

Mechanism of Action

Mancozeb is a broad-spectrum fungicide belonging to a chemical class of polymeric dithiocarbamates classified as EBDC fungicides. The chemical is a non-systemic, contact fungicide with preventive activity. The EBDCs (mancozeb, maneb, and metiram) can be metabolized to ETU which is of toxicological concern due to its carcinogenicity, teratogenicity, and thyroid agonistic activity. For the human health assessment, OPP has determined that there is sufficient evidence to group the EBDCs based on a common mechanism for the induction of thyroid effects.

Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for mancozeb represent the FIFRA regulatory action; therefore, labeled use and application rates specified on these labels 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.

In the RED for mancozeb, EPA determined that most uses are eligible for re-registration provided specific risk mitigation measures are adopted. As of the date of this assessment, not all measures were implemented. Therefore, this assessment includes only the mitigation measures that had already been implemented in all labels, which includes only reduction of the rate for papya use pattern.

Application parameters relevant to the labeled use patterns are included in **Table 2-4** and **Table 2-5.** These use patterns represent labeled uses up to 2007 and include the mitigation for papaya use. Of all federally labeled uses of mancozeb, pineapple, plaintains and flax use patterns were excluded from this assessment because these crops are not grown in California.

Table 2-4 Mancozeb use patterns (refer to bottom of the table for abbreviations).

Crop Use Pattern	*MSR*	*MNA*	*MTR*	*MAI*
Apple, crab apple, pear, and quince	4.80	4	19.20	7
Asparagus	1.60	4	6.40	10
Cereal Grains [1]	1.60	3	4.80	7
Corn (Field & seed crop)	1.20	10	12.00	4

Crop Use Pattern	*MSR*	*MNA*	*MTR*	*MAI*
Corn (Sweet/Pop) (one crop)	1.20	5	6.00	4
Corn (Sweet/Pop) (two crops)	1.20	10	12.00	4
Corn (Sweet/Pop) (three crops)	1.20	20	24.00	4
Cotton	1.60	4	6.40	10
Cucurbits [2]	2.40	8	19.20	7
Cucurbits, Others [3]	2.40	8	19.20	7
Fennel (one crop)	1.60	8	12.80	7
Fennel (two crops)	1.60	16	25.60	7
Forestry (Douglas Fir)	3.20	3	9.60	14
Garlic	2.40	10	24.00	7
Ginseng [4]	1.50	12	18.00	7
Grapes	2.00	3	6.00	7
Grapes (Wine)	2.00	3	6.00	7
Onion (dry) & Shallot	2.40	10	24.00	7
Ornamentals (in nursery) [5]	1.40	5	7.00	7
Ornamentals (residential, excluding pachysandra) [5]	1.40	5	7.00	7
Ornamentals (residential, Pachysandra only)	17.40	5	87.00	10
Ornamentals (Residential turf)	19.10	4	76.40	5
Papayas	2.00	14	28.00	14
Potatoes	1.60	7	11.20	3
Sugar beet	1.60	7	11.20	7
Tomatoes	1.60	4	6.40	7
Tropical fruits [6]	1.87	14	26.18	7
Tropical Fruits, Others [7]	2.00	14	28.00	14
Turf [8]	19.10	4	76.40	5
Turf (sod farms only) (two crops)	19.10	8	152.80	5
X-mass tree plantations	3.20	3	9.60	14

***MSR*=** maximum single rate (lb a.i./acre), ***MNA*=** maximum number of applications, ***MTR*=** maximum total rate (lb a.i./acre/crop cycle or year), and ***MAI*=** minimum application intervals

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale

[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds

[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon

[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment

[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants

[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop

[7] **Tropical Fruit, Others:** Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote

[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf

Table 2-5 Additional mancozeb use patterns in California: Dip and seed treatments (maximum application rate; all are single rates).

I. Dip or Seedling Treatment (as specified below): Rates in lbs/Acre

Use Pattern			Rate (lb a.i./Acre)
Asparagus: pre-plant crowns dip in burlap bag or dip tank			3.0
Capri fig: dip treatment in a dip tank			3.2
Potatoes: pre-plant seed/seed pieces dip tank @ 0.08 cwt [1]			2.72 (seedling rate of 3,400 lbs/Acre)[2]
II. Pre-plant Seed Treatment (Mist, Slurry and Planter/Drill boxes)			
Use Pattern	***Application Rate (cwt [1])***	***Seeding Rate (lb/Acre)[3]***	***Application Rate (lb a.i./Acre)***
Barely	0.2100	100	0.2100
Corn	0.2719	18.3	0.0498
Cotton	0.3156	10	0.0316
Oats	0.3150	100	0.3150
Rice	0.2094	150	0.3141
Rye	0.1801	90	0.1621
Safflower	0.1063	25	0.0266
Sorghum	0.2271	12	0.0273
Tomatoes	0.3984	0.5	0.0020
Triticale	0.1650	90	0.1485
Wheat	0.1625	89	0.1446

[1] cwt= hundredweight (i.e., lbs/100 lbs of seeds).
[2]Potatoes: http://gardenguide.montana.edu/additional%20info%20pages/Vegetable%20Charts.htm
http://www.hort.purdue.edu/newcrop/duke_energy/Avena_sativa.html#Cultivation
[3] Barley: http://www.ag.ndsu.edu/procrop/bar/baseed04.htm
Corn, cotton, rice and wheat: http://www.hort.purdue.edu/newcrop/duke_energy/
Rye, safflower sorghum: http://www.hort.purdue.edu/newcrop/afcm/flax.html
Oats: http://extension.oregonstate.edu/catalog/html/em/em8692/
Tomatoes: http://aggie-horticulture.tamu.edu/extension/vegetable/cropguides/tomato.html
Triticali: http://southeastfarmpress.com/news/90204Triticale-cover/
Other Reference: http://www.reimerseeds.com/Search.aspx?Keyword=Triticali

As shown in **Table 2-4** and **Table 2-5** above, three types of mancozeb applications are recommended by the labels: 1) foliar, 2) dip and 3) seed treatments. Equipment that can be used include: aerial equipment, ground-boom, chemigation, high- and low-pressure handheld equipment, and backpack sprayers.

EPA's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[5], Doane (www.doane.com, the full set is not provided due to its proprietary nature), and the California Department of Pesticide Regulation (CDPR), Pesticide

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

Use Reporting (PUR) database[6]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for mancozeb, by county in this CA-specific assessment were generated using CDPR PUR data **Appendix C**. Four years (2002-2005) of usage data were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all four years. The units of area treated are also provided where available. A summary of these data is presented in **Table 2-6**.

Table 2-6 California usage data for mancozeb.

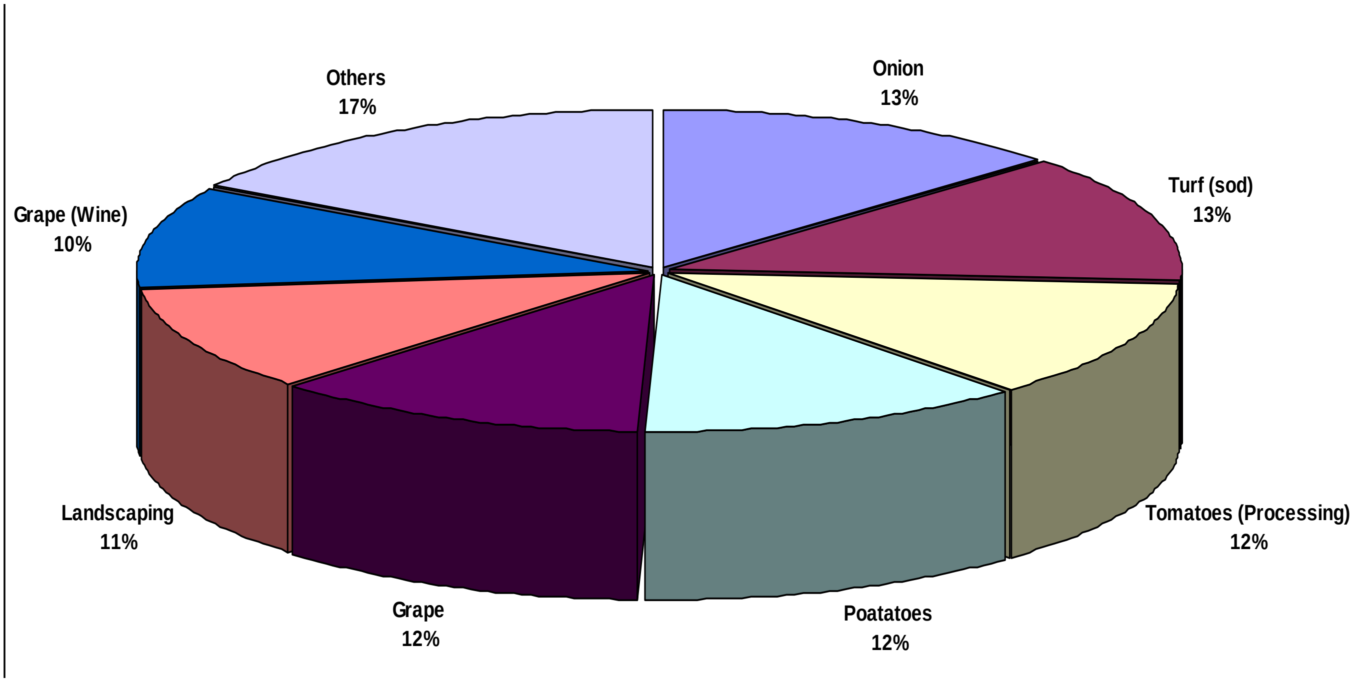
	Average Annual Applied Across 2002-2005				*Application Rate Across All Observations*	
	Lbs. Used		*Area Treated*			
Use Pattern	*Lbs*	*%*	*Acres*	*%*	*Average*	*Maximum*
ONION, DRY	62,707	12.97%	36,716	14.27%	1.8	4.4
TURF/SOD	61,721	12.77%	5,772	2.24%	8.2	33.8
TOMATO, PROCESSING	58,638	12.13%	47,729	18.55%	1.3	3.4
POTATO	58,597	12.12%	48,123	18.71%	1.1	4.1
GRAPE	57,209	11.84%	40,120	15.60%	1.4	4.8
LANDSCAPE MAINTENANCE	51,628	10.68%	ND*	ND	ND	ND
GRAPE, WINE	48,835	10.10%	34,080	13.25%	1.4	8.3
PEAR	30,767	6.37%	10,597	4.12%	2.9	7
N-OUTDR TRANSPLANTS	26,228	5.43%	21,931	8.52%	1.2	7.5
APPLE	18,517	3.83%	7,568	2.94%	2.6	8.9
WHEAT (FORAGE – FODDER)	3,276	0.68%	2,007	0.78%	1.7	3.1
FENNEL	1,380	0.29%	929	0.36%	1.3	1.5
SUGARBEET	1,379	0.29%	956	0.37%	1.5	1.5
GARLIC	396	0.08%	192	0.07%	2.1	2.3
ONION, GREEN	382	0.08%	253	0.10%	1.5	1.7
STRAWBERRY	105	0.02%	35	0.01%	2	2.3
ASPARAGUS	99	0.02%	87	0.03%	1.1	1.5
WATERMELON	90	0.02%	49	0.02%	1.7	2.4
CUCUMBER	32	0.01%	14	0.01%	2.3	3.4
CHRISTMAS TREE	25	0.01%	10	0.00%	2.8	3.1
OTHERS**	1,291	0.26%	90	0.05%	ND-1.3	ND-2.3
TOTALS	483,302	100%	257,258	100%		

* ND= Not determined; ** others = research commodity, right of way, soil fumigation/pre-plant, structural pest control and vertebrates control. These are not registered uses of mancozeb and the report may be attributed to misreporting, misuse, or data entry error.

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

In addition, Figure 2-5 summarizes the distribution of the California crop use patterns for mancozeb

Figure 2-5 Important California crop use patterns for mancozeb



Analysis of the 2002-2005 CDPR PUR usage data is important in determining the intensity and extent of mancozeb usage in California. For intensity of use, reported mancozeb application rates, across all reported uses, show average rates that are generally consistent within or less than the maximum allowable label rates. However, it appears that there are some problems in the reported maximum rates, as it appears to be generally higher than labeled maximum rates. Data on the average four-year annual amounts of applied mancozeb (a total of 483,302 lbs) suggest that nearly 99% of this amount is distributed between the top ten uses as follows: grapes (22%); onions (13%), turf/sod (13%); tomatoes (12%); potatoes (12%); landscaping (11%); pears (6%); nursery plants (5%); apples (4%); and wheat (1%). In terms of extent of use, the same crops also represent 99% of total acreage treated (257,258 Acres) but with different order of % treated as follows: grapes (29%); potatoes (19%); tomatoes (19%); onions (14%); nursery plants (9%); pears (4%); apples (3%); turf/sod (2%) and wheat (1%).

Finally, uses considered in this risk assessment represent all currently registered uses according to a review of all current labels. Historical uses are not considered part of the federal action and, therefore, are not considered in this assessment.

2.5. Assessed Species

Table 2-7 provides a summary of the current distribution, habitat requirements, and life history parameters for the listed species being assessed (CTS). More detailed life-history and distribution information can be found in **Attachment 3**. The distribution of CTS within California is presented in **Figure 2.5**

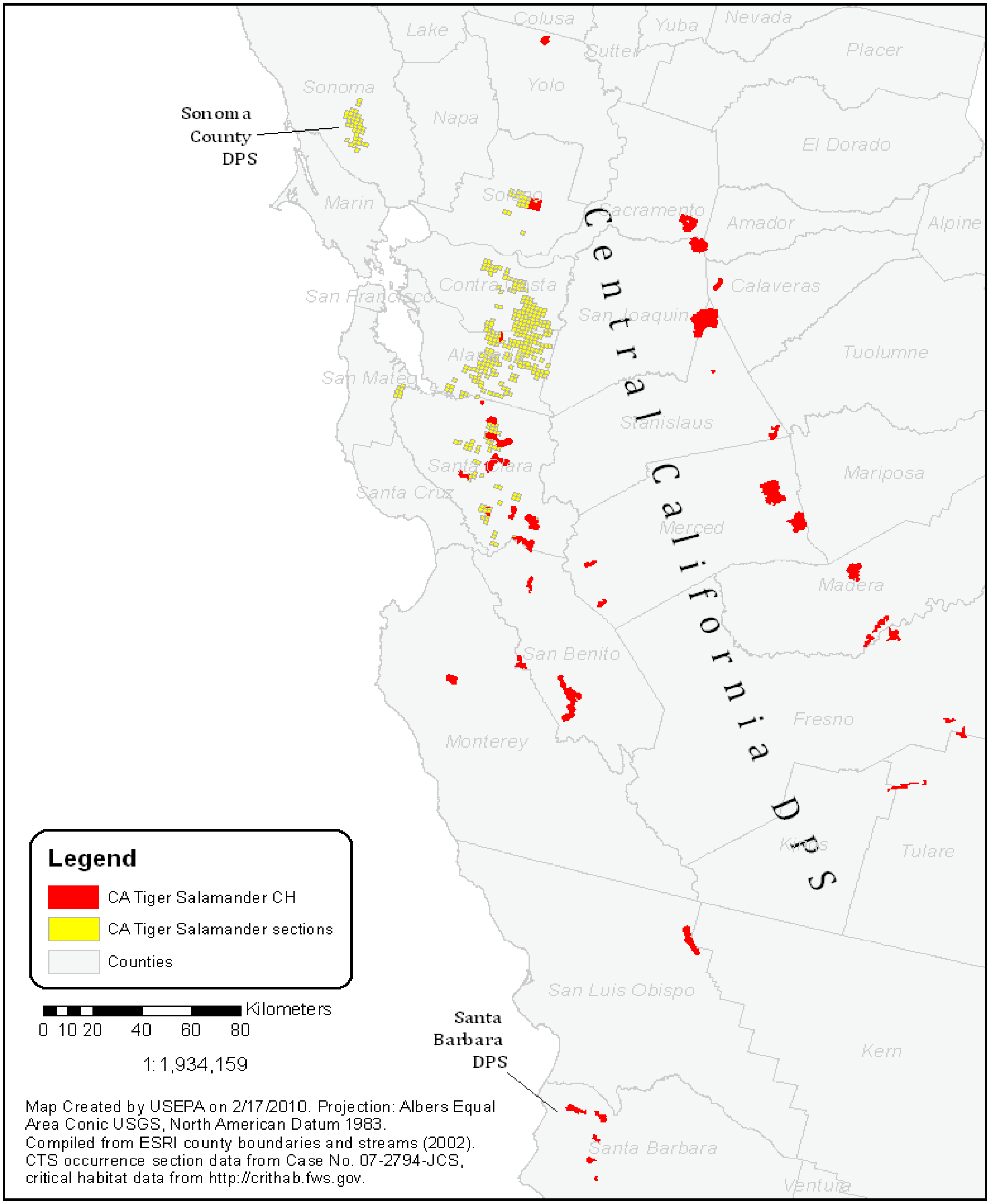
There are currently three CTS Distinct Population Segments (DPSs): the Sonoma County (SC) DPS, the Santa Barbara (SB) DPS, and the Central California (CC) DPS. Each DPS is considered separately in the risk assessment as they occupy different geographic areas. The main difference in the assessment will be in the spatial analysis. The CTS-SB and CTS-SC were down listed from endangered to threatened in 2004 by the USFWS, however, the down listing was vacated by the U.S. District Court. Therefore, the Sonoma and Santa Barbara DPSs are currently listed as endangered while the CTS-CC is listed as threatened. CTS utilize vernal pools, semi-permanent ponds, and permanent ponds, and the terrestrial environment in California. The aquatic environment is essential for breeding and reproduction and mammal burrows are also important habitat for aestivation.

Table 2-7 Summary of current distribution, habitat requirements and life history information for the CTS.

Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
California Tiger Salamander (CTS) (*Ambystoma californiense*)	50 g	CTS-SC are primarily found on the Santa Rosa Plain in Sonoma County. CTS-CC occupies the Bay Area (central and southern Alameda, Santa Clara, western Stanislaus, western Merced, and the majority of San Benito Counties), Central Valley (Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, and northwestern Madera Counties), southern San Joaquin Valley (portions of Madera, central Fresno, and northern Tulare and Kings Counties), and the Central Coast Range (southern Santa Cruz, Monterey, northern San Luis Obispo, and portions of western San Benito, Fresno, and Kern Counties). CTS-SB are found in Santa Barbara County	Freshwater pools or ponds (natural or man-made, vernal pools, ranch stock ponds, other fishless ponds); Grassland or oak savannah communities, in low foothill regions; Small mammal burrows	Yes	Emerge from burrows and breed: fall and winter rains Eggs: laid in pond Dec. – Feb., hatch: after 10 to 14 days Larval stage: 3-6 months, until the ponds dry out, metamorphose late spring or early summer, migrate to small mammal burrows	Aquatic Phase: algae, snails, zooplankton, small crustaceans, and aquatic larvae and invertebrates, smaller tadpoles of Pacific tree frogs, CRLF, toads; Terrestrial Phase: terrestrial invertebrates, worms, insects, frogs and small mammals

[1]For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see **Attachment 2.**

Figure 2-6 California Tiger Salamander Critical Habitat and Occurrence Sections Identified in Case No. 07-2794-JCS.



2.6. Designated Critical Habitat

Critical habitat has been designated for the CTS. Risk to critical habitat is evaluated separately from risk to effects on the species. 'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and 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 2-8** describes the PCEs for the critical habitats designated for the CTS.

Table 2-8 Designated critical habitat PCEs for the CTS[1].

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

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

More detail on the designated critical habitat applicable to this assessment can be found in **Attachment 2.** 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 mancozeb that may alter the PCEs of the designated critical habitat for the CTS form the basis of the critical habitat impact analysis.

As previously noted in **Section 2.1**, the Agency 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 mancozeb are expected to directly impact living organisms within the action area, critical habitat analysis for mancozeb 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.

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 sub-lethal effects available in the effects literature. It is recognized that the overall action area for the national registration of mancozeb is likely to encompass considerable portions of the United States based on the large array of agricultural and non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CTS and their designated critical habitat within the state of California. For this assessment, the entire state of California is considered the action area. The purpose of defining the action area as the entire state of California is to ensure that the initial area of consideration encompasses all areas where the pesticide may be used now and in the future, including the potential for off-site transport via spray drift and downstream dilution that could influence the 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 sub-lethal 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 CTS and designated critical habitat may be affected or modified via endpoints associated with reduced survival, growth, or reproduction.

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 1**) 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 mancozeb. An analysis of labeled uses and review of available product labels was completed.

Some of the currently labeled uses are special local needs (SLN) uses not specified for use in California or are restricted to specific states and are excluded from this assessment. For those uses relevant to the assessed species, the analysis indicates that, for mancozeb, the following agricultural uses are considered as part of the federal action evaluated in this assessment:

(1) Foliar application of mancozeb is summarized in **Table 2-9**.

Table 2-9 Summary of use patterns for mancozeb.

1. Row, field and vegetable crops
Asparagus
Cereal Grains [(1)]
Corn (Field & seed crop)
Corn (Sweet/Pop) (1-3 crops/year)
Cotton
Cucurbits [(2)]
Fennel (1-2 crops)
Garlic
Gingseng
Onion (Dried)
Ornamentals
Potato
Shallot
Sugar Beet
Tomatoes
X-mass tree plantations
2. Orchards & Vineyards
Apples
Crab apple, pear, and quince
Grapes
Grapes (Wine)
Papayas
Plantains
Tropical fruits, others: Canistel, mamey, sapote, mango
Tropical fruits: Atemoya, Cherimoya, Custard apple, sugar apple, sweetsop
Walnuts
3. Residential Landscaping
Ornamentals (Others) [(3)]
Ornamentals (Pachysandra)
Ornamentals (turf)
4. Turf
Turf (sod farms) (1-2 crops/year)
Turf [(4)]
5. Forestry
Douglas Fir

[(1)] Cereal grains include: wheat, barley, oats, rye, and triticale.

[(2)] Cucurbits: Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds, Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon

[3] Ornamentals include shade trees, ground cover plants, herbaceous plants, non-flowering plants and woody plants, shrubs and vines.
[4] Turf includes commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf.

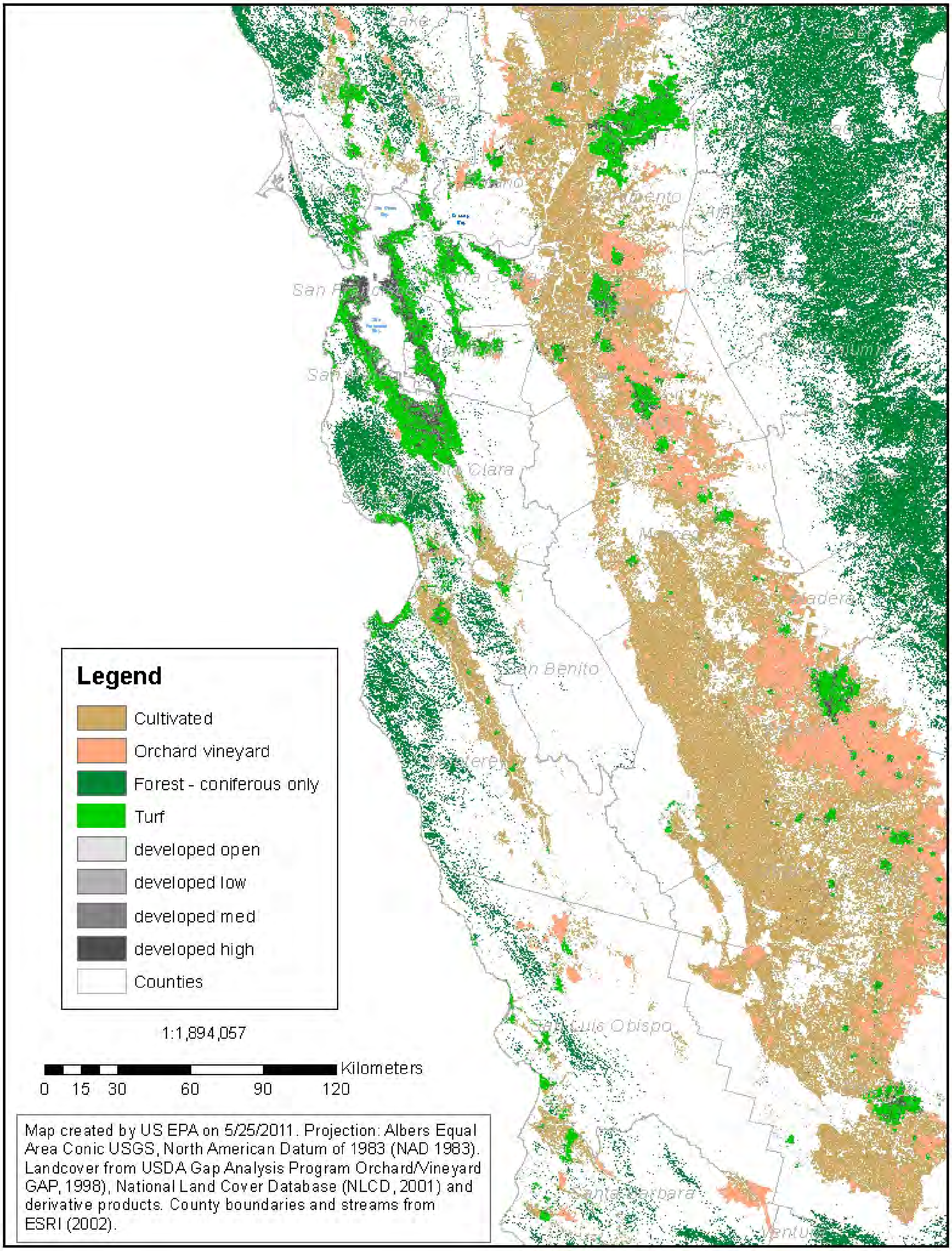
(2) Seed treatment with mancozeb that may also be treated with foliar sprays later in the season. The crops are: cereal grains, except triticale; cotton; corn; and tomatoes. Triticale seeds can only be treated with mancozeb. Seed treatment alone (with no foliar treatment) is labeled for an additional four crops, namely: flax, safflower, sorghum, and rice;

(3) Pre-plant potatoes seed/seed pieces dip treatment; and

(4) Dip treatment use for asparagus and Capri figs.

After a determination of which uses will be assessed, an evaluation of the locations of potential use sites that will be assessed is determined. The potential use sites represent the initial area of concern or "footprint" which is typically based on available land cover data. Local land cover data available for the state of California were analyzed to refine the understanding of potential mancozeb use. The initial area of concern is defined as all land cover types that represent the labeled uses of mancozeb in the state of California. For mancozeb, these land cover types include cultivated crop, orchard/vineyard, forestry, residential (developed open/developed low/developed medium/developed high), and turf. Therefore, a map (**Figure 2-7**) representing the five landcover types specified in **Table 2-9** is presented below.

Figure 2-7 Initial area of concern for the use of mancozeb.



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. The exposure routes for mancozeb most likely to affect non-target organisms are spray drift and runoff. To determine the action area for this assessment, the terrestrial and aquatic portions of the action area in California are determined separately and then are combined to produce a final action area. GIS maps for the final action area are included in **Appendix D.**

The AgDRIFT model (Version 2.01) is used to define how far from the initial area of concern an effect to a given species may be expected via spray drift (*e.g.*, the drift distance). The spray drift analysis for mancozeb uses the most sensitive endpoint of monocot plants; however, the endpoints from the seedling emergence and vegetative vigor studies are nondefinitive. Further details on the spray drift analysis are provided in **Section 5.2** and **Appendix E.**

In addition to the buffered area from the spray drift analysis, the Potential Area of LAA Effects also considers the downstream extent of mancozeb that exceeds the LOC based on downstream dilution analysis (discussed in **Section 5.2)**.

An evaluation of usage information was conducted to determine the area where use of mancozeb may impact the assessed species. This analysis is used to characterize where predicted exposures are most likely to occur, but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed. These data suggest that mancozeb has historically been used on a wide variety of agricultural and non-agricultural uses.

2.7. Assessment Endpoints and Measures of Ecological Effect

Assessment Endpoints

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in **Section 4** of this document. **Table 2-10** identifies the taxa used to assess the potential for direct and indirect effects of mancozeb on the CTS. The specific assessment endpoints used to assess the potential direct and indirect effects to CTS are provided in **Table 2-11**. The most sensitive endpoint from **Table 2-11** is used to evaluate direct and indirect effects from the use of mancozeb in this assessment. For more information on the assessment endpoints, see **Attachment 1**.

Table 2-10 Taxa used in the analyses of direct and indirect effects for the CTS.

Listed Species	Birds	Mammals	Terr. Plants	Terr. Inverts.	FW Fish	FW Inverts.	Aquatic Plants
California tiger salamander	Direct Indirect (prey)	Indirect (prey/ habitat)	Indirect (habitat)	Indirect (prey)	Direct Indirect (prey)	Indirect (prey)	Indirect (food/ habitat)

Abbreviations: Terr. = Terrestrial; Invert. = Invertebrate; FW = Freshwater

Table 2-11 Taxa and assessment endpoints used to evaluate the potential direct and indirect effects or modification of critical habitat from the use of mancozeb.

Taxa Used to Assess Direct and Indirect Effects to CTS and/or Modification to Critical Habitat	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects [1]
1. Freshwater Fish and Aquatic-Phase Amphibians	Direct Effect – - Aquatic Phase CA Tiger Salamander	Survival, growth, and reproduction of individuals via direct effects	1a. Most sensitive fish or amphibian acute LC_{50} Mancozeb -Rainbow trout (*Oncorhynchus mykiss*) 96 h LC_{50} =460 ug a.i/L 1b. Most sensitive fish or amphibian chronic NOAEC 1c. Most sensitive fish or amphibian early-life stage data Fathead minnow (*Pimephales promelas*) 35 Day Mancozeb NOAEC=2.19 µg a.i./L (MRID 432307-01)
2. Freshwater Invertebrates	Indirect Effect (prey) - Aquatic Phase CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	Water Column: 2a. Most aquatic invertebrate, Mancozeb - *Daphnid magna* 96 h LC_{50}= 580 ug a.i/L (MRID 401185-03) Water Column: 2b. Most sensitive aquatic invertebrate chronic 21 Day NOAEC, mancozeb *D. magna* NOAEC = 7.3µg a.i/L (MRID 409538-02) Sediment: Mancozeb *Chironomus dilutus* 10 day LC50=38.0 mg a.i./kg sediment (MRID 474101-01)
5. Aquatic Plants (freshwater)	Indirect Effect (food/habitat) - Aquatic Phase CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	5a. Vascular plant acute EC_{50}. Vascular plant acute EC_{50} (No data available for mancozeb). ETU *Lemna* (MRID 474412-03) resulted in no adverse effects at the highest tested concentration of 960 mg a.i./L. No definitive endpoints from this study were estimated. 5b. Non-vascular plant acute EC_{50} **(**Mancozeb *Pseudokirchneriella*

Taxa Used to Assess Direct and Indirect Effects to CTS and/or Modification to Critical Habitat	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects (1)
			subcaptitatum (formerly *Selenastrum Psedokirchneriella)* EC_{50} = 47 ug a.i/L (MRID 436647-01) *P. subcaptitatum* ETU EC_{50}=23µg/L and NOAEC=12.5µg a.i./L (MRID 464629-04)
6. Birds	Direct Effect - Terrestrial Phase CA Tiger Salamander	Survival, growth, and reproduction of individuals via direct effects Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on terrestrial prey (birds)	6a. Most sensitive bird or terrestrial-phase amphibian acute LC_{50} or LD_5 *Mancozeb*- English sparrow (*Passer domesticus)* multiple dose acute oral LD_{50} ~ 1,500 mg ai/kg bw (MRID 00036094) 6b. Most sensitive bird or terrestrial-phase amphibian chronic NOAEC: Mancozeb - *A. platyrhynchos* 22 week reproduction NOAEC = 125 ppm in diet (MRID 419484-01) *Colinus virginianus* 22 week Mancozeb NOAEC=125ppm in diet (MRID 441595-01)
7. Mammals	Indirect Effect (prey/habitat from burrows/rearing sites) - Terrestrial Phase CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on terrestrial prey (mammals) and/or burrows/rearing sites	7a. Most sensitive laboratory mammalian acute LC_{50} or LD_{50} **(**MRIDs 0014522, AC254377, AC25944): Mancozeb Rat LD_{50}>5,000 mg ai/kg bw Mancozeb EP (MRID AC238564): >5,000 mg/kg Vertebrate chronic NOAEC Mancozeb Rattus norvegicus reproductive NOAEC = 120 ppm in diet

Taxa Used to Assess Direct and Indirect Effects to CTS and/or Modification to Critical Habitat	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects [1]
8. Terrestrial Invertebrates	Indirect Effect (prey) - Terrestrial Phase CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on terrestrial prey (terrestrial invertebrates)	8a. Most sensitive terrestrial invertebrate and vertebrate acute EC_{50} or LC_{50} - Mancozeb: Honey bee *(Apis mellifra)* >179µg/bee (MRID 00018842) Mancozeb: predatory mite (*Typhlodromus pyri) Residual toxicity LR50a = 0.1lb a.i./A*
9. Terrestrial Plants	Indirect Effect (food/habitat) (non-obligate relationship) - CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on food and habitat (*i.e.*, riparian and upland vegetation)	Mancozeb Seedling Emergence (MRID 442834-01) 9a. Monocots: Most sensitive species is onion with 12% dry weight inhibition. 9b. Dicots: Most sensitive species are soybean and tomato with 4% dry weight inhibition.
			Mancozeb Vegetative Vigor (MRID 442834-01) Highest application rate for both monocots and dicots was 19.1 lb/A. Highest rate tested was 1.38 lbs a.i./A for mancozeb. Monocots: Most sensitive species are corn and onion with 2% dry weight inhibition. Dicots: Most sensitive species is tomato with 6% dry weight inhibition.

Taxa Used to Assess Direct and Indirect Effects to CTS and/or Modification to Critical Habitat	Assessed Listed Species	Assessment Endpoints	Measures of Ecological Effects (1)
			ETU: No toxicity data is available for either vegetative vigor or seedling emergence.

Abbreviations: SF=San Francisco
(1) the most sensitive toxicity endpoint for mancozeb or ETU was selected as the measure of ecological effect

**Birds are used as a surrogate for terrestrial-phase amphibians and reptiles.

Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of mancozeb that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species were previously described in **Section 2-6**. Actions that may modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the assessed species. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (*i.e.*, the biological resource requirements for the listed species associated with the critical habitat) and those for which mancozeb effects data are available.

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

2.8. Conceptual Model

Risk Hypotheses

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

The labeled use of mancozeb within the action area may:

- directly affect CTS by causing mortality or by adversely affecting growth or fecundity;

- indirectly affect CTS and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect CTS and/or modify their designated critical habitat by reducing shelter provided by mammal burrows or changing the composition of the plant community in the species' current range;
- indirectly affect CTS and/or modify their designated critical habitat by reducing or changing the composition of the aquatic plant community in the species' current range, thus affecting primary productivity and/or cover;
- indirectly affect CTS and/or modify their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;
- indirectly affect CTS and/or modify their designated critical habitat by reducing or changing aquatic habitat in their current range (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- indirectly affect CTS and/or modify their designated critical habitat by reducing or changing the composition of the benthic environment and food supply in reducing the number of sediment dwelling organisms.

Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the mancozeb release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for CTS and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in **Figure 2-7 and Figure 2-8**, respectively. Although the conceptual models for direct/indirect effects and modification of designated critical habitat PCEs are shown on the same diagrams, the potential for direct/indirect effects and modification of PCEs will be evaluated separately in this assessment. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to CTS and modification to designated critical habitat is expected to be negligible.

Figure 2-8 Conceptual model depicting stressors, exposure pathways and potential effects to aquatic organisms from the use of mancozeb (Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk).

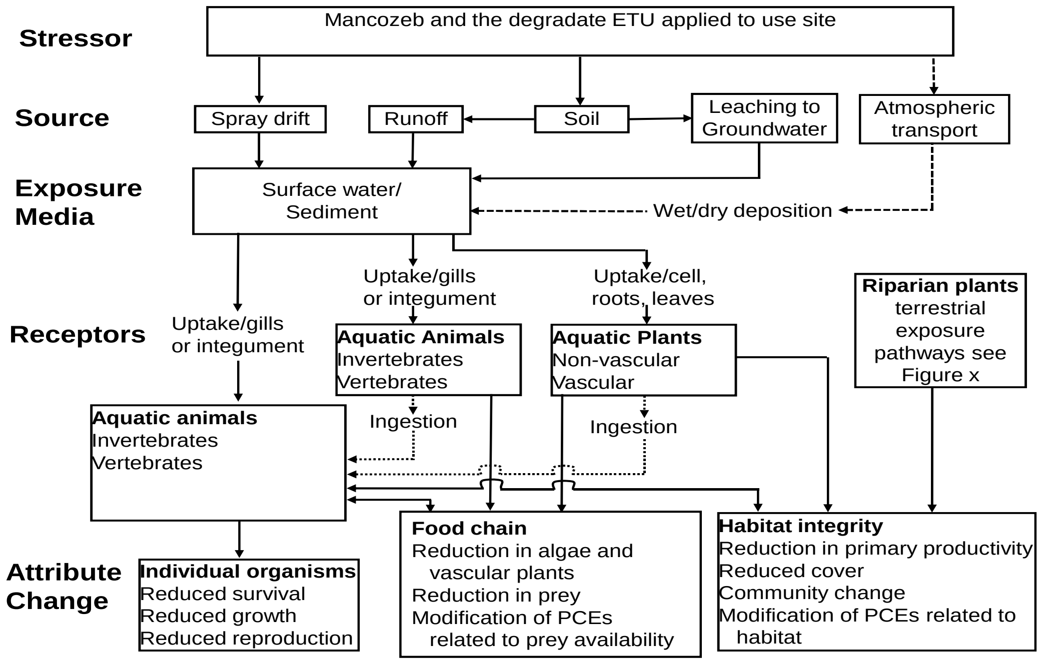
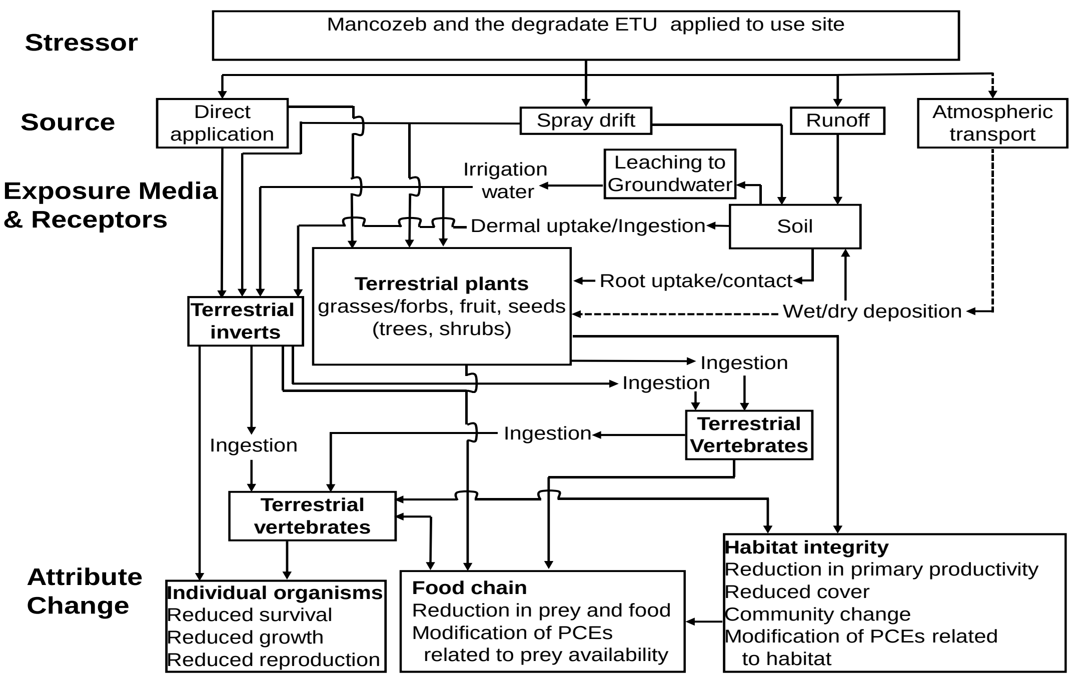


Figure 2-9 Conceptual model depicting stressors, exposure pathways and potential effects to terrestrial organisms from the use of mancozeb (Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk).



2.9. Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the assessed species, prey items, and habitat is estimated based on a taxon-level approach. In the following sections, the use, environmental fate, and ecological effects of mancozeb are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect.

However, as outlined in the Overview Document (USEPA, 2004), the likelihood of effects to individual organisms from particular uses of mancozeb is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

In addition to the estimated RQs for each taxa presented in Section 5.1, the Agency uses the probit dose response relationship as a tool for providing additional information on the potential for acute direct effects to individual listed species and animals that may indirectly affect the listed species of concern (USEPA, 2004). As part of the risk characterization, an interpretation of acute RQs for listed species is discussed. This interpretation is presented in terms of the chance of an individual event (*i.e.*, mortality or immobilization) should exposure at the EEC actually occur for a species with sensitivity to mancozeb on par with the acute toxicity endpoint selected for RQ calculation. To accomplish this interpretation, the Agency uses the slope of the dose response relationship available from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group that is relevant to this assessment. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available.

Individual effect probabilities are calculated based on an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The model allows for such calculations by entering the mean slope estimate (and the 95% confidence bounds of that estimate) as the slope parameter for the spreadsheet. If no slope was estimated, a default slope = 4.5 was used (Urban and Cook, 1986). In addition, the acute RQ is entered as the desired threshold. EFED recognizes extrapolation of low probability events is associated with much uncertainty in this estimate. Raw data to explore possible bounds for this estimate were unavailable.

Descriptions of routine procedures for evaluating risk to the San Francisco Bay Species are provided in **Attachment 1**.

Measures of Exposure

The environmental fate properties of mancozeb along with available monitoring data indicate that water and sediment runoff and spray drift are the principle potential transport mechanisms of mancozeb to the aquatic and terrestrial habitats. Based on the physical, chemical and environmental fate properties, part of the constituents of the mancozeb complex (i.e., ETU) have potential to leach into groundwater (this potential is low because of non-persistence in the soil system). In this assessment, transport of the mancozeb complex, resulting from hydrolysis of mancozeb, through runoff and the parent mancozeb in spray drift is considered in deriving quantitative estimates of mancozeb exposure to CTS and its prey and habitats. For addressing groundwater leaching potential and possibly irrigation with groundwater, the monitoring data were assessed. The potential contribution of atmospheric transport of volatile mancozeb was evaluated based on mancozeb concentrations in air and in rainfall samples from California monitoring results.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of mancozeb complex using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/ EXAMS).

Linked PRZM (v3.12.2, May 2005) and EXAMS (v2.98.04.06, April 2005) are screening simulation models coupled with the input shell PE5 (Aug 2007) were used to generate daily exposures and 1-in-10 year EECs of the mancozeb complex that may occur in surface water bodies adjacent to application sites receiving the mancozeb complex or mancozeb parent through runoff and spray drift, respectively. PRZM simulates pesticide application, movement and transformation on an agricultural field and the resultant pesticide loadings to a receiving water body via runoff, erosion and spray drift. EXAMS simulates the fate of the pesticide and resulting concentrations in the water body. The standard scenario used for ecological pesticide assessments assumes application to a 10-hectare agricultural field that drains into an adjacent 1-hectare water body, 2-meters deep (20,000 m^3 volume) with no outlet. PRZM/EXAMS was used to estimate screening-level exposure of aquatic organisms to the mancozeb complex. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10 year peak is used for estimating acute exposures of direct effects to the aquatic-phase CTS, as well as indirect effects to the CTS through effects to potential prey items and the food chain, including: algae and aquatic invertebrates. The 1-in-10-year 60-day mean is used for assessing chronic exposure to the aquatic-phase CTS; the 1-in-10-year 21-day mean is used for assessing chronic exposure for aquatic invertebrates, which are the chief prey items of the aquatic-phase CTS.

The standard scenario used in this assessment assumes standardized "geometry" (field size, pond depth and size, etc), and the soil, hydrogeologic, meteorological conditions, and agronomic practices utilized data specific to the crop and location being modeled. Therefore the scenarios for use in this assessment may not represent the highest exposure sites for mancozeb outside of California.

Terrestrial exposure is represented by the mancozeb complex. The model used to predict terrestrial EECs on food items is the Terrestrial Residue Exposure (T-REX) model. The Terrestrial Herpatofaunal Exposure Residue Program Simulation (T-HERPS) model is used to refine the risk to terrestrial animals.

Exposure estimates for the terrestrial-phase CTS and its prey items (terrestrial invertebrates and mammals) assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.4.1, 10/09/2008). This model incorporates the Kenaga nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenaga, 1972). For modeling purposes, direct exposures of the CTS to mancozeb through contaminated food are estimated using the EECs for the small bird (20 g), which consumes short grass. Dietary-based and dose-based exposures of potential prey (small mammals) are assessed using the small mammal (15 g) which consumes short grass. The small bird (20g) consuming short grass and the small mammal (15g) consuming short grass are used because these categories represent the largest RQs of the size and dietary categories in T-REX that are appropriate surrogates for the CTS and one of its prey items. Estimated exposures of terrestrial insects to mancozeb are bound by using the dietary based EECs for small insects and large insects.

Birds are currently used as surrogates for terrestrial-phase CTS. However, amphibians are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds or mammals. As a consequence, birds are likely to consume more food than amphibians on a daily dietary intake basis, assuming similar caloric content of the food items. Therefore, the use of avian food intake allometric equation as a surrogate to amphibians is likely to result in an over-estimation of exposure and risk for reptiles and terrestrial-phase amphibians. Therefore, T-REX has been refined to the T-HERPS model (v. 1.0, 5/15/2007), (in Risk Characterization) which allows for an estimation of food intake for poikilotherms using the same basic procedure as T-REX to estimate avian food intake.

The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. EECs for terrestrial plants inhabiting dry and wetland areas are derived using TerrPlant (version 1.2.2, 12/26/2006). This model uses estimates of pesticides in runoff and in spray drift to calculate EECs. EECs are based upon solubility, application rate and minimum incorporation depth. However, the TerrPlant model is not used in this assessment due to nondefinitive endpoints for seedling emergence and vegetative vigor toxicity studies. The EECs are compared to the highest tested concentration from each toxicity test.

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

Measures of Effect

Data identified in **Section 4** are used as measures of effect for direct and indirect effects. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. More information on the ECOTOXicology (ECOTOX) database and how toxicological data from the open literature are used in assessments is available in **Attachment 1**.

2.10. Integration of Exposure and Effects

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

Data Gaps

Data gaps for mancozeb are noted for each taxa. There are no mancozeb data gaps for aquatic animals. Although there is no toxicity data available to evaluate the effect of mancozeb on aquatic vascular plants, data from nonvascular plants is used to evaluate the indirect effect from alterations in the aquatic environment from the use of mancozeb. There is sufficient information from submitted toxicity tests for birds and mammals to evaluate the risk form mancozeb use. There is uncertainty due to a nondefinitve endpoint for the bee toxicity study. For terrestrial effects, there is uncertainty regarding the submitted toxicity tests for seedling emergence and vegetative vigor due to not testing up to the highest mancozeb application rate.

3. Exposure Assessment

3.1. Aquatic Exposure Assessment

For Tier 2 surface water assessments, two models are used in tandem. PRZM simulates fate and transport on the agricultural field. The version of PRZM (Carsel et al., 1997) used was 3.12.2, dated May, 2005. The water body is simulated with EXAMS version 2.98.04.06, dated April, 2005. Tier 2 simulations are run for multiple (usually 30) years and the reported EECs are the concentrations that are expected once in ten years based on the thirty years of daily values generated by the simulation. PRZM and EXAMS were run using the PE5 shell (version 5.0, dated November 15, 2006, which also summarizes the output. Spray drift was simulated using the AgDRIFT model version 2.01 dated May 24, 2001.

Aquatic Exposure Modeling

Modeling Approach

Mancozeb is highly vulnerable to hydrolysis and is not expected to persist in surface water as an intact parent. Therefore acute and chronic aquatic exposures are expected to be associated with the resultant suite of hydrolytic products, which is the total residue of concern or the mancozeb complex. For modeling, the total toxic residue procedure was used to estimate EECs of the total mancozeb complex for both short- and long-term. However, it is noted that the short- term aquatic exposure is expected to result from parent and chemicals forming immediately after hydrolysis (fresh mancozeb complex). In contrast, the long-term exposure is expected to be associated with the same suite of chemicals that are affected by the process of ETU formation and degradation, that is ETU, ETU degradates and the bound residue, a suspected ETU producer (2005a Mancozeb and 2005b ETU REDs). Both short-term and long-term exposures were estimated for the mancozeb complex based on fate and transport parameters using laboratory measured radioactivity associated with total toxic residue of the mancozeb complex.

In order to produce aquatic EEC values for both the short and long-term, the total toxic residue approach was used to obtain exposure EECs for the total toxic reside of mancozeb (i.e., the mancozeb complex) at the required time frames. Modeling was carried out using Tier II linked PRZM/EXAMS.

Modeling Inputs

The total toxic residue modeling exercises was executed using crop specific or surrogate scenarios. Necessary inputs for each of these simulations consisted of the following:

First, A scenario that represents a crop or "group of crops" along with the maximum application rate, maximum number of applications, minimum application interval and the expected application date. Representative scenarios for various crop use patterns and application parameters used in the short and long term modeling (**Table 3-1**) are listed below.
In modeling, the rate used is the parent mancozeb rate in kg a.i./ha (e.g., apples rate = 4.80 lb a.i./A multiplied by the conversion factor 1.121 = 5.381 kg/ha).

Table 3-1 Representative scenarios and application parameters (refer to the bottom of the table for abbreviations).

Crop (s) Represented	*California PRZM Scenario*	*MAR*	*MNA*	*MAI*	*Date (dd-mm)*
Apple, crab apple, pear, and quince	CAfruit_WirrigSTD	5.381	4	7	15-02
Asparagus	CARowCropRLF_V2	1.794	4	10	01-03
Cereal Grains [1]	CAWheatRLF_V2	1.794	3	7	15-02
Corn (Field & seed crop)		1.345	10	4	01-05
Corn (Sweet/Pop) (one crop)		1.345	5	4	01-05
Corn (Sweet/Pop) (two crops)		1.345	10	4	07-01
Corn (Sweet/Pop) (three crops)	CAcornOP	1.345	20	4	07-01
Cotton	CAcotton_WirrigSTD	1.794	4	10	15-04
Cucurbits [2]		2.690	8	7	15-06
Cucurbits, Others [3]	CAMelonsRLF_V2	2.690	8	7	15.06
Fennel (one crop)		1.794	8	7	07-03
Fennel (two crops)	CAonion_WirrigSTD	1.794	16	7	07-01
Forestry (Douglas Fir)	CAForestryRLF	3.587	3	14	01-03
Garlic	CAGarlicRLF_V2	2.690	10	7	15-03
Ginseng [4]	CAsugarbeet_WirrigOP	1.682	12	7	01-05
Grapes	CAgrapes_WirrigSTD	2.242	3	7	15-03
Grapes (Wine)	CAWineGrapesRLF_V2	2.242	3	7	15-03
Onion (dry) & Shallot	CAonion_WirrigSTD	2.690	10	7	1503
Ornamentals (in nursery) [5]	CAnurserySTD_V2	1.569	5	7	01-02
Ornamentals (residential, excl. pachysandra) [5]		1.569	5	7	01-03
Ornamentals (residential, Pachysandra only)	CAresidentialRLF &	19.505	5	10	01-03
Ornamentals (Residential turf)	CAImperviousRLF	21.411	4	5	15-03
Papayas	CAfruit_WirrigSTD	2.242	14	14	15-04
Potatoes	CApotatoRLF_V2	1.794	7	3	15-03
Sugar beet	CAsugarbeet_WirrigOP	1.794	7	7	01-02
Tomatoes	CAtomato_WirrigSTD	1.794	4	7	01-03
Tropical fruits [6]	CAalmond_WirrigSTD	2.096	14	7	15-04
Tropical Fruits, Others [7]	CAfruit_WirrigSTD	2.240	14	14	15-04
Turf [8]	CATurfRLF	21.411	4	5	07-01
Turf (sod farms only) (two crops)	CATurfRLF	21.411	8	5	07-01
X-mass tree plantations	CAForestryRLF	3.587	3	14	01-03

***MSR*=** maximum single rate (Kg a.i./ha), ***MNA*=** maximum number of applications, ***MTR*=** maximum total rate (Kg a.i./ha/crop cycle or year), ***MAI*=** minimum application intervals in days, and ***Date*=** Application Date.

Second, the physicochemical, fate and transport properties along with other parameters necessary for modeling (**Table 3-2**) contains a summary of the inputs used in the simulations representing the total toxic residue or the Mancozeb residue.

Table 3-2 PRZM/EXAMS input parameters for the total toxic residue of mancozeb (the mancozeb complex).

Input Parameter	*PRZM/EXAMS Parameters Used for Simulations* [1]	*Reference Or MRID Number*
Molecular Wt. (g/mol)	**271**	Registrant data
Vapor Pressure (torr)	**1.003 e**$^{-7}$	Registrant data
Bacterial Bio-lyses in the water column t½ (days)	**682** 90th percentile From two values (111 and 391)	462043-01
Bacterial Bio-lyses in benthic sediment t½ (days)	**276** (One value of 92 x 3)	000888-20
Aerobic Soil Metabolism t½ (days)	**164** 90th percentile From three values (121, 161, and 143)	457445-01
Application Method	Aerial Or Ground, if specified	Product Label
Incorporation depth (cm)	0	Product Label
Application Efficiency	0.95 (aerial) Or 0.99 (ground) as a fraction	Guidance
Spray Drift (fraction)	0.05 (aerial) Or 0.01 (ground) the short-term; and	Guidance
Solubility (ppm)	**6**	Registrant data
Koc (L Kg-1)	**1,167** (Average value)	405883-02
pH 7 Hydrolysis t½ (days)	**4** **(**90th percentile From three values (0.8, 0.7, and 1.4)	000971-62 and 402582-01
Photolysis t½ (days)	**0**	001621-03

[1] Values were chosen as per: Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version 2/Feb, 2002 (http://www.epa.gov/oppefed1/models/water/input_guidance2_28_02.htm)

Modeling Results

Surface Water

The results obtained from the mancozeb complex simulations are included in **Table 3-3** for all crop use patterns. EECs used for the aquatic risk assessment were the acute peak values from the short-term simulations and the chronic 21- and 60-day EECs from the long-term simulations.

Table 3-3 EECs in the surface waters for the short- and long-term constituents of the mancozeb complex (ppb) resulting from mancozeb application [1].

Crop	*Peak (short-term)*	*21-day (Long-term)*	*60-day (Long-term)*
Apple, crab apple, pear, and quince	13.44	4.49	2.23
Asparagus	17.23	5.92	3.21
Cereal Grains [1]	30.35	9.73	5.85
Corn (Field & seed crop)	51.72	15.29	7.40
Corn (Sweet/Pop) (one crop)	24.16	7.14	3.40
Corn (Sweet/Pop) (two crops)	74.33	25.08	11.11
Corn (Sweet/Pop) (three crops)	147.65	49.72	26.82
Cotton	13.12	4.51	2.62
Cucurbits [2]	40.64	13.39	6.17
Cucurbits, Others [3]	40.64	13.39	6.17
Fennel (one crop)	8.01	4.30	3.62
Fennel (two crops)	18.11	7.16	5.63
Forestry (Douglas Fir)	44.89	14.38	7.64
Garlic	41.93	17.20	13.76
Ginseng [4]	14.51	1.02	0.73
Grapes	13.50	4.88	2.34
Grapes (Wine)	14.60	6.61	3.07
Onion (dry) & Shallot	12.79	7.57	6.24
Ornamentals (in nursery) [5]	33.29	10.04	5.36
Ornamentals (residential, excluding pachysandra) [5]	1.77	0.71	0.39
Ornamentals (residential, Pachysandra only)	22.68	7.45	4.28
Ornamentals (Residential turf)	24.18	9.06	4.48
Papayas	38.43	10.90	4.51
Potatoes	12.37	7.40	3.46
Sugar beet	12.27	5.80	4.10
Tomatoes	11.81	4.68	3.07
Tropical fruits [6]	43.03	3.52	1.44
Tropical Fruits, Others [7]	5.58	0.39	0.14
Turf [8]	125.50	61.65	30.69
Turf (sod farms only) (two crops)	190.0	94.79	59.55
X-mass tree plantations	44.89	14.38	7.64

Note 1: for a complete list of the categorized crops refer to the use patter Table above **(Table 2-4)**

Additionally, results obtained from the mancozeb complex simulations are included in Table 3-4 for all seed and dip treatments.

Table 3-4 EECs for seed and dip treatments for the short- and long-term constituents of the mancozeb complex (ppb) resulting form mancozeb application [1].

Seed & Dip Treatments	*Scenario*	*Single Rate*		*Exposure EECs (ppb)*		
		lb /A [1]	*Kg/ha [1]*	*Peak*	*21 Day*	*60 Day*
Asparagus (seed dip)	CARowCropRLF_V2	0.3000	0.3363	0.224	0.0643	0.0277

Seed & Dip Treatments	Scenario	Single Rate		Exposure EECs (ppb)		
		lb /A [1]	Kg/ha [1]	Peak	21 Day	60 Day
Capri Fig (dip)	CAfruit_WirrigSTD	0.3200	0.3587	0.110	0.0313	0.0126
Cereal Grains (seed treatment): Max. for barley	CAWheatRLF_V2	0.2100	0.2354	1.012	0.3239	0.1653
Cereal Grains (seed treatment): Min. for wheat	CAWheatRLF_V2	0.1446	0.1621	0.697	0.2230	0.1139
Corn (seed treatment)	CAcornOP	0.0498	0.0558	0.210	0.0659	0.0301
Cotton (seed treatment)	Cotton	0.0316	0.0354	0.171	0.0457	0.0175
Potatoe (seed dip)	Potatoes	0.2720	0.3049	0.085	0.0209	0.0078
Rice (seed treatment)	Rice Model	0.3141	0.3521	91.41	90.49	88.72
Safflower & Sorgham (seed treatment maximum)	CAWheatRLF_V2	0.0273	0.0306	0.132	0.0421	0.0215
Tomatoes (seed treatment)	CAtomato_WirrigSTD	0.0020	0.0022	0.000	0.0001	0.0001

Calculation of rates for dip treatments: Based on the assumption that 10% of the active ingredient became associated with seed to be planted. For example the rate for potatoes= 2.72 lbs a.i x 0.10= 0.272 lb a.i/Ax 1.121= 0.3049 kg/ha. Not all seed treatments were modeled; modeling was executed for maximums and minimums for crop groups (i.e. cereal grains) and for other crops.

RQs are determined for dip treatment to Capri figs, and asparagus due to minimal potential risks resulting from negligible exposure. The method of application itself does not result in ecologically significant releases to the environment and all active ingredient applied is expected to be tightly adsorbed to the surface of the plant parts or seed pieces making it also unavailable for dissolution and transport. Dietary exposure to residues on these items to the CTS is highly unlikely as these are not food items of the CTS.

With regard to seed treatment uses, potential aquatic risks are considered minimal based on negligible aquatic exposure resulting from seed treatment compared to the rate of application used for the assessed foliar treatment to the same crop. In making this comparison, mancozeb use on grains, for which the application rate is the highest (lb a.i./Acre), is below concentrations with any listed acute RQ exceedance. Therefore, these uses too should not exceed LOCs. Potential terrestrial risks associated with seed treatment use are also considered minimal. Further, in the previous terrestrial risk assessment (2005 mancozeb RED), RQ values were calculated for numerous mancozeb seed treatment uses. That evaluation considered seed treatment only use sites, not foliar use sites. The results indicated that the acute risk to endangered species LOC would not be exceeded (RQs < 0.01).

Sediment Exposure

The mancozeb complex includes bound and unbound residue loadings, indicating potential exposure for benthic organisms. Exposure EECs to sediment and pore-water, from selected use patterns, were extracted from "report.xms" file of the surface water PRZM/EXAMS runs. Acute EECs are reported to match the 10-day sediment toxicity study received. Selected data representing the range of EECs are summarized in **Table 3-5**. The numbers expressed in this table reflect concentrations of mancozeb complex in the sediment and pore-water resulting from use.

Table 3-5 Modeled sediment and sediment pore water mancozeb complex EECs (ppb) resulting from use on various crop patterns.

Crop (s) Represented	*California PRZM Scenario*	*Application Parameters*			*Date (dd-mm)*[1]	*Peak EECs (ppb)*[1]	
		MAR[1]	*MNA*[1]	*MAI*[1]		*Sediment*	*Pore Water*
Tropical Fruits, Others [2]	CAfruit_WirrigSTD	2.240	14	14	15-04	4.51	0.096
Turf [3]	CATurfRLF	21.411	4	5	07-01	924.7	19.660
Turf (sod farms only) (two crops)	CATurfRLF	21.411	8	5	07-01	1,787.0	37.890

[1] ***MSR*****=** maximum single rate (Kg a.i/ha), ***MNA*****=** maximum number of applications, ***MAI*****=** minimum application intervals in days, and ***Date*****=** Application Date.
[2] Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[3] Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf

As shown in **Table 3-5**, exposure EECs for sediment range from 5 to 1,787 µg/Kg which is nearly one order of magnitude higher than surface water exposure EECs. This is likely related to the expected affinity of a significant part of the mancozeb residue to sediment particles. In contrast, exposure EECs for pore-water range from 0.1 to 38 ppb which is much lower than surface water exposure EECs.

Aquatic Monitoring

Mancozeb is highly vulnerable to hydrolysis and is not expected to persist intact in surface water. A USGS/NAWQA [7] database search for mancozeb resulted in "no data returned for those criteria". The same results were obtained from EPA/STORET [8] and the CALDPR surface water databases[9]. In contrast to parent, sporadic detections of the main metabolite ETU have been reported in both surface and ground water. For example, a value of 16 ppb was recorded beneath an Iowa apple orchard, which had been treated with an EBDC fungicide (USGS/NAWQA). In California, it appears that no monitoring was executed for ETU in surface water, however, ETU was detected once at an unconfirmed concentration of 0.725 ppb in one well out of 583 (the cumulative well inventory report for the period from 1986-2003).

In a 2-year targeted surface water and ground water monitoring program conducted by the EBDC Task Force[10] at many locations around the US (MRID 46145401), no ETU was measured above the limit of detection of 0.1 ppb in either raw or treated community surface water sources. Sampling was executed every 14-days during the historical EBDC use season. In the same

[7] http://infotrek.er.usgs.gov/traverse/f?p=136:23:0:QUERY:NO
[8] http://www.epa.gov/storet/dw_home.html
[9] http://www.cdpr.ca.gov/docs/emon/surfwtr/surfcont.htm
[10] The EBDC Task Force consists of the registrants of the EBDC chemicals mancozeb, maneb and metiram

study, targeted ground water monitoring indicated a peak of 0.21 ppb measured in a public drinking water well located in Lee County, Florida. In rural areas, the highest value measured by the EBDC Task Force was 0.57 ppb and was for ground water from a private well near an EBDC treated field in an apple growing region of New York. ETU concentrations in the range of 0.1 to 0.25 were also measured in 8 out of the 125 monitored rural wells. Based upon the monitoring results, it appears that ETU has the potential to reach shallow GW water in spite of its nonpersistence in the soil system (short half-life in the Laboratory). This might be explained by expected possible continous release from the mancozeb complex and its stability to hydrolysis.

3.2. Terrestrial Exposure Assessment

Models to estimate exposure to terrestrial animals are described in the following sections. No EECs were estimated for terrestrial plants.

Terrestrial Exposure Modeling

The current terrestrial exposure model, T-REX (Version 1.43.1, dated October 9, 2008), is used to estimate exposures and risks to terrestrial animals, including birds, mammals, and terrestrial invertebrates for mancozeb complex. Input values on chemical application, avian and mammalian toxicity as well as foliar dissipation half-life data are required to run the model. For the exposure estimate, the 90^{th} percentile of the foliar residue data (20 days) was used to determine the half life.

Only the data from the Western states were used to account for information indicating half lives were typically twice as long in the west as in the east (Dole and Dawson, 2003). The mancozeb foliar residue data represent the parent chemical as well as ETU. Application rates for the estimated lowest, middle and highest mancozeb exposure uses, as well as four uses not evaluated in the CRLF assessment were modeled.

The T-REX model generates estimated environmental concentrations (EECs) and calculates risk quotients (RQs). Specifically, the model provides estimates of upper bound and mean concentrations of chemical residues on the surfaces of different food items that may be sources of dietary exposure to the CTS in the terrestrial-phase (*e.g.*, small and large insects, small mammals and terrestrial invertebrates). The surface residue concentration (ppm) is estimated by multiplying the application rate (pounds active ingredient per acre) by a value specific to each food item. Information regarding the T-REX model can be found in **Appendix G.**

EECs in T-REX that are applicable to assess direct effect to the terrestrial-phase CTS are for small birds (20g) consuming short grass[11]. For birds (surrogates for terrestrial-phase CTS), EECs and RQs for acute dose based and chronic dietary based exposure, are calculated as these are the most sensitive values. If the LC_{50} is lower than the LD_{50}, the highest acute dietary EEC and RQ are shown as well. For mammals, EECs and RQs for acute dose based and chronic dose based exposure are calculated as these are typically the most sensitive values. If the dietary assessment results in higher RQs than the dose-based assessment, the highest dietary RQs are shown as well.

To determine the chronic RQs, the most sensitive avian and mammalian toxicity endpoints for either mancozeb or ETU were used. The toxicity endpoints for mammalian developmental data for ETU are used as additional lines of evidence in the assessment. Model inputs and estimated terrestrial dietary exposures are provided (**Table 3-6).** T-REX model inputs for mancozeb uses. Half-life was determined to be 20 days* for all uses.

				Upper-bound EECs (ppm)			
Use	***Rate (lbs a.i./A)***	***Minimum Interval (Days)***	***Max. No. Applications Per Year***	***Short Grass***	***Long Grass***	***Broadleaf Plants, Small Insects***	***Fruits, Pods, Seeds, Large Insects***
Atemoya, cherimoya, custard apple, sugar apple and sweetsop	2.10	7	14	2261.30	1036.43	1271.98	141.33
Cereal Grains	1.6	7	3	921.66	422.43	518.43	57.60
Cucurbit (Chayote, Chinese wax gourd, citron melon, cucumber, gherkin, edible gourd, Momordica spp., musk melon, pumpkin, squash (summer and winter) and watermelon	2.69	7	8	2566.66	1176.39	1443.75	160.42
Cucumbers	2.4	7	8	2289.96	1049.56	1288.10	143.12
Fennel	1.6	7	8	1526.64	699.71	858.73	95.41
Ginseng	1.68	7	12	1769.89	811.20	995.56	110.62
Ornamentals (other)	1.2	7	3	691.25	316.82	388.83	43.20
Shallot	2.4	7	10	2437.56	1117.21	1371.13	152.35
Tropical Fruit: canistel, mammy, sapote, mango, sapodilla, star apple (caimito) and white	2.24	14	14	1396.87	640.23	785.74	87.30

Use	Rate (lbs a.i./A)	Minimum Interval (Days)	Max. No. Applications Per Year	Upper-bound EECs (ppm)			
				Short Grass	Long Grass	Broadleaf Plants, Small Insects	Fruits, Pods, Seeds, Large Insects
sapote							
Turf	17.4	7	4	13216.24	6057.44	7434.14	826.02

*For foliar degradation, foliar half-life measurements used (Mancozeb MRID #s 449596-01, 418369-01, 411339-01, 418369-02, 449596-03, 449585-01). Assuming these values are distributed normally, the value which represents the one tail upper 90% confidence limit of the mean is 20 days.

For mammals, the residue concentration is converted to daily oral dose based on the fraction of body weight consumed daily as estimated through mammalian allometric relationships. The base-line risk assessment for mancozeb uses upper bound predicted residues as the measure of exposure.

The upper bound Kenaga Nomogram-based EECs for terrestrial-phase CTS and small mammal prey items suggests that exposure concentrations were highest for turf (**Table 3-6**). Terrestrial EECs were lowest for figs.

T-REX is also used to calculate EECs to estimate the exposure for terrestrial invertebrates exposed to mancozeb. EECs from mancozeb exposure for CTS consuming small and large insects are presented in **Table 3-6**.The EECs estimated for small insects range from 388.83 to 7434.14 ppm and for large insects from 43.20 to 826.02 ppm.

Terrestrial Atmospheric Monitoring

Air monitoring data reported by the CDPR show that mancozeb was included in the monitoring program (Kollman, 2002). In this program, pesticide concentrations were measured in close proximity to a field at the short-term, during and after pesticide application (15-20 meters from the edge of the treated field during/just after pesticide application) and in the ambient community air at the long-term (at three sites further “>1 km” from the application site and within longer periods from the time of application). Although the study did not distinguish between the routes of transport associated with observed detections, the close proximity of the location of the air monitoring sites to the application site suggests that these detections are likely related to spray drift rather than long-range atmospheric transport. For mancozeb, the two types of monitoring were conducted in Kern County in 1993 after aerial application of mancozeb to a potato field. Mancozeb was not detected at the long-term monitoring (limit of detection= 2 ppt) while it was detected at the short-term in the range of 0.02 to 0.13 ppb in 46% of the 93 samples analyzed. Observed mancozeb detection level at the long-term was compared to the group of pesticides reported to have moved into the Sierra Nevada ecosystems (Fellers et al., 2004). In contrast to mancozeb no detection (over the concentration of 2 ppt), the reported long-range transport pesticide detections ranged from 6.7 to 56.9 ppt in more than 80% of the time). The comparison suggests that the potential for long-range transport of mancozeb is relatively small.

For the mancozeb metabolite ETU, partitioning into the air from dry soil/plant surfaces is expected (vapor pressure= 9.728×10^{-1} torr). However, ETU's high water solubility results in relatively low Henry's law constant (3.4×10^{-7} atm. m^3 $mole^{-1}$) and renders such partition unimportant because ETU forms only when water is present (i.e. in wet soil or water bodies). Additionally, if ETU reaches air, it is expected to partition into rain or is not expected to persist as it is affected by OH-radicals present in the air (a half-life of 0.9 hours was predicted by EPI suite). Data collected from a micro-agro-ecosystem chamber indicate that small amounts of ETU may volatilize from soil and plant surfaces (Nash and Beall, 1980). However, ETU was not detected in a US ambient air-monitoring study of the US EPA designated 189 Hazardous Air Pollutants (Kelly et al, 1994).

4. Effects Assessment

This assessment evaluates the potential for mancozeb to adversely affect the CTS. As previously discussed in **Section 2.8**, assessment endpoints for the CTS include direct toxic effects on the survival, reproduction, and growth as well as indirect effects such as reduction of the prey base or modification of its habitat. Assessment endpoints are selected based on the most sensitive endpoint reported for available data. Direct effects to the aquatic-phase of the CTS are based on toxicity information for freshwater fish, while the terrestrial-phase is based on avian toxicity data since birds are generally used as a surrogate for terrestrial-phase amphibians. Given that the prey items and habitat requirements of the CTS are dependent on the availability of freshwater fish and invertebrates, small mammals, terrestrial invertebrates, and aquatic and terrestrial plants, toxicity information for these taxa are also discussed. Acute (short-term) and chronic (long-term) toxicity information are characterized based on registrant-submitted studies (**Appendix H**) and a comprehensive review of the open literature on mancozeb and ETU (**Appendix I**). A comparison of mancozeb and ETU toxicity values is presented in **Table 4-7.**

As described in the Agency's Overview Document (U.S. EPA, 2004a), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater fish (surrogate for aquatic-phase amphibians), freshwater invertebrates, birds (surrogate for terrestrial-phase amphibians), mammals, terrestrial invertebrates, and aquatic plants. (See **Section 4.1.3** for more discussion).

In addition to the registrant submitted toxicity studies, the ECOTOX database was searched for mancozeb toxicity endpoints on January 21, 2011. Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (U.S. EPA, 2004). In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

- the toxic effects are related to single chemical exposure;
- the toxic effects are on an aquatic or terrestrial plant or animal species;
- there is a biological effect on live, whole organisms;
- a concurrent environmental chemical concentration/dose or application rate is reported; and
- there is an explicit duration of exposure.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, maintenance of CTS survival, reproduction, and growth) identified in **Section 2.8**. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated unless quantitative relationships between modifications and reduction in species survival, reproduction, or growth are available.

4.1. Toxicity of Mancozeb and ETU to Aquatic Organisms

The most sensitive aquatic toxicity endpoints for the CTS are summarized in Table 4-1, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the CTS is presented below. In considering the available data, the most sensitive toxicity endpoints for either mancozeb or ETU were selected for two reasons: (1) the EECs reflect a mancozeb complex (which includes some ETU for short term and much ETU in the long-term), and (2) it is unclear under laboratory toxicity test conditions how much parent mancozeb would be converted to ETU under acute and chronic exposures. Therefore, selecting the most sensitive of the two endpoints (when both were available) reflects a conservative approach for addressing this uncertainty in the effects assessment. Notably, however, available data indicate that the toxicity of ETU to aquatic organisms is considerably less than that of mancozeb. Additional information is provided in **Appendices I and J.**

Table 4-1 Aquatic toxicity profile for mancozeb and ETU.

Species	***Measures of Ecological Effects***	***MRID***	***Study Classification***
Direct toxicity to aquatic-phase CTS	Mancozeb: Rainbow trout (*Oncorhynchus mykiss*) 96 h LC_{50} = 460 ug a.i/L.	*40118502*	Acceptable
	Mancozeb: Fathead minnow (*Pimephales promelas*) 35 Day NOAEC=2.19µg a.i. /L.	43230701	Acceptable
Indirect toxicity to aquatic-phase CTS (via toxicity to prey items)	Mancozeb: Daphnid (*Daphnia magna*) 48 h LC50 =580 a.i. µg/L	40118503	Acceptable
	Mancozeb: *Daphnia magna* 21 Day NOAEC = 7.3 ug a.i/L	40953802	Acceptable
	ETU: *Lemna*: No adverse effects observed at 960 mg a.i./L, the highest concentration. (7 day EC50>960 mg a.i./L)	47441203	Acceptable
	Mancozeb freshwater green algae (*Pseudokirchneriella ubcaptitatu*) 120 h EC_{50} = 47.0 ug a.i/L	43664701	Acceptable
	TEP: Diatom (*Navicula pelliculosa*) 120 h EC50=13.7µg a.i./L	44283402	Acceptable

	Mancozeb : *Chironomus dilutus* (Freshwater midge) Sediment toxicity study 10Day LC_{50} = 38.2 mg a.i/kg sediment	47410101	Supplemental

Categories for acute toxicity to aquatic animals are shown in **Table 4-2** (EPA, 2004). Toxicity categories for aquatic plants have not been defined. Based on these categories, mancozeb is classified as highly toxic to freshwater fish, invertebrates, and amphibians on an acute exposure basis.

Table 4-2 Categories of acute toxicity for aquatic animals.

LC_{50}	*Toxicity Category*
< 0.1 mg/L	Very highly toxic
0.1- 1 mg/L	Highly toxic
1 - 10 mg/L	Moderately toxic
10 - 100 mg/L	Slightly toxic
> 100 mg/L	Practically non-toxic

Toxicity to Freshwater Vertebrates (Amphibians and Fish)

Freshwater fish toxicity data were used as a surrogate for aquatic-phase amphibians to assess potential direct effects to amphibians that may serve as prey of the CTS, according to the Overview Document (USEPA, 2004). Effects to freshwater fish as a surrogate for aquatic-phase amphibians resulting from exposure to mancozeb complex are also assessed as potential prey for the CTS.

Freshwater Fish: Acute Exposure (Mortality) Studies

No acute toxicity studies are available for aquatic-phase amphibians to determine the effect of mancozeb complex, therefore, fish are used as a surrogate. The most sensitive endpoint derived from the acute rainbow trout test conducted with mancozeb (96-h LC_{50} of 460 ug a.i/L) is used to assess potential direct effects and also to assess indirect effects to the CTS via reduction of prey items.

Sublethal effects were reported in an ETU acute Rainbow trout study (MRID 459104-01). The measured concentrations were 21.6, 49.9, 100.7, 218.7 and 502 mg/L. Ten fish per vessel with 20 total fish per treatment group were used in the study. There was 10% mortality in 502 mg/L treatment group at 96 h. The ETU acute LC50 value reported for freshwater fish was > 502 ppm. Sub-lethal Observations: 1 fish observed tumbling in 502 mg/L treatment group at 48 h. No other sub-lethal effects reported.

Freshwater Fish: Chronic Exposure (Growth, Reproduction) Studies

A mancozeb toxicity study using the fathead minnow (MRID 43230701) resulted in a 35 Day NOAEC= 2.19µg a.i./L. Nominal mancozeb concentrations tested were 0.30, 0.60, 1.3, 2.5, 5.0, 10, and 20 µg/L along with a dilution water control. These values were 79 to 96% of the nominal test concentrations. Mancozeb concentrations were measured by GC in the top 5 concentrations. Mean measured concentrations were 0.592, 1.07, 2.19, 4.56, and 7.97 µg/L from GC analysis.

The most sensitive endpoint was survival. Overall percent survival was 87.1, 97.1, 91.2, 94.3, 93.5, 91.1, 62.6, and 22.9%, respectively in the control and test levels. A significant reduction in survival in the measured 9.57 µg/L (4.56 µg/L nominal) and 19.0µg/L (7.97 µg/L nominal) test concentrations when compared to the control.

Physical abnormalities included spinal curvature. This was observed in 4 individuals in the 4.56 µg/L treatment level and 2 individuals in the 7.97µg/L treatment level. The two in the highest concentration (7.97µg/L) level were observed resting on the bottom of the test chamber.

Freshwater Vertebrates: Sublethal Effects

One ETU toxicity study reported sub-lethal effects for amphibians. Sub-lethal effects were noted in mancozeb and ETU toxicity studies for freshwater fish, that may be used as a surrogate for the aquatic phase CTS. A toxicity study conducted with ETU which evaluated the developmental stages of to *Xenapus laevis (*South African clawed frog) is described (ECOTOX Reference 90116). *Xenapus laevis* developmental stages were exposed to ETU via water column under static water conditions with daily renewal for 4 days. The developmental stages were from the blastulation (shortly after fertilization) to the free swimming tadpole stage. Developmental stages were assessed for morphological developmental, growth (length), and death during development at 0, 100, 250, 500, 750, and 1000 mg/liter with 40 embryos per concentration. No adverse affects were observed at the highest concentration tested. There was no indication if the gel was removed from the organisms during the blastulation stage; therefore, there is uncertainty regarding the exposure to the test substance the organism. Based on the highest concentration tested, a 4 Day LOAEC was ≥1000 mg a.i./L was reported.

Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data were used to assess potential indirect affects of mancozeb to the aquatic phase CTS. Effects to freshwater invertebrates resulting from exposure to mancozeb may indirectly affect the aquatic phase CTS via reduction in available food items.

A summary of available data for acute and chronic freshwater invertebrates in the water column and freshwater invertebrates in sediment is provided below.

Freshwater Invertebrates: Acute Exposure (Mortality) Studies

Available freshwater invertebrate acute toxicity studies suggest that mancozeb is highly toxic to aquatic invertebrates. The only freshwater invertebrate species tested for both chemicals was *Daphnia magna*. The most sensitive freshwater invertebrate acute toxicity endpoint for mancozeb (48 h LC_{50} 580 ug a.i/L) was determined from a static 48 hour LC_{50} test (MRID 401185-03). In this study, a substantial decrease in test substance concentration was noted between the beginning and end of the test (final values averaged 34% of nominal); therefore, test results were based on the most conservative concentration, which was the final measured concentration. The most sensitive endpoints derived from the *Daphnia magna* test conducted with mancozeb were used to assess potential indirect effects to the CTS via reduction of prey items (freshwater invertebrates).

Freshwater Invertebrates: Chronic Exposure (Growth, Reproduction) Studies

Mancozeb. A chronic freshwater invertebrate toxicity test (MRID 40953802) was conducted with mancozeb. The flow through toxicity study resulted in a measured 21Day NOAEC=7.3µg/L. The most sensitive endpoints were for immobility, length and time to first brood. Nominal concentrations used in the toxicity study were 3, 5.9, 12, 25, 50 and 5000µg/L.

ETU. A chronic freshwater invertebrate toxicity test (MRID 46429-01) was conducted with ETU (the major degradate of mancozeb). Adverse effects on growth and reproduction of *Daphnia magna* were reported at 4100µg a.i/L with a NOAEC of 2000 µg a.i/L. Adult length, survival, and fecundity (mean number of young per adult per reproductive day) were significantly reduced at the 4100µg/L treatment level. The minimum significant detectable difference for the reproductive endpoint (# young/adult/day) was approximately 30% relative to controls due to the small number of replicates used (two instead of the recommended four). The study was classified as supplemental.

Freshwater Invertebrates in Sediment: 10-Day Exposure (Emergence) Studies

A sediment toxicity study was previously required to characterize the risk to organisms living in the benthic zone due to mancozeb's tendency to sorb to the sediment. This study (MRID 47410101) was submitted and is classified as supplemental. Mancozeb caused a significant reduction in survival at the two highest test concentrations (26.1 and 73.0 mg a.i/kg sediment). For growth, increases in mean dry weight occurred with increasing test concentrations of mancozeb compared to the negative control. This may have been due to lower competition for food by surviving organisms with increased mortality at higher test concentrations. As average dry weight increased with increasing test concentrations, a definitive NOAEC for growth was not determined as the increase of growth for the test organism is not viewed as a detrimental biological effect. For survival, the NOAEC was determined to be 15.7 mg a.i./kg sediment and the LC_{50} was determined to be 38.2 mg a.i/kg sediment.

Toxicity to Aquatic Plants

Mancozeb. One study has been submitted for a mancozeb technical formulation using the freshwater green algae *P. subcaptitatum* (MRID 436647-01). The EC_{50} for *P. subcaptitatum* was 47.0 ug a.i/L based on growth inhibition; the NOAEC was <22.0 ug a.i/L. Four end-use formulations with mancozeb co-formulated with dimethomorph or dimethomorph/zoxamide using *P. subcaptitatum*, freshwater diatom *(Navicula pelliculosa)*, and freshwater blue-green algae *(Anabaena flosaquae)* were also submitted (MRID 44283402). The EC_{50}s ranged from 13.71 ug a.i/L-130.0 ug a.i/L. The NOAEC ranged from 2.88 ug a.i/L-28.0 ug a.i/L.

ETU. ETU toxicity studies for vascular and nonvascular aquatic plants are presented based on mancozeb fate characteristics. ETU is persistent in the environment, it is the major degradate of all three EBDC compounds, and the EBDCs rapidly breakdown to ETU in aquatic environments.

A study to determine the effect of ETU on aquatic vascular plants, represented by *Lemna gibba* was submitted (MRID 474412-03). Effects were tested at 59, 120, 230, 480 and 960 mg a.i./L. No adverse effects were reported at the highest measured concentration of 960 mg a.i./L for decrease in frond density, biomass/DWT, or growth relative to control.

In addition to the vascular aquatic study, EFED reviewed one Tier II supplemental study for *P. subcapitata* (formerly *S. capricomutum*), which is a freshwater green alga. The EC_{50} for *P.subcapitata* was 23.0 mg a.i/L based on a decline in cell density; the NOAEC was 12.5 mg a.i/L. EFED classified this study as supplemental because the test duration was only 72 hours and the guidelines require the test duration to be 120 hours.

A nonvascular study for ETU on *S. capricorutum* (MRID 464629-04) resulted in no adverse effects at the 50% effect level. Effects were tested at measured concentrations of 7.5, 15, 29, 58 and 119 mg/L. No dose response was demonstrated for percent inhibition, growth or percent biomass.

Freshwater Field Studies

A mesocosm study (MRID 461530-01) conducted with mancozeb is available (**Table 4-3**). This study followed the Society of Environmental Toxicology and Chemistry (SETAC) "Guidance Document on Testing Procedures for Pesticides in Freshwater Mesocosms" (July 1991) and employed the regression approach. Ten outdoor fiberglass tanks (mesocosms) were used in this study: 3 controls and 7 treatment tanks. Each mesocosm was approximately 2 m in diameter and 1.6 m deep with an approximate volume of 5 m^3. The treatment tanks received eight simulated spray drift applications of Penncozeb 80 WP (80% mancozeb a.i.) each separated by one week. The nominal concentrations selected for each treatment tank were: 1.25, 4.0, 12.5, 40, 125, 400, and 1250 ppb of Penncozeb 80 WP. The results were based upon nominal concentrations of the formulated product and not measured concentrations of the actual test material in the treatment tanks.

Since the mesocosm study was conducted using non-replicated treatments, the study authors calculated EC_{20} and EC_{50} values using employing non-linear regression analysis. The study authors regarded the EC_{20} as the threshold level below which no ecologically relevant effects would be expected. The following table provides the toxicity of Penncozeb 80 WP to various aquatic species in this study.

Table 4-3 Toxicity of Penncozeb 80 WP to various aquatic species.

Species	***Period***	***ppb Penncozeb 80 WP***	
		EC_{20}	***EC_{50}***
Zooplankton			

Species	*Period*	*ppb Penncozeb 80 WP*	
		EC_{20}	*EC_{50}*
Daphnia magna	Application	252	408
Daphnia longispina	Application	332	398
Chydorus sphaericus	Application	67	134
Scapholeberis mucronata	Application	188	263
Copepod nauplii	Application	29	57
Brachionus leydigi	Application	5.5	9.2
Keratella quadrata	Application	22	27
Hexarthra sp.	Application	12	12
	Post-Application	12	12
Cephalodella sp.	Application	15	31
Phytoplankton			
Volvox sp.	Application	1.6	4.8

It should be noted that EPA's guidance for conducting mesocosm studies (Aquatic Mesocosm Tests to Support Pesticide Registrations_EPA 540/09-88-035, March 1988) requires three replicates per treatment level, a mesocosm size of 300 m^3 in volume and the inclusion of viable finfish in the study. These three major departures from EPA guideline requirements are noted at this time. Despite these deficiencies, the study does provide some supplemental information for characterizing the risk to lower trophic level organisms.

4.2. Toxicity of Mancozeb to Terrestrial Organisms

Table 4-4 summarizes the most sensitive terrestrial toxicity endpoints for the terrestrial phase CTS, based on an evaluation of submitted studies. A brief summary of submitted data considered relevant to this ecological risk assessment for the CTS is presented below.

Table 4-4 Terrestrial profile for mancozeb.

Assessment Endpoint	Measures of Ecological Effects	MRID or Reference	Study Classification
Direct toxicity to terrestrial-phase CTS	Mancozeb - English sparrow (*Passer domesticus*) acute oral LD50 = ~1500 mg a.i./kg	00036094	Supplemental
	Mancozeb - *Anas platyrhynchos* chronic reproduction NOAEC = 125.0 ppm	41948401	Acceptable
Indirect toxicity to terrestrial-phase CTS (via toxicity to prey items)	Mancozeb - Honey bee (*Apis mellifra*) acute contact-LD_{50}>179µg/bee	00018842	Acceptable
	Mancozeb – Mite (*Typhlodromus pyri*)- Residual toxicity LR50a = 0.01lb a.i./A	45577201	Acceptable

	Mancozeb laboratory rat *Rattus norvegicus* acute oral LD_{50} > 5,000 mg/kg	00142522	Acceptable
	Mancozeb - *Rattus norvegicus* reproductive NOAEL =120 ppm	41365201	Acceptable

Table 4-4 shows classifications for acute toxicity to terrestrial animals (EPA, 2004). Toxicity categories for terrestrial plants have not been defined. Based on these categories, mancozeb is classified as slightly to practically non-toxic to birds on an acute oral basis. Mancozeb are classified as practically non-toxic to mammals on an acute exposure basis.

Table 4-5 Categories of acute toxicity for terrestrial organisms.

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

Toxicity to Birds

Acute and chronic avian toxicity data were used to assess the potential direct effects to the terrestrial phase CTS due to the absence of toxicity data for terrestrial-phase amphibians. A summary of mancozeb toxicity values is described in **Section 4.2.1.**

Birds: Acute Exposure (Mortality) Studies

Mancozeb. Acute oral toxicity data for three avian species indicate that mancozeb is slightly to practically nontoxic to avian species. The most sensitive species for mancozeb, English sparrow, exhibits an LD_{50} of ~1500 mg/kg. This was an approximated LD_{50} value because the studies conducted with mancozeb were multiple oral dose studies instead of the more common single oral dose study and regurgitation made determination of toxicity dosages difficult.

Birds: Chronic Exposure (Growth, Reproduction) Studies

Mancozeb. Two reproductive toxicity studies were reviewed to evaluate the effect of mancozeb on birds. A study (MRID 441595-01) is scientifically sound and is classified as core/acceptable for an avian reproduction toxicity study using northern bobwhite quail. The NOAEC was determined to be 125 mg/L a.i. based on significant reductions in the percentage of 14-day old survivors of normal hatchlings and reductions in hatchling and 14-day old survivor bodyweights at the 1,000 ppm ai level when compared to the control.

The second mallard duck reproductive toxicity study (MRID 419484-01) with mancozeb is scientifically sound and is classified as core/acceptable. Nominal dietary concentrations of 10, 50, 125, and 1,000 ppm a.i. had no effects upon mortality, behavior, adult body weight, egg shell thickness, or food consumption in mallards during the 18-week exposure period. However, the following reproductive parameters were significantly reduced at 1,000 ppm a.i.: egg production, early and late embryo viability, hatchability, and offspring weight at hatch and 14-days of age. Based on the reductions, the NOAEC was 125 mg/L a.i.

Although both studies resulted in an NOAEC = 125 mg/L, the mallard duck toxicity study endpoints will be used in the assessment due to the larger number of endpoints affected and the overlap of offspring weight at hatch and 14 days of age for both the quail and duck studies.

ETU. No chronic avian toxicity studies are available for ETU.

Toxicity to Mammals

The CTS uses mammal burrows for shelter. Therefore, toxicity to mammals is used to assess the potential for indirect effect to the CTS as a result of effects to its modification to the environment.

A summary of available mancozeb acute and chronic mammalian data is provided in the following sections.

Mammals: Acute Exposure (Mortality) Studies

Mancozeb. Three acute oral toxicity mammalian studies with the laboratory rat (**Table 4-6**) were submitted for mancozeb. The LD_{50} values for all three studies was >5,000 mg/kg bw. In the mancozeb LD_{50} study (MRID # 00014522) there were ten rats tested and all animals survived. The only clinical signs were mild constipation, tan-stained muzzles, and brown-stained anogenital areas.

Based on this endpoint, mancozeb is categorized as practically nontoxic to mammals on an acute oral basis.

ETU. A nonguideline developmental toxicity study (45937601) was submitted for ETU. Due to the absence of an acute oral ETU toxicity study, this nonguideline toxicity study was used to determine risk from ETU as described in the 2007 RED chapter.

Table 4-6 Mammalian acute oral toxicity for mancozeb.

Species	*% a.i.*	*Test Type*	*LD_{50} (mg a.i /kg))*	*Toxicity Category)*	*Affected Endpoints*	*MRID*
			Technical			
Laboratory rat (*Rattus norvegicus*)	70-80%	oral - single dose	>5,000	practically nontoxic	mortality	00142522 41365201 41975601

Sub-chronic toxicity data are available for two mammal species for mancozeb. They indicate that extended exposure to mancozeb via the diet at levels of 250 ppm will cause decreased serum thyroxin levels in females and body weight decrements, changes in thyroid hormones, changes in liver enzymes, microscopic changes in the liver and thyroids, increased absolute and relative thyroid weights, and increased relative liver weights in males. A summary of mammal toxicity values are in the HED RED chapter (**Appendix J)**.

Mammals: Chronic Exposure (Growth, Reproduction) Studies

Mancozeb. Chronic mammalian data are available for two species for mancozeb (rat and mouse). The most sensitive of the two species for mancozeb is the laboratory rat, with a reproductive NOAEC of 120 ppm (MRID 41365201). The LOAEC of 1200 ppm from the reproductive study conducted with mancozeb was based on body weight decrements, increased relative thyroid weights, and increased incidence of thyroid follicular cell hyperplasia (parental effects). The rat toxicity study will be used to calculate RQs as it is the most sensitive species.

In addition to the mancozeb reproductive study submitted described above, a developmental mancozeb toxicity study using the rat was also submitted (MRID 00246663).The developmental study resulted in gross developmental defects, central nervous system defects, skeletal defects, cryptorchidism, abortions, and decreased fetal weight at a LOAEC of 500 ppm and a NOAEC of 128 ppm. This toxicity study may be used qualitatively in the risk description section of the assessment.

ETU. ETU studies were requested in the RED as confirmatory data. No ETU two-generation rat study is available. However, a developmental ETU study (MRID 459376-01) is available.
A single dose for the rat resulting a NOAEL = 5 mg/kg/day for developmental effects on the brain.

Mammals : Sublethal effects

For human health effects, OPP has determined that there is sufficient evidence to group the EBDCs (mancozeb, maneb, and metiram) based on a common mechanism for the induction of thyroid effects. Submitted and open literature mammalian studies have noted thyroidal effects such as thyroid weight increase, follicular cell hyperplasia, and decreased thyroid hormone levels. Nevertheless, these effects are difficult to quantify because they are not clearly tied to the ecological risk assessment endpoints for the CTS (*i.e.*, survival, growth, and reproduction of individuals) and are not used as part of the quantitative risk characterization consistent with the Overview Document (U.S. EPA, 2004).

Toxicity to Terrestrial Invertebrates

Terrestrial invertebrates are a food source for terrestrial phase CTS. Therefore, toxicity to terrestrial invertebrates as a result of mancozeb use is assessed to determine whether there may be indirect effects to the CTS via reduction in available food.

The use of mancozeb on agricultural crops may result in exposure to non-target beneficial insects, such as the honey bee. Acute contact studies suggest that mancozeb (MRID 00018842) are practically nontoxic to honey bees. The acute contact honey bee LD_{50} = >179 µg/bee (converted by the study authors to 1396.2 ppm based on Mayer and Johansen, 1990) for mancozeb and LD_{50} = 12.09 µg/bee (converted by the study authors to 94.30 ppm based on Mayer and Johansen, 1990) is used to assess potential indirect effects to the terrestrial-phase CTS.

Additionally, a mite (*Typhlodromus pyri*) on foliage study conducted with mancozeb was submitted (MRID 455772-01). The residue concentration on foliage causing 50% lethality at 7 days was 0.1 lb ai/acre for *Typhlodromus pyri* and a 14 day reproductive LOEAC=0.02 lbs a.i./A. (number of eggs).

Toxicity to Terrestrial Plants

Mancozeb. Terrestrial plant data are not available for mancozeb as a sole active ingredient in the TEP. Terrestrial plant data for mancozeb are based on a TEP containing 60% mancozeb co-formulated with 9% dimethomorph. The non-target terrestrial plant seedling emergence toxicity (Tier 1) and vegetative vigor toxicity (Tier 1) studies were conducted on four monocot species and six dicot species, none of the species exposed displayed 25% inhibition for the parameters tested. For seedling emergence, soybean and tomato are the most sensitive dicots with 4% plant dry weight inhibition; onion is the most sensitive monocot with 12% dry weight inhibition when compared to the controls at the application rate of 1.38 and 0.02 lb a.i./A of mancozeb and dimethomorph, respectively. For vegetative vigor, tomato is the most sensitive dicot with a 6% plant dry weight inhibition, corn and onion are the most sensitive monocots with 2% plant dry weight inhibition when compared to the controls at the application rate previously indicated.

Terrestrial Field Studies

No field studies with terrestrial vertebrates or invertebrates were submitted for mancozeb. In addition, no such studies were identified in the open literature.

4.3. Incident Database Review

Terrestrial Incidents

A search of the Ecological Incident Information System (EIIS) [15] on June 1, 2011 yielded one avian incident for mancozeb. The incident, which was reported in France in 1992, involved mancozeb but was later reported that the pesticide methomyl was likely the cause of the bird deaths through residue analysis. This was reported as a registered legal use and the certainty index for this incident was unlikely for mancozeb. Conversely, based on residue analysis in one dead bird of 0.018 ppm methomyl, the certainty index for methomyl causing the bird deaths is highly likely.

Plant Incidents

There were a total of five mancozeb plant incidents in the United States found in the Ecological Incident Information System (EIIS)[12]. In one reported incident, a tank mixture of mancozeb and benomyl applied to apple trees may have caused leaves and blossoms to drop from the trees. The certainty index for this incident was possible. In a second incident there was reported possible fruit and vegetable garden damage resulting from spray drift while neighbor's birch trees were sprayed. The extent of damage was not reported. Chemical analysis showed a trace of the applied mancozeb. The certainty index for this incident was probable. The third incident report indicated plant damage to 50 acres of a crop of ornamentals resulting from direct application of mancozeb and trifloxystrobin. The application rate and method was not reported for mancozeb but was reported for trifloxystrobin. The certainty index for this incident was possible for mancozeb and probable for trifloxystrobin. Terrestrial plant data for trifloxystrobin resulted in an EC_{25} greater than the highest concentration tested; therefore an assessment of risks was not possible. However, another strobilurin fungicide is highly toxic to terrestrial plants. In a fourth incident, damage was reported to an onion field resulting from aerial application of diazinon, metalaxyl, mancozeb, and chlorothalonil. The certainty index for this incident was possible for all the chemicals. Terrestrial plant data for mancozeb conducted with a TEP containing 60% mancozeb co-formulated with 9% dimethomorph does not suggest toxicity to terrestrial plants. The non-target seedling emergence study resulted in a 12% dry weight inhibition for onions and the non-target terrestrial plant vegetative vigor toxicity (Tier 1) study resulted in 2% dry weight inhibition. The fifth reported incident was 46% plant damage to 240 acres of potatoes resulting from seed treatment with mancozeb and fludioxonil. The product had been applied to seed but no mention was made of the type of damage that occurred with the plants. The certainty index for this incident was possible for both chemicals. Terrestrial plant data for mancozeb conducted with TEP containing 60% mancozeb co-formulated with 9% dimethomorph does not suggest toxicity to terrestrial plants. There is no available non-target terrestrial plant data for fludioxonil; however, there is numerous terrestrial plant incidents associated with this chemical. More details can be found in **Appendix K**.

Aquatic Incidents

The Ecological Incident Information System (EIIS) reported mancozeb in three fish kill incidents. One incident occurred in 1970, another in 1992 and the latest occurred in 1995. In the 1970 and 1992 incidents, mancozeb had been applied with an insecticide highly toxic to fish and, because of sample analysis, EFED classified mancozeb as unlikely to have been responsible

[12] http://www.epa.gov/oppefed1/general/databasesdescription.htm#eiis)

for these fish kills. The third incident in 1995 involved a mancozeb accidental spill into a stream that was the source water for a salmon hatchery which resulted in a fish kill at the salmon hatchery. Although EFED has classified mancozeb to be a probable contributory cause to the kill, the exposure associated with accidental spills are much higher than label use rates for mancozeb.

The short- term and long-term stressor mancozeb complex measures of effect for each taxa are estimated using the most sensitive toxicity endpoint for either mancozeb or ETU because ETU is a component of the short-term and long-term mancozeb complex. If an acceptable toxicity endpoint is only available for either mancozeb or ETU, that endpoint is used in the assessment. A summary of toxicity studies for mancozeb and ETU listing the endpoints for each taxa is presented in Table 4.7.

Table 4-7 Summary of toxicity endpoints for mancozeb and the degradate ETU.

	Acute Toxicity		**Chronic Toxicity**	
Species	Mancozeb	ETU	Mancozeb	ETU
Fish	***Salmo gairdneri*** **96 h LC50=460µg/L (MRID 40118502)**	*Oncorhynchus mykiss* 96 LC50>502000 µg/L (MRID 45910401)	**Pimephales promelas 35 Day NOAEC=2.19µg/L (MRID 43230701)**	Not Available
Aquatic Invertebrate Water Column	***Daphnia magna*** **48h EC50=580µg/L (MRID 40118503)**	*Daphnia magna* 48 h LC50=26,900 µg/l (MRID 45910402)	***Daphnia magna*** **21 Day NOAEC=7.3µg/L (MRID 40953802)**	*Daphnia magna 21 Day Growth NOAEC=540µg/L* *21 Day Reproductive NOAEC=2000µg/L* (MRID45462901)
Aquatic Invertebrates Benthic	***Chironomus dilutus*** **10 Day LC50=38.2 mg a.i./kg sediment (MRID 47410101)**	*NA*	Not requested	Not requested
Aquatic Vascular Plants	Not Available	*Lemna* Highest application rate evaluated in this assessment was for turf (19.1 lbs/A) with the highest EEC=190 µg/L. No effects at highest tested concentration of 960000 µg a.i./L (MRID 47441203)	NA	NA
Aquatic NonVascular	*Technical:Pseudokirchneriella subcapitata*	Ethylene Urea (ETU Degradate):	NA	NA

Plants	120 h EC50=47.0 µg a.i./L (MRID 43664701) *TEP: Navicula pelliculosa* 120 h EC50=13.7 µg a.i./L (MRID 44283402)	S. capricorutum 96 hr EC50=2300µg a.i./L (MRID 46462904**)**		
Birds	***Anas platyrhynchos*** *7 day LD50>6400 ppm (MRID 00080716)* *Colinus virginianus* *7 d**ay*** ***LD50>6,400mg/kg (MRID 00080717)*** ***English Sparrow (Passer domesticus)*** **Multiple dose 10 Day LD50=~1500mg a.i./kg (Regurgitation affected determination of toxicity doses) (MRID 00036094)**	1. *Colinus virginianus* 14 Day LD50>2250mg a.i./kg (MRID 48343001) 2. *Colinus virginianus* 14 Day LD50>4000 mg a.i./kg (MRID 48343100)	*1.**Anas platyrhynchos*** **22 week Reproductive NOAEC = 125ppm (MRID 41948401)** 2. *Colinus virginianus* 22 week Reproductive NOAEC= 125ppm (MRID44159501) 3. *Colinus virginianus* 22 week Reproductive NOAEC= 300ppm (MRID 44238001)	Not Available
Mammals	*1. Rattus norvegicus* LD50>5,000 mg/kg (MRID 00142522) *2.Rattus norvegicus* LD50>5,000 mg/kg (MRID 41365201) *3.Rattus norvegicus* LD50>5,000 mg/kg (MRID 41975601)	HED used a nonguideline developmental toxicity study (45937601) to determine acute risk from ETU.	***Rattus norvegicus*** **Reproductive NOAEL=120pp (MRID 41365201)**	Reproductive Study Not Available. ETU Developmental Study ***Rattus norvegicus*** NOAEL= 5mg/kg/day (MRID 45937601)-Use for lines of evidence
Terrestrial Invertebrates	*Apis mellifra* LD50>179 µg/bee (MRID 00018842)	Not requested	NA	NA
Seedling Emergence	The highest tested concentration for mancozeb was 1.38 lbs a.i./A. For seedling emergence, soybean and tomato are the most sensitive dicots with 4% plant dry weight	Not Available	NA	NA

	inhibition; onion is the most sensitive monocot with 12% dry weight inhibition when compared to the controls at the application rate of 1.38 and 0.02 lb a.i./A of mancozeb and dimethomorph, respectively. (MRID 44283401)			
Vegetative Vigor	The highest tested concentration for the vegetative vigor toxicity study was 1.38 lbs a.i./A. For vegetative vigor, tomato is the most sensitive dicot with a 6% plant dry weight inhibition, corn and onion are the most sensitive monocots with 2% plant dry weight inhibition when compared to the controls at the application rate previously indicated. (MRID 44283401)	Not Available	NA	NA

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to the CTS or for modification to their designated critical habitat from the use of mancozeb in CA. The risk characterization provides an estimation (**Section 5.1**) and a description (**Section 5.2**) of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of adverse effects to the assessed species or their designated critical habitat (*i.e.*, "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect"). In the risk estimation section, risk quotients are calculated using standard EFED procedures and models. In the risk description section, additional analyses may be conducted to help characterize the potential for risk.

5.1. Risk Estimation

Risk is estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (**Appendix F**). For acute exposures to the listed aquatic animals, as well as terrestrial invertebrates, the LOC is 0.05. For acute exposures to the listed birds (and, thus, terrestrial-phase amphibians) and mammals, the LOC is 0.1. The LOC for chronic exposures to animals, as well as acute exposures to plants is 1.0.

Acute and chronic risks to aquatic organisms are estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs in **Table 3-3** (mancozeb complex) based on the label-recommended mancozeb usage and the appropriate aquatic toxicity endpoint from **Table 4-7**.

Acute and chronic risks to terrestrial animals are estimated based on exposures resulting from applications of mancozeb (**Tables 3-8, 3-9, and 3-10**) and appropriate toxicity endpoint from **Table 4-7.** Exposures for terrestrial plants are not derived due to the absence of terrestrial plant data to be used in the TerrPlant model.

RQs were not determined for dip treatment to Capri figs, and asparagus due to minimal potential risks resulting from negligible exposure. The method of application itself does not result in ecologically significant releases to the environment and all active ingredient applied is expected to be tightly adsorbed to the surface of the plant parts or seed pieces making it also unavailable for dissolution and transport. Dietary exposure to residues on these items to the CTS is highly unlikely as these are not food items of the CTS. Therefore, dip treatment uses are considered to have “no effect” on the CTS.

With regard to seed treatment uses, potential aquatic risks are considered minimal based on negligible aquatic exposure resulting from seed treatment compared to the rate of application used for the assessed foliar treatment to the same crop. In making this comparison, mancozeb use on grains, for which the application rate is the highest (lb a.i./Acre), is below concentrations with any listed acute RQ exceedance. Therefore, it is presumed that these uses would not exceed LOCs. Potential terrestrial risks associated with seed treatment use are also considered minimal. Further, in the previous terrestrial risk assessment (2005, mancozeb RED), RQ values were calculated for numerous mancozeb seed treatment uses. That evaluation considered seed treatment only use sites, not foliar use sites. The results indicated that the acute risk to endangered species LOC would not be exceeded (RQs < 0.01). Therefore, all mancozeb seed treatment uses are considered to have “no effect” on the CTS. All subsequent RQs are for nonseed and dip treatment uses unless otherwise indicated.

Exposures in the Aquatic Habitat

Direct Effects to Freshwater Fish and Aquatic-phase Amphibians

Exposure for acute risk to aquatic-phase CTS is based on 1-in-10 year peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. Chronic risk is based on the 1-in-10 year 60-day EECs and the lowest chronic toxicity value for freshwater fish. Freshwater fish RQs are used to estimate direct acute and chronic risks to the aquatic-phase CTS (all 3 DPSs). Freshwater fish RQs are also be used to assess potential indirect effects of mancozeb to the aquatic-phase CTS via reduction in available prey items.

The potential for direct effects for the aquatic-phase CTS from mancozeb uses resulting from exposure to the mancozeb complex are shown in **Tables 5-1** and **5-2.** Acute RQ values exceeding the endangered species LOC (0.05) were found for cereal grains, corn (field), corn (sweet/pop), cucurbits, forestry, garlic, ornamentals (residential turf), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple, and sweetsop), turf (commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf), turf (sod farms) and christmas tree plantations. Acute RQs estimated for uses identified as mancozeb range from <0.01 to 0.41.

Table 5-1 Direct effect mancozeb acute RQs for the aquatic-phase CTS.

Use	*Peak EEC (ppb)*[9]	*Acute RQ*[10]	*Listed Species LOC Exceedance*[11]
Apple, crab apple, pear, and quince	13.44	0.03	No
Asparagus	17.23	0.04	No
Cereal Grains [1]	30.35	**0.06**	Yes
Corn (Field & seed crop)	51.72	**0.11**	Yes
Corn (Sweet/Pop) (one crop)	24.16	**0.05**	Yes
Corn (Sweet/Pop) (two crops)	74.33	**0.16**	Yes
Corn (Sweet/Pop) (three crops)	147.65	**0.32**	Yes
Cotton	13.12	0.03	No
Cucurbits [2]	40.64	**0.09**	Yes
Cucurbits, Others [3]	40.64	**0.09**	Yes
Fennel (one crop)	8.01	0.02	No
Fennel (two crops)	18.11	0.04	No
Forestry (Douglas Fir)	44.89	**0.10**	Yes
Garlic	41.93	**0.09**	Yes
Ginseng [4]	14.51	0.03	No
Grapes	13.50	0.03	No
Grapes (Wine)	14.60	0.03	No
Onion (dry) & Shallot	12.79	0.03	No
Ornamentals (in nursery) [5]	33.29	**0.07**	Yes
Ornamentals (residential, excluding pachysandra) [5]	1.77	<0.01	No
Ornamentals (residential, Pachysandra only)	22.68	**0.05**	Yes
Ornamentals (Residential turf)	24.18	**0.05**	Yes
Papayas	38.43	**0.08**	Yes
Potatoes	12.37	0.03	No
Sugar beet	12.27	0.03	No
Tomatoes	11.81	0.02	No
Tropical fruits [6]	43.03	**0.09**	Yes
Tropical Fruits, Others [7]	5.58	0.01	No
Turf [8]	125.50	**0.27**	Yes

Use	Peak EEC (ppb)[9]	Acute RQ[10]	Listed Species LOC Exceedance[11]
Turf (sod farms only) (two crops)	190.0	**0.41**	Yes
X-mass tree plantations	44.89	**0.10**	Yes

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf
[9]Peak EECs are Table 3-3.
[10]Acute RQ = peak EEC/acute LC_{50}; the acute mancozeb LC_{50} used is Rainbow trout 96-hour LC_{50} = 460 ug a.i/L (MRID# 40118502)
[11]For acute exposures, the listed species acute LOC is 0.05.

Chronic RQs are presented in **Table 5-2**. RQ values exceeding the chronic LOC (1.0) were found for apple, asparagus, cereal grains, corn (field), corn (sweet/pop), cotton, cucurbits, fennel, forestry, garlic, grapes, onion, ornamentals(nursery, pachysandra, residential turf), papayas, potatoes, sugar beets, tomatoes, turf, turf (sod farms) and christmas tree plantations. Chronic RQs estimated for uses identified as mancozeb range from 0.06 for tropical fruit) to 27.19 for sod farms.

Table 5-2 Direct effect mancozeb chronic RQs for the aquatic-phase CTS.

Use	Chronic EEC (ppb)[9]	Chronic RQ[10]	Chronic Listed Species LOC Exceedance? [11]
Apple, crab apple, pear, and quince	2.232	**1.0**	Yes
Asparagus	3.207	**1.5**	Yes
Cereal Grains [1]	5.846	**2.7**	Yes
Corn (Field & seed crop)	7.396	**3.4**	Yes
Corn (Sweet/Pop) (one crop)	3.398	**1.5**	Yes
Corn (Sweet/Pop) (two crops)	11.109	**5.1**	Yes
Corn (Sweet/Pop) (three crops)	26.822	**12.2**	Yes
Cotton	2.624	**1.2**	Yes
Cucurbits [2]	6.174	**2.8**	Yes
Cucurbits, Others [3]	6.174	**2.8**	Yes
Fennel (one crop)	3.625	**1.6**	Yes
Fennel (two crops)	5.635	**2.6**	Yes

Use	Chronic EEC (ppb)[9]	Chronic RQ[10]	Chronic Listed Species LOC Exceedance? [11]
Forestry (Douglas Fir)	7.644	**3.5**	Yes
Garlic	13.760	**6.3**	Yes
Ginseng [4]	0.729	0.33	No
Grapes	2.341	**1.1**	Yes
Grapes (Wine)	3.073	**1.4**	Yes
Onion (dry) & Shallot	6.242	**2.8**	Yes
Ornamentals (in nursery) [5]	5.358	**2.4**	Yes
Ornamentals (residential, excluding pachysandra) [5]	0.389	0.18	No
Ornamentals (residential, Pachysandra only)	4.284	**1.9**	Yes
Ornamentals (Residential turf)	4.485	**2.0**	Yes
Papayas	4.509	**2.0**	Yes
Potatoes	3.461	**1.6**	Yes
Sugar beet	4.102	**1.9**	Yes
Tomatoes	3.069	**1.4**	Yes
Tropical fruits [6]	1.441	0.66	No
Tropical Fruits, Others [7]	0.140	0.06	No
Turf [8]	30.694	**14.0**	Yes
Turf (sod farms only) (two crops)	59.548	**27.2**	Yes
X-mass tree plantations	7.644	**3.5**	Yes

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** (Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote)
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf
[9]Peak EECs are Table 3-3.
[10]Chronic RQ = 60 Day EEC/chronic NOAEC; the *Pimephales promelas* 35 Day NOAEC used is 2.19 ug a.i/L (MRID# 43230701)
[11] RQs indicate exceedence of the chronic risk, listed and non-listed species LOC of 1.0.

Indirect Effects to the CTS

Indirect effects include a reduction in prey items as well as changes in the habitat.

Evaluation of Potential Indirect Effects for the aquatic-phase CTS via Reduction in Food Items (freshwater fish and aquatic amphibians)

The diet of the CTS includes amphibians. Therefore, effects on fish as surrogates of amphibians are presented in **Table 5-1** and **5-2**.

Evaluation of Potential Indirect Effects for the aquatic-phase CTS via Reduction in Food Items (freshwater Invertebrates)

Acute risk to freshwater invertebrates is based on 1-in-10 year peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. Chronic risk is based on 1-in-10 year 21-day EECs and the lowest chronic toxicity value for freshwater invertebrates. Acute (peak) EECs of short-term mancozeb complex and chronic (21-d) EECs of long-term mancozeb complex in surface water (**Table 3-5**) were used to calculate acute and chronic RQ values, respectively, for freshwater invertebrates. Peak EECs for short-term mancozeb complex in sediment (Table 5-13) were used to calculate RQ values for freshwater benthic organisms.

Risk quotients for freshwater invertebrates are shown in **Table 5-3** for acute exposure and **Table 5-4** for chronic exposure. Freshwater invertebrate RQs will be used to assess potential indirect effects of mancozeb to the aquatic-phase CTS (all 3 DPSs) via reduction in available prey items.

Acute RQs for cereal grains, corn (field), corn (sweet/pop), cucurbit, forestry, garlic, ornamentals (nursery), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweetsop) turf (commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf), turf (sod farms) and christmas tree plantations uses exceed the endangered species LOC of 0.05.

Table 5-3 Indirect effects for the aquatic-phase CTS via acute effects to freshwater invertebrates from mancozeb.

Use	*Acute EEC (ppb)*[9]	*Acute RQ*[10]	*Acute Listed Species LOC Exceedance?*[11]	*Acute Non-listed Species LOC Exceedance?*[12]
Apple, crab apple, pear, and quince	13.44	0.02	No	No
Asparagus	17.23	0.03	No	No
Cereal Grains [1]	30.35	**0.05**	Yes	No
Corn (Field & seed crop)	51.72	**0.09**	Yes	No
Corn (Sweet/Pop) (one crop)	24.16	0.04	No	No
Corn (Sweet/Pop) (two crops)	74.33	**0.13**	Yes	No
Corn (Sweet/Pop) (three crops)	147.65	**0.25**	Yes	No
Cotton	13.12	0.02	No	No
Cucurbits [2]	40.64	**0.07**	Yes	No
Cucurbits, Others [3]	40.64	**0.07**	Yes	No
Fennel (one crop)	8.01	0.01	No	No
Fennel (two crops)	18.11	0.03	No	No

Use	*Acute EEC (ppb)*[9]	*Acute RQ*[10]	*Acute Listed Species LOC Exceedance?* [11]	*Acute Non-listed Species LOC Exceedance?* [12]
Forestry (Douglas Fir)	44.89	**0.08**	Yes	No
Garlic	41.93	**0.07**	Yes	No
Ginseng [4]	14.51	0.02	No	No
Grapes	13.50	0.02	no	No
Grapes (Wine)	14.60	0.02	no	No
Onion (dry) & Shallot	12.79	0.02	No	No
Ornamentals (in nursery) [5]	33.29	**0.06**	yes	No
Ornamentals (residential, excluding pachysandra) [5]	1.77	<0.01	no	No
Ornamentals (residential, Pachysandra only)	22.68	0.04	no	No
Ornamentals (Residential turf)	24.18	0.04	No	No
Papayas	38.43	**0.07**	Yes	No
Potatoes	12.37	0.02	No	No
Sugar beet	12.27	0.02	No	No
Tomatoes	11.81	0.02	No	No
Tropical fruits [6]	43.03	**0.07**	Yes	No
Tropical Fruits, Others [7]	5.58	<0.01	No	No
Turf [8]	125.50	**0.22**	Yes	No
Turf (sod farms only) (two crops)	190.00	**0.33**	Yes	No
X-mass tree plantations	44.89	**0.08**	Yes	No

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf
[9] Peak EECs are Table 3-3.
[10] Acute RQ = Peak EEC/acute EC_{50}; the *D. magna* acute mancozeb 48-hour EC_{50} used is 580 ug a.i/L (MRID# 4011803)
[11] Bold RQs indicate exceedence of the acute risk listed species LOC of 0.05.
[12] For acute risks, the non-listed species acute risk LOC is 0.5.

In addition to the acute RQs, chronic RQs for freshwater invertebrates are also estimated. Chronic RQs for cereal grains, corn (field), corn (sweet/pop), cucurbit, forestry, garlic, onions, ornamentals (nursery, pachysandra and residential turf), papayas, potatoes, turf (commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf), turf (sod farms) and christmas tree plantations uses exceed the chronic LOC of 1.0

Table 5-4 Indirect effect RQs for the aquatic-phase CTS via chronic effects to freshwater invertebrates using the highest long-term constituent exposure concentration.

Use	*Chronic EEC (ppb)*[9]	*Chronic RQ*[10]	*Chronic Listed Species LOC Exceedance?*[11]
Apple, crab apple, pear, and quince	4.486	0.61	no
Asparagus	5.921	0.81	no
Cereal Grains [1]	9.732	**1.33**	yes
Corn (Field & seed crop)	15.286	**2.09**	yes
Corn (Sweet/Pop) (one crop)	7.143	0.98	no
Corn (Sweet/Pop) (two crops)	25.081	**3.43**	yes
Corn (Sweet/Pop) (three crops)	49.724	**6.81**	yes
Cotton	4.508	0.62	no
Cucurbits [2]	13.391	**1.83**	yes
Cucurbits, Others [3]	13.391	**1.83**	yes
Fennel (one crop)	4.301	0.59	no
Fennel (two crops)	7.158	0.98	no
Forestry (Douglas Fir)	14.383	**1.97**	yes
Garlic	17.199	**2.36**	yes
Ginseng [4]	1.022	0.14	no
Grapes	4.880	0.67	no
Grapes (Wine)	6.608	0.90	no
Onion (dry) & Shallot	7.572	**1.04**	yes
Ornamentals (in nursery) [5]	10.038	**1.37**	yes
Ornamentals (residential, excluding pachysandra) [5]	0.715	0.10	no
Ornamentals (residential, Pachysandra only)	7.448	**1.02**	yes
Ornamentals (Residential turf)	9.061	**1.24**	yes
Papayas	10.903	**1.49**	yes
Potatoes	7.403	**1.01**	yes
Sugar beet	5.801	0.79	no
Tomatoes	4.682	0.64	no
Tropical fruits [6]	3.524	0.48	no
Tropical Fruits, Others [7]	0.389	0.05	no
Turf [8]	61.653	**8.44**	yes
Turf (sod farms only) (two crops)	94.793	**12.98**	yes
X-mass tree plantations	14.383	**1.97**	yes

Use	Chronic EEC (ppb)[9]	Chronic RQ[10]	Chronic Listed Species LOC Exceedance? [11]

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf
[9]Peak EECs are Table 3-3.
[10]Acute RQ = Peak EEC/acute EC_{50}; the *D. magna* mancozeb 21-day NOAEC used is 7.3 ug a.i/L (MRID# 409538-02)
[11] Bold RQs indicate exceedence of the chronic risk listed species LOC of 1.0.

Evaluation of Potential Indirect Effects for the aquatic-phase CTS via Reduction in Food Items (freshwater aquatic plants)

Indirect effect RQs for the aquatic-phase CTS via effects to algae, a food resource, are presented in Table 5-5 for mancozeb complex. Based on the projected peak aquatic EECs and aquatic plant toxicity data, the RQs exceed the non-listed aquatic plant species LOC of 1.0 for mancozeb complex uses on asparagus, cereal grains, corn (field), corn (sweet/Pop), cucurbits, fennel, forestry, garlic, ginseng, grapes (wine), ornamental (nursery, pachysandra and residential turf), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweetsop), turf (commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf), turf (sod farms) and Christmas tree plantations.

Table 5-5 Indirect effects for the aquatic-phase CTS via effects to freshwater aquatic plants for mancozeb uses.

Use	*Peak EEC (ppb)9*	*Non-listed Plant RQ*[10]	*Non-listed species LOC Exceedance?*
Apple, crab apple, pear, and quince	13.44	0.98	no
Asparagus	17.23	**1.26**	yes
Cereal Grains [1]	30.35	**2.21**	yes
Corn (Field & seed crop)	51.72	**3.77**	yes
Corn (Sweet/Pop) (one crop)	24.16	**1.76**	yes
Corn (Sweet/Pop) (two crops)	74.33	**5.42**	yes
Corn (Sweet/Pop) (three crops)	147.65	**10.78**	yes
Cotton	13.12	0.96	no

Cucurbits [2]	40.64	**2.97**	yes
Cucurbits, Others [3]	40.64	**2.97**	yes
Fennel (one crop)	8.01	0.58	no
Fennel (two crops)	18.11	**1.32**	yes
Forestry (Douglas Fir)	44.89	**3.28**	yes
Garlic	41.93	**3.06**	yes
Ginseng [4]	14.51	**1.06**	yes
Grapes	13.50	0.98	no
Grapes (Wine)	14.60	**1.06**	No
Onion (dry) & Shallot	12.79	0.93	**no**
Ornamentals (in nursery) [5]	33.29	**2.43**	yes
Ornamentals (residential, excluding pachysandra) [5]	1.77	0.13	**no**
Ornamentals (residential, Pachysandra only)	22.68	**1.65**	yes
Ornamentals (Residential turf)	24.18	**1.76**	yes
Papayas	38.43	**2.80**	yes
Potatoes	12.37	0.90	**no**
Sugar beet	12.27	0.89	**no**
Tomatoes	11.81	0.86	**no**
Tropical fruits [6]	43.03	**3.14**	yes
Tropical Fruits, Others [7]	5.58	0.41	**no**
Turf [8]	125.50	**9.16**	yes
Turf (sod farms only) (two crops)	190.00	**13.87**	yes
X-mass tree plantations	44.89	**3.28**	yes

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** (Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf
[9]Peak EECs are Table 3-3.
[10] RQ = peak EEC/EC50.
[11]For evaluating plant chronic risk, the non-listed species LOC is 1.0.

Evaluation of Potential Indirect Effects for the aquatic-phase CTS via Alteration in the Habitat (freshwater vascular plants)

Although no toxicity data is available to determine the effect of mancozeb on vascular plants, a registrant submitted study has been reviewed for the degradate ETU (MRID 474412-03). No risk quotients for the degradate ETU are calculated as no adverse effects were observed the highest concentration tested, 960 mg/L. However, the maximum 1-in-10 year peak EEC (190 ug/L for turf sod farms) is three orders of magnitude below this level (960 mg/L) This suggests there is a very low potential risk of ETU to aquatic vascular plants. Given the much higher sensitivity of aquatic non-vascular plants to mancozeb (parent) compared to ETU (i.e., over three orders of magnitude), it is reasonable to presume risk to aquatic vascular plants in absence of mancozeb toxicity data assuming similar sensitivity as aquatic non-vascular plants.

Exposures in the Terrestrial Habitat

Evaluation of Potential Direct Effects for the terrestrial-phase CTS

Potential for direct effects to the terrestrial-phase CTS are assessed based on acute and chronic toxicity data with birds as surrogates when terrestrial phase amphibian toxicity data is not available. Potential direct risks to the terrestrial-phase CTS are evaluated using T-REX, acute and chronic toxicity data for the most sensitive bird species for which data are available, and the most sensitive dietary item and size class for that species. For terrestrial-phase amphibians, the most sensitive RQ in T-REX is for the small bird consuming small short grass.

Avian RQs, based on acute exposure to mancozeb or ETU could not be calculated because no definitive acute toxicity endpoints are available. Further discussion of acute endpoints is presented in **Section 5.2**. Direct risk to the CTS is further characterized using chronic toxicity values.

Potential direct chronic effects of mancozeb to the terrestrial-phase CTS are derived by considering dietary-based exposures modeled in T-REX for a small bird (20g) consuming short grass. Chronic effects are estimated using the lowest available toxicity data for birds. EECs are divided by toxicity values to estimate chronic dietary-based RQs.

Chronic RQs for the terrestrial-phase CTS are shown in **Table 5-6.** Chronic RQs ranged from 5.53 – 105.73. Chronic RQs exceeded LOCs for all uses evaluated. Therefore, mancozeb may have the potential to directly affect terrestrial-phase CTS (all 3 DPSs).

Table 5-6 Direct effect dietary-based chronic RQs for the terrestrial-phase CTS.

Use[1]	*Rate (lbs a.i./A)*	*Number of Apps.*	*Minimum Interval (Days)*	*Chronic RQ*[2]	*Chronic LOC Exceedance?*[3]
Cereal Grains (barley, oats, rye, triticale, and wheat)	1.6	3	7	7.37	Yes
Cucurbit	2.4	8	7	18.32	Yes
Cucurbit, Other (Chayote, Chinese wax gourd, citron melon, cucumber, gherkin, edible gourd, Momordica	2.69	8	7	20.53	Yes

Use[1]	*Rate (lbs a.i./A)*	*Number of Apps.*	*Minimum Interval (Days)*	*Chronic RQ*[2]	*Chronic LOC Exceedance?*[3]
spp., muskmelon, pumpkin, squash (summer and winter) and watermelon)					
Fennel	1.6	8	7	12.21	Yes
Ginseng	1.68	12	7	14.16	Yes
Onion & Shallot	2.4	10	7	19.50	Yes
Tropical Fruits: Atemoya, cherimoya, custard apple, sugar apple and sweetsop	2.10	14	7	18.09	Yes
Tropical Fruits, Others Canistel, mamey, sapote, mango, sapodilla, star apple(caimito) and white sapote	2.24	14	14	11.17	Yes
Ornamentals (other)	1.2	3	7	5.53	Yes
Turf	19.1	4	7	105.73	Yes

[1]All uses calculated using mancozeb toxicity values. Chronic toxicity endpoint based on mancozeb's mallard duck chronic reproduction NOAEC = 125 ppm (MRID # 41948401)
2The RQ values are for a 20 gram (small) animal consuming short grass.
3 Chronic LOC = 1

Evaluation of Potential Indirect Effects for the terrestrial-phase CTS via Reduction in Food Items (birds)

The diet of the terrestrial-phase CTS includes amphibians; therefore indirect effects are evaluated using the bird as a surrogate for amphibians. **Table 5-6** presents the chronic RQs for birds as discussed under direct effects.

Evaluation of Potential Indirect Effects for the terrestrial-phase CTS via Reduction in Food Items (mammals)

The potential for indirect effects to the terrestrial-phase CTS may result from direct effects to mammals, which serve as prey to the terrestrial-phase CTS. Potential indirect effects to the CTS may also result from direct effects to mammals due to effects on habitat or a reduction in rearing sites. RQs for indirect effects are calculated in the same manner as those for direct effects.

Potential risks to mammals are evaluated using T-REX, acute and chronic mammalian toxicity data, and a variety of body-size and dietary categories. Indirect risks are derived for dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass. Acute and chronic effects are estimated using the most sensitive mammalian toxicity data. EECs are divided by the toxicity value to estimate acute and chronic dose-based RQs as well as chronic dietary-based RQs.

Potential direct chronic effects to the mammals are evaluated by considering dietary-based EECs modeled in T-REX consuming a variety of dietary items. The specific EECs for each species are for the same size mammals and same dietary items as those considered for acute exposure. Chronic effects are estimated using the lowest available NOAEC from a chronic reproductive study for mammals. Dietary-based EECs are divided by toxicity values to estimate chronic dietary-based RQs.

Chronic RQs exceed the chronic LOC of 1.0 for all of the assessed mancozeb uses, with RQs ranging from 0.36 to 110.14 (**Table-5-7**). RQs exceeded four of the dietary items for turf, cucumbers, shallot, fennel, atemoya and cucurbits. RQs exceeded three of the dietary items for ornamentals, cereal grains, ginseng and canistel.

The mammal analysis will also be used to evaluate indirect effects due to changes in the habitat. The CTS uses mammal burrows for shelter and effects on mammals will reduce available burrows.

Table 5-7 Indirect effects for the terrestrial-phase CTS via dietary-based exposure effects to mammals.

Use[1]	*Rate(lbs a.i./A)*	*Number of Applications*	*Minimum Interval (Days)*	*Chronic RQ*[2]	*Chronic LOC Exceedance?*[3]
Cereal Grains	2.4	1	N/A	0.48-7.68	Yes
Cucurbit, Other: (Chayote, Chinese wax gourd, citron melon, cucumber, gherkin, edible gourd, Momordica spp., muskmelon, pumpkin, squash (summer and winter) and watermelon)	2.4	8	7	1.34-21.39	Yes
Cucurbits:	2.4	8	7	1.19-19.08	Yes
Fennel	1.6	6	5	1.30-82.64	Yes
Ginseng	1.6	8	7	0.92-14.75	Yes
Onion & Shallot	6.4	4	7	1.27-20.31	Yes
Ornamentals(other)	1.2	3	7	0.36-5.76	Yes
Tropical Fruits: Atemoya, cherimoya, custard apple, sugar apple and sweetsop	2.4	10	7	1.18-18.84	Yes
Tropical Fruits, Other: Canistel, mamey, sapote, mango, sapodilla, star apple(caimito) and white sapote	2.0	14	14	0.73-11.64	Yes
Turf	19.1	4	7	6.88-110.14	Yes

Use[1]	*Rate(lbs a.i./A)*	*Number of Applications*	*Minimum Interval (Days)*	*Chronic RQ*[2]	*Chronic LOC Exceedance?*[3]
[1]. Chronic toxicity endpoint based on lab rat reproduction study - NOAEC = 125 ppm (MRID # 413652-01) conducted with mancozeb [2]Since the EECs are estimated for several scenarios (e.g., short grass, tall grass, broadleaf plants, seeds, etc.); the RQs are shown as a range of values. [3]Chronic risk LOC = 1					

Evaluation of Potential Indirect Effects for the terrestrial-phase CTS via Reduction in Food Items (terrestrial invertebrates)

The potential for indirect effects to the terrestrial-phase CTS may result from direct acute effects to terrestrial invertebrates due to a reduction in prey. In order to assess the risks of mancozeb to terrestrial invertebrates, the honey bee is used as a surrogate for terrestrial invertebrates. EFED usually does not provide a quantitative analysis for terrestrial invertebrates. For this assessment, the effect of mancozeb on terrestrial invertebrates is described in the risk characterization **Section 5.2.**

Evaluation of Potential Indirect Effects for the terrestrial-phase CTS via Alteration in Habitat (terrestrial plants)

The potential indirect effects are evaluated due to direct effects from mancozeb uses on terrestrial plants as these plants provide habitat to both the species. Generally, for indirect effects, potential effects on terrestrial vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. No RQs were calculated as only nondefinitive toxicity values are available. Additional characterization of risk to terrestrial plants is provided in the Risk Description.

Primary Constituent Elements of Designated Critical Habitat

For mancozeb 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 analysis of risk quotients and a comparison to the Level of Concern. The final No Effect/May Affect determination is made after the spatial analysis is completed at the end of the risk description, **Section 5.2.** In **Section**

5.2.4.c, a discussion of any potential overlap between areas where potential usage may result in LAA effects and areas where species are expected to occur (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

If the RQs presented in the Risk Estimation (**Section 5.1**) show no direct or indirect effects for the assessed species, and no modification to PCEs of the designated critical habitat, a preliminary "no effect" determination is made, based on mancozeb's use within the action area. However, if LOCs for direct or indirect effect are exceeded or effects may modify the PCEs of the critical habitat, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding mancozeb. A summary of the risk estimation results for nonseed treatments are provided in **Table 5-8** for direct and indirect effects to the listed species assessed here and in **Table 5-9** for the PCEs of their designated critical habitat.

Table 5-8 Risk estimation summary for mancozeb- direct and indirect effects.

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Freshwater Fish and Aquatic-phase Amphibians	Listed Species (Yes: acute; Yes:chronic)	RQs range from <0.01for residential ornamental to 0.41 for turf. For listed species, RQs for cereal grain, corn (field), corn (sweet/Pop), cucurbit, forestry, garlic, ornamental (nursery and residential), papayas, tropical fruit (Atemoya, cherimoya, custard apple, sugar apple and sweetsop), turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farms), turf (sod farms) and Christmas tree plantation uses exceeded the acute risk LOC of 0.05. Chronic RQs exceeding the chronic LOC of 1.0 included apple, asparagus, cereal grain, corn (field), corn (sweet/Pop), cotton, cucurbit, fennel, forestry, garlic, grapes (table & wine), onion, ornamental (nursery, pachysandra and residential), papayas, potato, sugar beet, tomato, turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farms), turf (sod farms) and Christmas tree plantation.	CTS (all 3 DPSs) CTS (all 3 DPSs)

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Freshwater Invertebrates	Listed Species (Yes: acute; Yes: chronic)	RQs range from 0.1 to 0.32. RQs for cereal grain, corn (field), corn (sweet/Pop), cucurbit, forestry, garlic, ornamental (nursery), papayas , tropical fruit, turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farms), turf (sod farms) and Christmas tree plantation uses exceed the listed species LOC of 0.05 Chronic RQs exceeding the chronic LOC included cereal grain, corn (field), corn (sweet/Pop), cucurbit, forestry, garlic, ginseng, onion, ornamental (nursery, pachysandra and residential), papayas, potato, turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farms), turf (sod farms) and Christmas tree plantation. .	CTS (all 3 DPSs)
Freshwater Benthic Invertebrates	Listed Species (Yes: acute; No: chronic)	The turf use resulted in the highest RQ and was the only use that equaled or exceeded the listed species LOC=0.05 RQs range from <0.1 to 0.32.	CTS (all 3 DPSs)
Vascular Aquatic Plants	Non-listed Species (NA)	No toxicity data is available to estimate RQs for mancozeb. No RQs for ETU were calculated due to non-definitive endpoints. Aquatic nonvascular plants will serve as surrogates for vascular plants.	CTS (all 3 DPSs)

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Non-Vascular Aquatic Plants	Non-listed Species (Yes)	RQs using the EC50 value to estimate the risk to non-listed plants exceeded the LOC for asparagus, cereal grain, corn (field), corn (sweet/Pop), cucurbit, fennel, forestry, garlic, ginseng, grapes (wine), ornamental (nursery, pachysandra and residential), papayas, tropical fruit (Atemoya, cherimoya, custard apple, sugar apple and sweetsop), turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farms), turf (sod farms) and Christmas tree plantation uses. RQs range from 0.13 for ornamental (residential) to 13.87 for sod farm uses.	CTS (all 3 DPSs)
Birds, Reptiles, and Terrestrial-Phase Amphibians	Listed Species (No: acute Yes: chronic)	No acute RQs estimated due to no definitive endpoints available. Chronic RQs range from 5.53(ornamentals) to 105.73 (turf). RQs for all uses exceed the chronic LOC of 1.	CTS (all 3 DPSs)
Mammals	Listed Species (No: acute Yes: chronic)	No acute RQs estimated due to nondefinitive endpoints. Chronic RQs range from 0.36 (ornamentals) to 110.14 (turf). All uses resulted in RQs exceeding the LOC for at least one food group.	CTS (all 3 DPSs)
Terrestrial Invertebrates	Listed Species	The bee toxicity study resulted in a nondefinitive endpoint, therefore no RQs were estimated. Further analysis is described in Section 5.2.	CTS (all 3 DPSs)
Terrestrial Plants – Monocots Terrestrial Plants – Dicots	Non-listed Species (Yes) - Only non-listed LOCs were evaluated because CTS do not have an obligate relationship with terrestrial monocots and dicots	Uncertainty based on seedling emergence and vegetative vigor toxicity studies no testing concentrations up to the highest application rate. For seedling emergence, soybean and tomato are the most sensitive dicots with 4% plant dry weight inhibition; onion is the most sensitive monocot with 12% dry weight inhibition when compared to controls at the application rate of	CTS (all 3 DPSs)

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Assessed Species Potentially Affected
		1.38 and 0.02 lb a.i. /A for mancozeb and dimethomorph, respectively. For vegetative vigor, tomato is the most sensitive dicot with a 6% plant dry weight inhibition; corn and onion are the most sensitive monocots with 2% plant dry weight inhibition when compared to the controls at the application rate.	

Table 5-9 Risk estimation summary for mancozeb-PCEs.

Assessment Endpoint	Effects Determination	Basis for Determination
Aquatic Phase PCEs (Aquatic Breeding Habitat)		
Standing bodies of fresh water, including natural and man-made (e.g., stock) ponds, vernal pools, dune pools and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (i.e., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle. FR Vol 69 No. 226 CTS, 68584, 2004	*Vascular Plants* **Habitat Modification** All uses	Vascular plant toxicity will be evaluated using nonvascular aquatic plants as surrogated due to the absence of vascular plant toxicity data.
	Non-vascular Plants **Habitat Modification** Mancozeb uses asparagus, cereal grain, corn (field), corn (sweet/Pop), cucurbit, fennel, forestry, garlic, ginseng, grapes (wine), ornamental (nursery, pachysandra and residential), papayas, tropical fruit (Atemoya, cherimoya, custard apple, sugar apple and sweetsop), turf, turf (sod farms) and Christmas tree plantation uses.	Using aquatic plant toxicity data (EC50) the RQ exceeds the non-listed species LOC of 1.0. RQs ranged from 0.13 for ornamentals (residential) to 13.87 for sod farm uses.
	Non-vascular Plants Mancozeb uses Apples, papayas, grapes, cucumber, ornamentals (nursery), onion, potatoes, ornamentals (ground cover), ornamentals (Pachysandra), ornamental (residential turf), sugar beet, tomatoes, grapes (wine), corn (field, seed crop), cotton, pome	Using aquatic plant toxicity data (EC50) the RQ exceeds the non-listed species LOC of 1.0. RQs ranged from 0.13 for ornamentals to 13.87 for cucurbits

Assessment Endpoint	Effects Determination	Basis for Determination
	fruits, cucurbits (musk melon, gourds), shallot, fennel, asparagus,	
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend on for food, shelter and protection from the elements and predation.	**Habitat Modification** Mancozeb use All non-seed and dip uses	Chronic RQs exceed the chronic LOC = 1 for all non-seed uses. RQs range from 0.36 to 100.33for turf.
Upland areas between breeding locations (PCE 1) and areas with small mammal burrow (PCE 2) that allow for dispersal among sites.	*Terrestrial plant (protection from predators)* **Habitat Modification** All nonseed mancozeb uses	For seedling emergence, soybean and tomato are the most sensitive dicots with 4% plant dry weight inhibition; onion is the most sensitive monocot with 12% dry weight inhibition when compared to controls at the application rate of 1.38 and 0.02 lb a.i. /A for mancozeb and dimethomorph, respectively. For vegetative vigor, tomato is the most sensitive dicot with a 6% plant dry weight inhibition; corn and onion are the most sensitive monocots with 2% plant dry weight inhibition when compared to the controls at the application rate. However, the seedling emergence and vegetative vigor studies did not test up to the highest application rate.

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** through **5.2.3**. 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. Direct risk to fish as a surrogate for the CTS and indirect effects from reduction in prey for fish as surrogates for amphibians, aquatic invertebrates and terrestrial invertebrates is further refined using probit analysis. This analysis provides the probability of an individual effect from the use of mancozeb. 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 mancozeb.

Finally, in **Section 5.2.4**, 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.

Direct Effects to the Aquatic-Phase CTS

The aquatic-phase CTS inhabits freshwater pools or ponds. Direct effects to the aquatic-phase CTS are estimated based on acute and chronic toxicity data from freshwater fish. The aquatic-phase considers life stages of the CTS that are obligatory aquatic organisms, including eggs and larvae. It also considers submerged terrestrial-phase juveniles and adults, which spend a portion of their time in water bodies that may receive runoff and spray drift containing mancozeb. A preliminary screen is represented by the RQs, shown in section 5.1 for direct effects. The risk is further refined for acute exposure through the probit analysis.

An analysis of the likelihood of individual direct mortality (**Table 5-10**) indicates that at the listed species LOC, *i.e.*, RQ = 0.05, the likelihood of individual mortality for mancozeb is 1 in 4.18E+08. An analysis of the likelihood of individual direct mortality for the uses listed below indicates that the likelihood of individual mortality for mancozeb complex is ~ 1 in 27.3 to ~1 in 5.25E+26. There is a “likely to adversely affect” determination made for the mancozeb uses listed below for survival of CTS individuals using the fish as a surrogate via direct effects on aquatic phases. The adverse affect cannot be discounted because there is an overlap in space and time between areas of the expected adverse affect and species location as well as the probability of occurrence.

Table 5-10 Probit refinement for fish acute RQs.

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Use	*LOC or RQ*	*Likelihood of Individual Effect Slope default = 4.5*
At the LOC=0.05	0.05	~1 in 4.18 E+08
Apple, crab apple, pear, and quince	0.03	~ 1 in 2.76E+11
Asparagus	0.04	~ 1 in 6.33E+9
Cereal Grains [1]	0.06	~ 1 in 9.88E+6
Corn (Field & seed crop)	0.11	~ 1 in 1.25E+5
Corn (Sweet/Pop) (one crop)	0.05	~ 1 in 4.18E+8
Corn (Sweet/Pop) (two crops)	0.16	~ 1 in 5.85E+3
Corn (Sweet/Pop) (three crops)	0.32	~ 1 in 7.70E+1
Cotton	0.03	~ 1 in 2.76E+11
Cucurbits [2]	0.09	~ 1 in 7.91E+5
Cucurbits, Others [3]	0.09	~ 1 in 7.91E+5
Fennel (one crop)	0.02	~ 1 in 9.60E+13
Fennel (two crops)	0.04	~ 1 in 6.33E+9
Forestry (Douglas Fir)	0.10	~ 1 in 2.94E+5
Garlic	0.09	~ 1 in 7.91E+5
Ginseng [4]	0.03	~ 1 in 2.76E+11
Grapes	0.03	~ 1 in 2.76E+11
Grapes (Wine)	0.03	~ 1 in 2.76E+11
Onion (dry) & Shallot	0.03	~ 1 in 2.76E+11
Ornamentals (in nursery) [5]	0.07	~ 1 in 9.88E+6
Ornamentals (residential, excluding pachysandra) [5]	<0.01	~ 1 in 5.25E+26
Ornamentals (residential, Pachysandra only)	0.05	~ 1 in 4.18E+8
Ornamentals (Residential turf)	0.05	~1 in 4.18E+8
Papayas	0.08	~1 in 2.51E+6
Potatoes	0.03	~ 1 in 2.76E+11
Sugar beet	0.03	~ 1 in 2.76E+11
Tomatoes	0.02	~ 1 in 2.76E+11
Tropical fruits [6]	0.09	~ 1 in 7.91E+5
Tropical Fruits, Others [7]	0.01	~ 1 in 8.86E+18
Turf [8]	0.27	~ 1 in 1.90E+2
Turf (sod farms only) (two crops)	0.41	~ 1 in 2.73E+1
X-mass tree plantations	0.10	~ 1 in 2.94E+5

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** (Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf

Direct effects are also indicated through chronic RQ exceedence for fish as a surrogate for the CTS. All uses except ginseng, ornamentals and tropical fruits (atemoya, cherimoya, custard apple, sugar apple, sweet sop, canistel, mamey, sapote, mango, sapodilla, star apple and white sapote) exceeded the chronic LOC = 1.

Direct Effects to the Terrestrial-Phase CTS

Potential for direct effects to the terrestrial-phase CTS are assessed based on direct acute and chronic toxicity effects to birds as surrogates for terrestrial phase amphibians. Risk quotients to evaluate acute effects were not calculated for registrant submitted toxicity endpoints for birds due to non-definitive endpoints.

Chronic terrestrial risks drive this assessment and the acute endpoints are not definitive. The EECs for a 20 g bird consuming short grass ranged from 787.26 for ornamental use to 15,051.98 for the turf use. However, there is uncertainty due to the most sensitive available avian acute oral toxicity studies for mancozeb resulting in LD_{50}s ~1500 from a multiple dose toxicity test.

EFED believes that based on the avian acute toxicity data, which is used as a surrogate for the terrestrial-phase amphibian, there is minimal terrestrial risk associated with all mancozeb uses. The acute dietary risk to birds from exposure to mancozeb is low because; 1) dietary testing attempted on mallard ducks and bobwhite quail indicated an aversion to test diet (the birds would not consume the test material); 2) there is low acute toxicity of mancozeb to birds in multiple dosing LD_{50} studies; 3) there are no incidents showing mancozeb has been responsible for bird kills or poisonings.

Based on the T-REX modeled dietary exposures and the surrogate avian toxicity data, the chronic RQs for direct effects to the terrestrial-phase CTS exceed the chronic LOC of 1.0 for all of the assessed mancozeb uses. Thus, a “may affect” determination is made based on chronic impaired survival of terrestrial-phase CTS.

A refinement of the chronic risks posed to the terrestrial-phase CTS from ingestion of residues on short grass was performed. This refinement was performed because the avian exposure values from T-REX likely overestimated risks to amphibians. Amphibians are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds or mammals. As a consequence, birds are likely to consume more food than amphibians on a daily dietary intake basis, assuming similar caloric content of the food items. The use of avian food intake allometric equation as a surrogate to amphibians is likely to result in an over-estimation of exposure and risk for reptiles and terrestrial-phase amphibians. Therefore, the T-REX (version 1.3.1) model has been modified to the T-HERPS model, which allows for an estimation of food intake for poikilotherms using the same basic procedure as T-REX to estimate avian food intake. The T-Herps model is described in **Appendix L**. Based on chronic risk quotients for animals consuming small herbivores which exceeded LOCs, risk to terrestrial-phase CTS (all 3 DPSs) are expected from mancozeb uses. However, as indicated in **Table 5-11**, only the turf use exceeds the LOC for animals consuming small amphibians in which some of the food items do not exceed the chronic level of concern.

Table 5-11 Direct CTS effects from upper bound Kenaga chronic terrestrial herpetofauna RQs using the T-HERPs model for mancozeb applications.

Use	*CTS ConsumingSmall Herbivore Mammals Chronic RQ*	*CTS Consuming Small Terrestrial Phase Amphibians Chronic RQ*
Turf	**96.67**	**1.96**
Cucumbers	**18.39**	0.37
Ornamentals(other)	**5.55**	0.11
Shallot	**19.57**	0.40
Fennel	**12.26**	0.25
Grains (barley, oats, rye, triticale, and wheat)	**7.40**	0.15
Atemoya	**16.21**	0.33
Ginseng	**12.69**	0.26
Cucurbits	**18.39**	0.37
Canistel	**10.01**	0.20

Mancozeb dip and seed treatments uses have been determined to have a “no effect” determination effect to CTS.

An additional refinement was conducted to evaluate how far away from the use site the terrestrial-phase CTS might be able to consume contaminated food items to determine if direct effects to CTS are likely. To evaluate this, T-REX was first used to determine the application rate at which the LOC was cleared for all food items. The clearance application rate was 1.0 lb a.i./A. To determine how far away from the use site this “application rate” could occur for each crop, AgDRIFT was used to estimate the deposition. For the highest single application rate of 4.0 lb a.i./A (corn), off-site deposition dropped below 1.0 lb a.i./A at a distance of 23 feet from the use site. When estimating clearance distance, an important consideration is the foraging distance of the organism (T-REX is based on the assumption that the animal evaluated forages exclusively in the treated area). Thus, terrestrial-phase CTS foraging exclusively within 23 feet of the treatment site would be at risk. It is recognized that there is potential for off-site movement of the pesticide via biological vectors (*i.e.*, the residue deposited on or accumulated in the body of an animal leaving the field that is then consumed by the CTS), however at this time there is no standard method to evaluate this route of exposure. It is anticipated biological vectors will not be an important exposure pathway for mancozeb because it is not bioaccumulative, a slow-acting poison, or potentially more toxic to a predator consuming the contaminated organism. This means that terrestrial-phase CTS foraging in the application site will only be at risk from mancozeb applications.

Evaluation of Indirect Effects

Evaluation of Indirect Effects for the CTS via Potential Loss of Prey to CTS

The diet of the aquatic-phase CTS is comprised of algae, snails, zooplankton, small crustaceans, and aquatic larvae and invertebrates, smaller tadpoles of Pacific tree frogs, CRLF toads. The terrestrial-phase CTS feeds on terrestrial invertebrates, insects, frogs, small mammals and worms.

Aquatic Vertebrates:

There is no evidence in the literature that the aquatic-phase CTS consumes fish. However, indirect effects to CTS through direct effects to fish (prey items) were considered in this assessment as CTS eats other aquatic vertebrates such as frogs, and fish serve as surrogates for frogs. The effects of mancozeb on fish as surrogates for the amphibians in the diet of the CTS are detailed under direct effects.

Aquatic Invertebrates:

Water column Exposure*:*

RQs estimated for aquatic invertebrates are further refined using probit analysis. The results of the analysis at the LOC and for each crop scenario are described in Table 5-12. No acute RQs exceeded the non-listed (LOC = 0.5) for freshwater species. Based on the default slope of 4.5, the estimated chance of an individual acute mortality is calculated to be very low (1 in 4.18E+08 at the LOC level and ~1 in 1.71E+03 to ~1 in 8.86E+18 at the RQ level for freshwater invertebrates).

Table 5-12 Probit refinement using *Daphnia* acute RQs for mancozeb applications.

Use	*LOC or RQ*	*Likelihood of Individual Effect (1 in …) Default slope = 4.5*
At the LOC	0.05	~1 in 4.18 E+08
Apple, crab apple, pear, and quince	0.02	~1 in 9.60E+13
Asparagus	0.03	~1 in 2.76E+11
Cereal Grains [1]	0.05	~1 in 4.18E+8
Corn (Field & seed crop)	0.09	~1 in 8.86E+18
Corn (Sweet/Pop) (one crop)	0.04	~1 in 6.33E+9

Use	*LOC or RQ*	*Likelihood of Individual Effect (1 in …) Default slope = 4.5*
Corn (Sweet/Pop) (two crops)	0.13	~1 in 2.99E+4
Corn (Sweet/Pop) (three crops)	0.25	~1 in 2.97E+2
Cotton	0.02	~1 in 9.60E+13
Cucurbits [2]	0.07	~1 in 9.88E+6
Cucurbits, Others [3]	0.07	~1 in 9.88E+6
Fennel (one crop)	0.01	~1 in 8.86E+18
Fennel (two crops)	0.03	~1 in 2.76E+11
Forestry (Douglas Fir)	0.08	~1 in 2.51E+6
Garlic	0.07	~1 in 9.88E+6
Ginseng [4]	0.02	~1 in 2.76E+11
Grapes	0.02	~1 in 9.60E+13
Grapes (Wine)	0.02	~1 in 2.76E+11
Onion (dry) & Shallot	0.02	~1 in 9.60E+13
Ornamentals (in nursery) [5]	0.06	~1 in 5.22E+7
Ornamentals (residential, excluding pachysandra) [5]	<0.01	NR
Ornamentals (residential, Pachysandra only)	0.04	~1 in 6.33E+9
Ornamentals (Residential turf)	0.04	~1 in 6.33E+9
Papayas	0.07	~1 in 9.88E+6
Potatoes	0.02	~1 in 9.60E+13
Sugar beet	0.02	~1 in 9.60E+13
Tomatoes	0.02	~1 in 9.60E+13
Tropical fruits [6]	0.07	~1 in 9.88E+6
Tropical Fruits, Others [7]	<0.01	NR
Turf [8]	0.22	~1 in 6.48E+2
Turf (sod farms only) (two crops)	0.33	~1 in 6.61E+1
X-mass tree plantations	0.08	~1 in 2.51E+6

[1] **Cereal grains:** Wheat, barley, oats, rye, and triticale
[2] **Cucurbits:** Cucumber, cantaloupe, honeydew, casaba melon, crenshaw melon, watermelon, musk melon and gourds
[3] **Cucurbits, Others:** Chayote, Chinese wax gourd, citron melon, gherkin, Momordica spp., pumpkin, squash (summer and winter) and water melon
[4] **Ginseng note:** For this crop two scenarios were run: CA citrus and CA almonds. The highest EECs for CA Almonds is used in the assessment
[5] **Ornamentals:** Ornamentals used in residential landscaping including: shade trees, ground cover plants, herbaceous plants
[6] **Tropical fruits:** Atemoya, cherimoya, custard apple, sugar apple, and sweetsop
[7] **Tropical Fruit, Others:** (Canistel, mamey, sapote, mango, sapodilla, star apple, and white sapote
[8] **Turf:** Turf excludes residential turf but includes: commercial/industrial/recreational area lawns, golf course turf, and ornamental sod farm turf

Indirect effects are also indicated through chronic RQ exceedence for aquatic invertebrates as prey items. RQs for cereal grains, corn (field and seed crop), corn (sweet/pop), cucurbits, forestry, garlic, onion, shallot, ornamentals (nursery, pachysandra, turf), papayas, potatoes and turf exceeded the chronic LOC = 1.

Sediment Exposure*:*

As summarized in **Section 4.1.2.3**, toxicity data are available for freshwater invertebrates via exposure to contaminated sediment for mancozeb. Exposure via sediment is of interest because it can involve both uptake through respiration of pore and overlying water in addition to ingestion of contaminated sediment. Chronic risk to freshwater sediment invertebrates is based on peak sediment EECs and the lowest 10-day LC_{50} value for freshwater sediment invertebrates. Freshwater sediment toxicity data for mancozeb in pore water (LC_{50} = 38.2 mg a.i./kg sediment for midge), and peak sediment EECs are used to calculate RQs. The highest two crop scenarios (turf and sod farms) were used to represent all of the agricultural uses of mancozeb in California, with acute RQs for freshwater invertebrates ranging from 0.02 for turf to 0.05 for Sod farms. The only sediment RQ exceeding the LOC=0.05 resulted from turf (sod farm) use (**Tables 5-13).**

Based on exceedances at the Agency's acute endangered species LOC=0.05 for turf use (sod farms), there is potential for indirect effects to the CTS via reduction in its freshwater sediment invertebrates prey base, provided that exposures occur at or near modeled EECs and that the sensitivity of tested invertebrates via sediment exposure is similar to those found in aquatic ecosystems upon which the CTS relies for prey.

Table 5-13 Indirect effects for the aquatic-phase CTS via acute effects to freshwater benthic invertebrates for mancozeb uses.

Use	*Peak Sediment EEC (ppb)*	*RQ*	*Endangered Species LOC Exceedance?*
Turf	924.7	0.02	no
Turf (sod farms only) (two crops)	1787.00	0.05	yes

RQs estimated for benthic invertebrates are refined using probit analysis. The results of the probit analysis at the LOC and for each crop scenario are described in **Table 5-14**.

Table 5-14 Probit refinement for freshwater benthic invertebrate RQs from mancozeb use.

Use	*LOC or RQ*	*Likelihood of Individual Effect (1 in …) Default slope = 4.5*
At the LOC	0.05	~1 in 4.18 E+08
Turf	0.02	~1 in 9.60E+13
Turf (sod farms only) (two crops)	0.05	~1 in 4.18 E+08

Based on the default slope of 4.5, the estimated chance of an individual acute mortality is calculated to be very low (1 in 4.18E+08) at the LOC level. The probit analysis is also assessed at the RQ for each use. The estimated chance of an individual acute mortality ranged from ~1 in 4.18 E+08 for turf (sod farms) uses to 1 in 9.60E+13 for turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farm) uses for CTS consuming benthic prey.

*Birds as surrogates for amphibians***:**

The CTS diet is composed of amphibians. In the absence of amphibian toxicity studies, toxicity data for birds is used to evaluate the effect of mancozeb. Acute RQs were not calculated due to nondefinitive endpoints. The probit analysis also was not used due to the nondefinitive endpoints. Chronic RQs for all uses exceed the chronic LOC. RQs range from 5.53 to 105.73.

Terrestrial Invertebrates:

Potential for indirect effects to the terrestrial-phase CTS may result from direct acute effects to terrestrial invertebrates due to a reduction in prey. In order to assess the risks of mancozeb to terrestrial invertebrates, the honey bee is used as a surrogate for terrestrial invertebrates. Typically, the toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available acute contact LD_{50} by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs (µg a.i./g of bee) calculated by T-REX for small and large insects are divided by the calculated toxicity value for terrestrial invertebrates. RQs for indirect effects are not calculated due to the nondefinitive endpoint from the toxicity study. Table 5-15 presents the application rates and EECs for the CTS consuming small and large insects.

Table 5-15 Indirect effects for the terrestrial-phase CTS via dietary-based exposure to terrestrial invertebrates.

Use[1]	*Application Rate lbs a.i./A*	*Small Insect EECs (mg/kg)*	*Large Insect EECs (mg/kg)*
Atemoya, cherimoya, custard apple, sugar apple and sweetsop	2.10	1135.70	126.19
Cereal Grains	1.6	518.43	57.60
Cucumbers	2.4	1288.10	143.12
Canistel, mammy, sapote, mango, sapodilla, star apple(caimito) and white sapote	2.24	701.55	77.95
Cucurbit Crops (Chayote, Chinese wax gourd, citron melon, cucumber, gherkin, edible gourd, Momordica spp., muskmelon, pumpkin, squash (summer and winter) and watermelon)	2.69	1288.10	143.12
Fennel	1.6	858.73	95.41

Use[1]	*Application Rate lbs a.i./A*	*Small Insect EECs (mg/kg)*	*Large Insect EECs (mg/kg)*
Ginseng	1.68	888.89	98.77
Ornamentals(other)	1.2	388.83	43.20
Shallot	2.4	1371.13	152.35
Turf	17.4	6772.46	752.50

The bee toxicity study reported an LD50>179µg a.i./bee. For small insects, the EECs for all uses are above the reported LD50 value. For large insects, the turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms) use EEC is the only use with an EEC above the LD50 value. There is a potential concern for bees representing terrestrial invertebrates based on the uncertainty due to the nondefinitive endpoint from the toxicity study.

In addition, a toxicity study on the mite resulted in a 7 day residual toxicity LR50=0.1 lb/A. The LR50 value is below application rates for all uses. An adverse reproductive effect was also reported. A 14 day LOAEC =0.02 lbs a.i./A was noted for eggs laid per female. Use rates range from 1.2 lbs a.i./A for ornamentals to 19.1 lba a.i./A for turf.

Mammals:

Acute RQs were not calculated due to nondefinitive endpoints. EECs for small mammals ranged from 9.15 for ornamental to 12,600.68 turf uses. The probit analysis also was not used due to the nondefinitive endpoints. Chronic RQs for all uses exceed the chronic LOC. RQs range from 0.36 to 110.14. In addition to consuming small mammal, the CTS also uses small mammal burrows for shelter.

Potential Modification of Habitat

Aquatic Plants:

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

Potential indirect effects to the CTS based on impacts to habitat and/or primary production are assessed using RQs from freshwater aquatic vascular and non-vascular plant data. There is uncertainty due to the absence of toxicity data to determine the risk of mancozeb on aquatic vascular plants. However, there is a registrant submitted study used to evaluate the effect of ETU on vascular plants. The study (MRID 464629-04) indicated that there was no adverse effect at the highest tested concentration (960 mg/L). Therefore, there is no concern for aquatic vascular plants from the use of ETU. In the absence of mancozeb toxicity data for vascular plants, data from nonvascular plants for mancozeb is used as a surrogate to evaluate the indirect effect on vascular plants.

Mancozeb acute risk LOCs for non-vascular plants were exceeded for the uses on corn, turf, sod farms, forestry, Christmas tree farms, atemoya, ginseng and cucurbits using mancozeb toxicity values. Plant LOCs were exceeded for corn, garlic, commercial turf, sod farms, forestry, Christmas tree, cereal grains, atemoya, ginseng, cucurbits and canistel uses based on ETU toxicity values.

Even though the CTS depends on a wide range of non-vascular plants, it is expected that mancozeb, would elicit adverse impacts on non-vascular plants resulting in indirect effects to CTS via direct habitat-related impacts to non-vascular plants. Therefore, there is a potential for mancozeb to cause indirect effects to CTS (all 3 DPSs).

Presence of pesticides in the water bodies supporting the CTS (all 3 DPSs) could reduce populations of sensitive non-vascular plants, and/or cause a shift in phytoplankton community dynamics. Typically, aquatic plant populations are relatively dynamic, and the presence of mancozeb in the water may result in an overall reduction of biomass, and/or a shift in community composition as more sensitive species are eliminated. Mancozeb may also modify timing of maximum plant growth.

Terrestrial Plants:

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

In a healthy riparian system, there is often a three-tier vegetation system, with trees as an overstory, shrubs as an understory, and grasses and forbs forming the ground cover. The aquatic-phase CTS may occupy waterbodies with dense riparian vegetation. Upland habitat for the terrestrial-phase CTS includes shrubs.

Guideline data are available to evaluate the use of mancozeb on terrestrial plants (MRIDs 474861-01, 474861-02 and 442834-01), indicating that there is no effect at the highest tested concentration from the use of mancozeb.   There is uncertainty based on the categorization of the five reported terrestrial plants incident. Four of the incidents were associated with exposure to other active ingredients, and only one showed trace amounts of mancozeb during chemical analysis. A “ likely to adversely affect” determination is made for CTS through effects to plants composing the riparian and terrestrial habitats due to the uncertainty from the toxicity tests not testing up to the highest application rate used for mancozeb.

There is also absence of toxicity data for ETU resulting in potential concern for terrestrial plants. Information is available for aquatic plants, indicating that aquatic plants are more sensitive to ETU (EC_{50}=23 µg/L) than mancozeb (EC_{50}=47 µg/L).

Modification of Designated Critical Habitat

Based on the weight-of-evidence, there is a potential for the modification of designated critical habitat for CTS based on freshwater invertebrate prey loss due to changes in the composition of food supply. Aquatic and terrestrial plants are also at risk from mancozeb uses. However, risk to terrestrial plants is much higher compared to aquatic plants. As a result of risk to plants, both aquatic, and terrestrial, CTS (all 3 DPSs) will be impacted due to effects such as changes in primary productivity, modification of water quality parameters, habitat morphology, and/or sedimentation.

Spatial Extent of Potential Effects

Spray drift analysis is necessary to define the full extent of the action area, which is defined by the initial area of concern or “footprint” of potential uses extended by drift. Spray drift analysis determines the additional distance from the treated area where listed species LOCs are exceeded as a result of spray drift. This distance is based on the taxonomic group that yields the largest RQ to LOC ratio. Both terrestrial and aquatic taxonomic groups are considered in this analysis. For mancozeb, the results of the screening-level assessment indicate that the mammalian “RQ to LOC ratio” is highest. The results of the spray drift analysis are summarized in **Table 5-16** for the various use patterns.

To determine this area, the footprint of mancozeb’s use pattern is identified, using corresponding land cover data. For mancozeb, these land cover types include cultivated, orchard/vineyard, developed open/developed low/developed medium/ developed high, and turf. Actual usage is expected to occur in a smaller area as the chemical is only expected to be used on a portion of the identified area. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift (Use Footprint + distance downstream or downwind from use sites where organisms relevant to the assessed species may be affected).

Table 5-16 Estimation of spray drift effect.

Use Category: Use Pattern	*Determination of Species with Largest RQ to LOC Ratio*					*Buffer (ft)**
	EEC (ppm)	*Toxicity (ppm)*	*RQ*	*LOC*	*Ratio*	
(1) Mancozeb Use Only						
Cultivated crops: Shallot	2,437.56	120	80.70	1	**80.70**	2,051 to 2,067
Turf: Turf	12,039.93	75	637.73	1	**637.73**	3,494 to 3,615

- Range was obtained by changing the volume of product used to prepare a 15 gallons finished spray.

The ranges of buffers are expected to vary depending on the application parameters used as these parameters change not only with change in droplet size distribution but also with formulation type and % of a.i. among many others. **Appendix E** contains a summary of input parameters used in this analysis.

The total area of the initial concern is: 90,467 sq km for mancozeb use. Application of the maximum buffers distances in the above table results in an increase of the initial action area by nearly 93% for mancozeb use. Detailed analysis is included in **Appendix D,** for mancozeb use.

Downstream Dilution Analysis

Down-stream dilution analysis is necessary to define the full extent of the action area. This is because the action area is defined by the initial area of concern or "footprint" of potential uses which is extended by downstream dilution and by drift. This analysis determines downstream extent of exposure in streams and rivers where the EEC could potentially be above levels that would exceed the highest RQ to LOC ratio. The downstream analysis results are from the CRLF assessment.

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

The downstream dilution analysis is based on the greatest ratio of aquatic RQ to LOC, which was calculated to be 52.8 for mancozeb based on direct chronic effects. This value was estimated using the NOAEC value for the most sensitive aquatic species (fathead minnow) of 2.19 ppb and EECs from mancozeb applications to Sod farms of 111.07 ppb from the CRLF assessment. The downstream dilution approach is described in more detail in **Appendix D.**

The total length of streams in the initial area of concern to the total length of California streams is 57% (189,441 km) for mancozeb use. By applying the downstream approach described above, the total length added increased by 2% for mancozeb use. It is noted that stream lengths of the initial area of concern is the highest for mancozeb use that may be attributed to the forestry use of mancozeb. In this respect, it is noted that there were no reported usage of mancozeb in the PUR data. Detailed summary is included in **Appendix C,** for mancozeb use.

By applying the downstream approach described above, the total length added increased by 10% for the mancozeb use. In this respect, it is noted however, that there was no reported forestry usage of mancozeb in the PUR database during the period 2002 to 2005.

Overlap of Potential Areas of LAA Effect and Habitat and Occurrence of CTS

The spray drift and downstream dilution analyses help to identify areas of potential effect to the CTS from registered uses of mancozeb. The Potential Area of LAA Effects on survival, growth, and reproduction for the CTS from mancozeb spray drift extend from the site of application to >1000 feet from the site of application. For exposure to runoff and spray drift, the area of potential LAA effects extends up to 285 km downstream from the site of application. When these distances are added to the footprint of the Initial Area of Concern (which represents potential mancozeb complex use sites) and compared to CTS habitat, there are several areas of overlap (**Figures 5-1, 5-2, 5-3, 5-4 and 5-5**). An enlarged map of the Santa Barbara distinct population is included in the spatial analysis **Appendix D**. The overlap between the areas of LAA effect and CTS habitat, including designated critical habitat, indicates that mancozeb use in California has the potential to affect the CTS (all 3 DPSs). More information on the spatial analysis is available in **Appendix D for mancozeb**.

Figure 5-1 Spatial analysis indicating the overlap for mancozeb orchard use and the CTS.

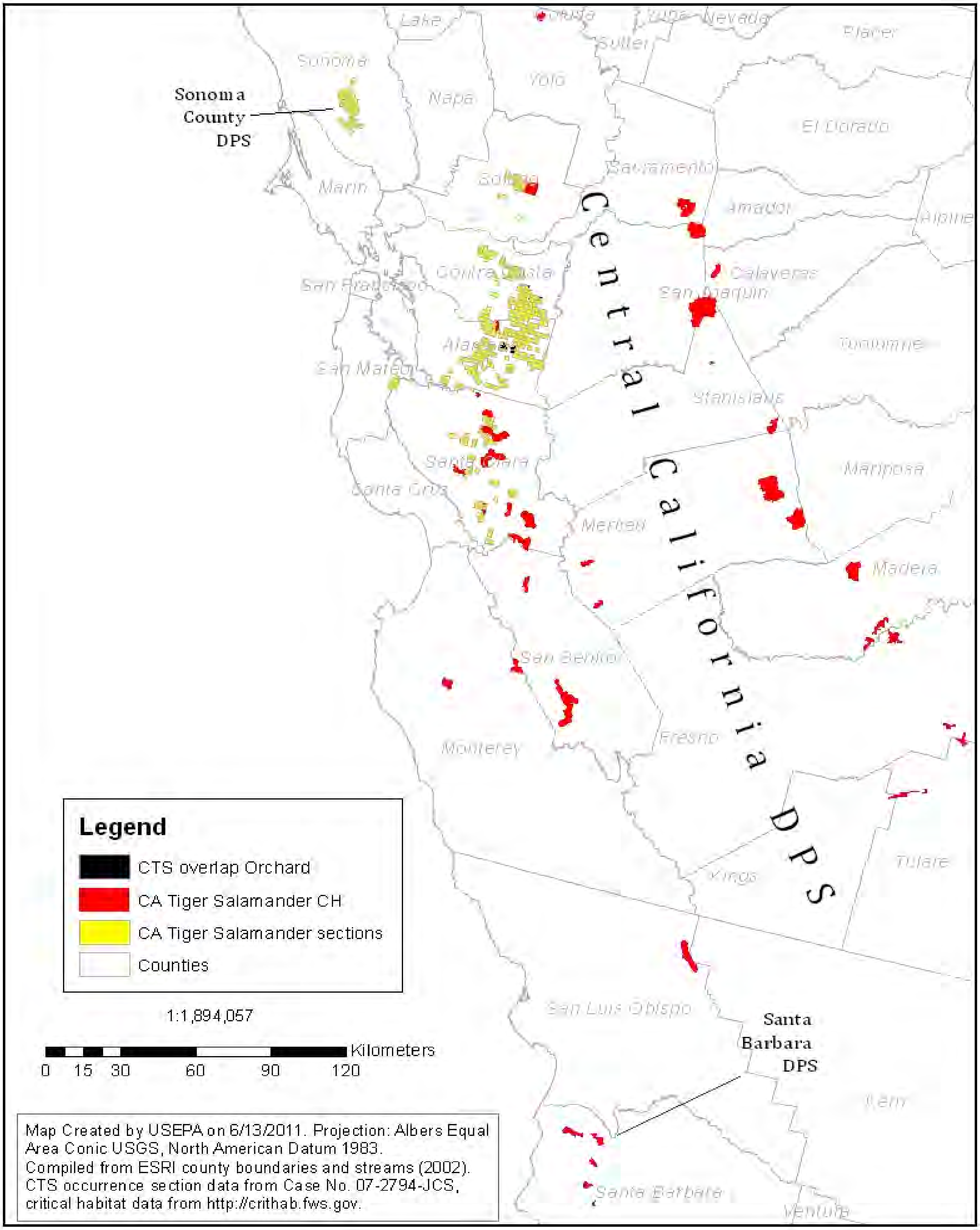


Figure 5-2 Spatial analysis indicating the overlap for mancozeb cultivated use and the CTS.

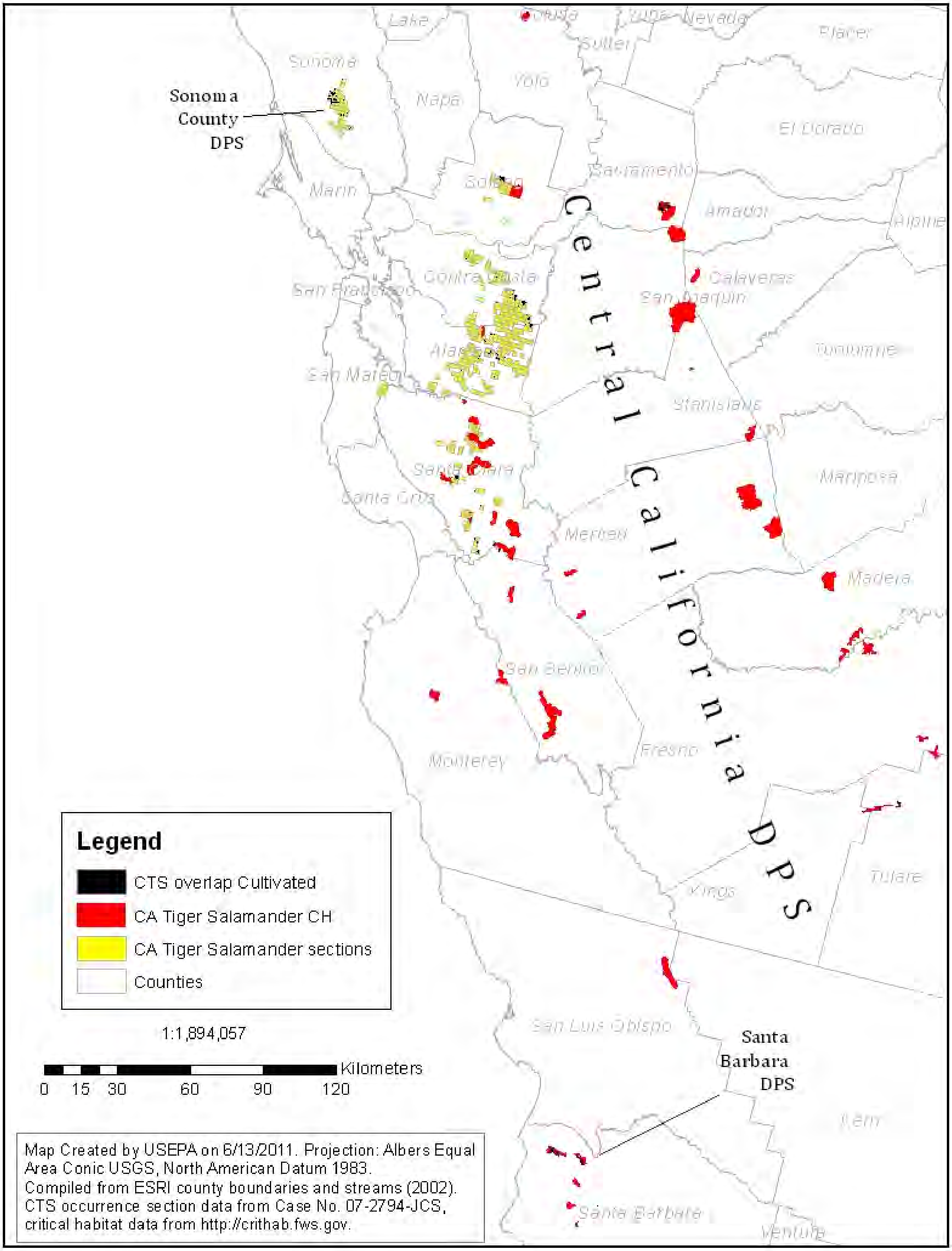


Figure 5-3 Spatial analysis indicating the overlap for mancozeb conifer use and the CTS.

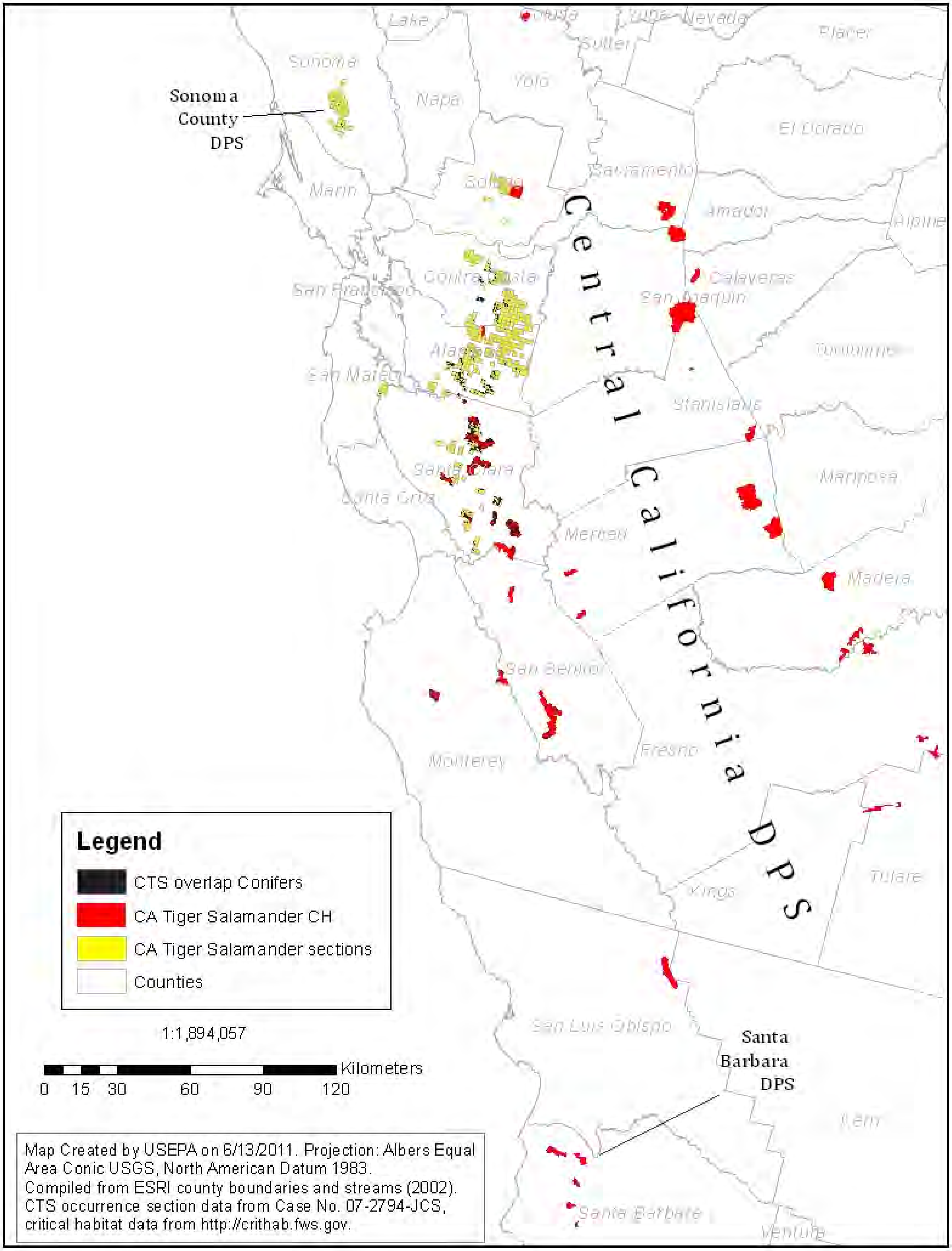


Figure 5-4 Spatial analysis indicating the overlap for mancozeb residential use and the CTS.

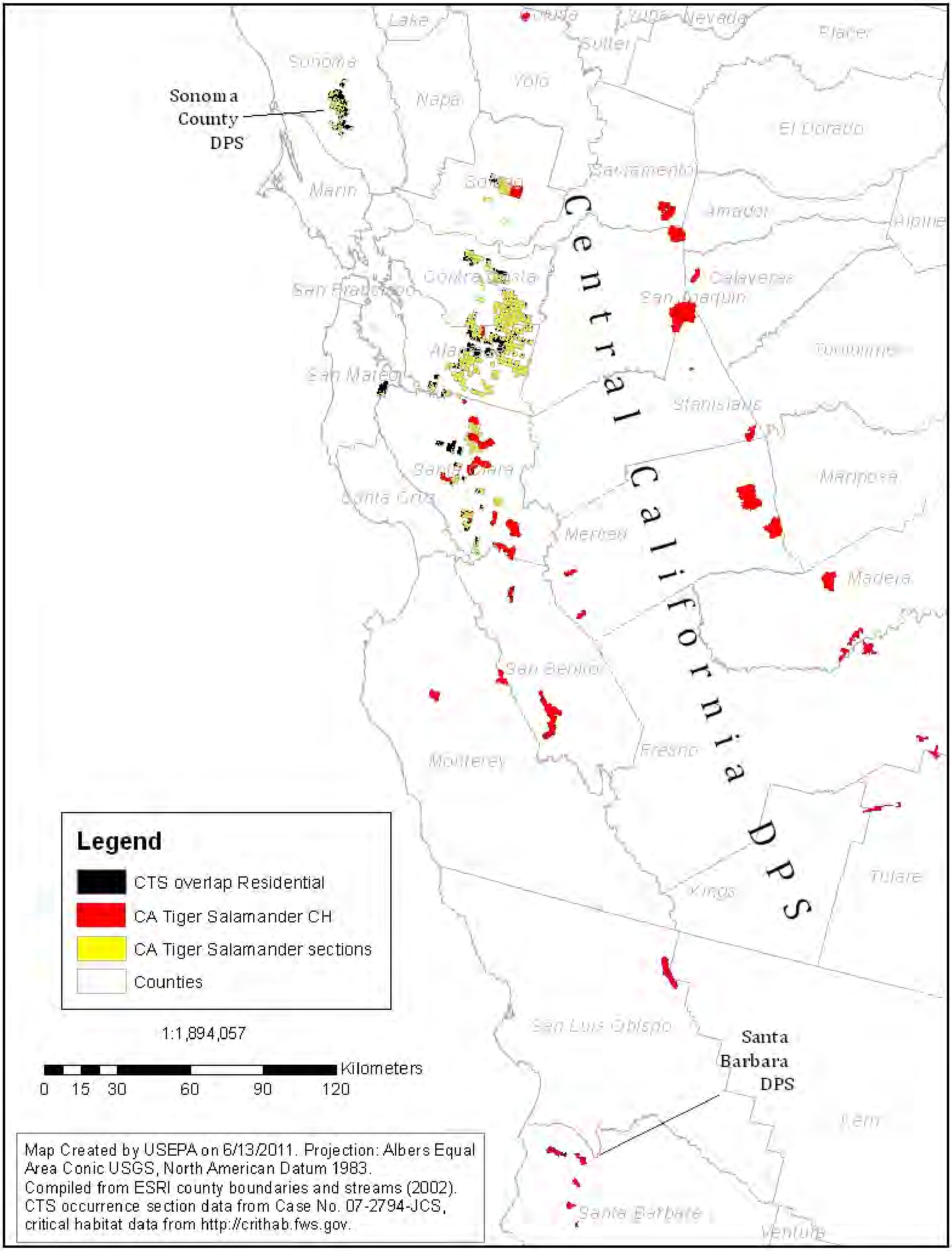
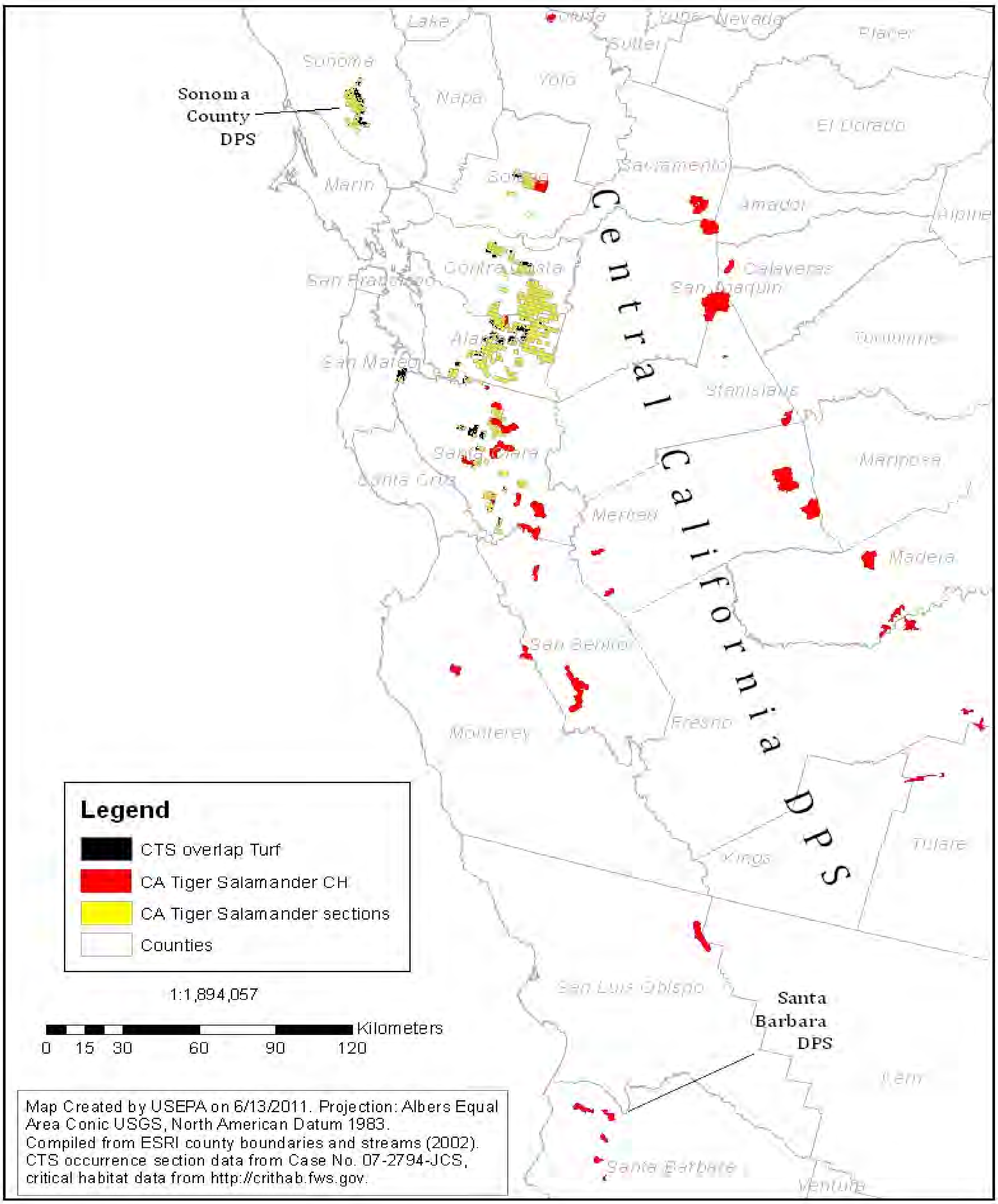


Figure 5-5 Spatial analysis indicating the overlap for mancozeb turf use and the CTS.



5.3. Effects Determinations

CTS

The available evidence suggests that direct effects to aquatic phase CTS are likely, as well as direct effects to the terrestrial phase CTS. Indirect effects to the aquatic-phase CTS are likely due to reduction in fish as surrogates for amphibians and nonvascular aquatic plants as part of the diet. Indirect effects to the terrestrial phase CTS are possible due to adverse effects on prey items such as amphibians, mammals, terrestrial invertebrates for the terrestrial phase CTS. Alteration in habitat for aquatic and terrestrial plants habitat is also likely. Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the CTS (all 3 DPSs) and a **habitat modification determination** for their designated critical habitat based on the potential for direct and indirect effects and effects to the PCEs of critical habitat.

Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in Section 0. Based on the conclusions of this assessment, one of the seven of the hypotheses, that mancozeb complex may indirectly affect CTS and/or modify their designated critical habitat by reducing or changing the composition of the benthic environment and food supply in reducing the number of sediment dwelling organisms, can be rejected. However, the other six hypotheses listed below cannot be rejected:

- Mancozeb complex may directly affect CTS (all 3 DPSs) by causing mortality or by adversely affecting growth or fecundity;
- Mancozeb complex may indirectly affect CTS (all 3 DPSs) and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- Mancozeb complex may indirectly affect CTS and/or modify their designated critical habitat by reducing shelter provided by mammal burrows or changing the composition of the plant community in the species' current range; Mancozeb and the degradate ETU may indirectly affect the CTS (all 3 DPSs) and/or affect their designated critical habitat by reducing or changing the composition of the aquatic plant community in the species' current range, thus, affecting primary productivity and/or cover;
- Mancozeb complex may indirectly affect the CTS (all 3 DPSs) and affect their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;
- Mancozeb complex and the degradate ETU may indirectly affect the CTS (all 3 DPSs) and affect their designated critical habitat by reducing or changing aquatic habitat in their current range.

6. Uncertainties

Uncertainties that apply to most assessments completed for the San Francisco Bay Species Litigation are discussed in **Attachment 1**. This section describes additional uncertainties specific to this assessment.

6.1. Exposure Assessment Uncertainties

Overall, the uncertainties inherent in the exposure assessment tend to result in over-estimation of exposures. This is apparent when comparing modeling results with monitoring data. In particular, estimated peak exposures are generally an order of magnitude above 90th percentile site concentrations in the surface water monitoring data. In general, the monitoring data should be considered a lower bound on exposure, while modeling represents an upper bound.

Uncertainty Associated with Maximum Use Scenario

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

Aquatic Exposure Modeling of Mancozeb

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

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

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

Usage Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR-PUR) database. Eight years of data (2002-2005) were included in this analysis because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was provided by CDPR for these years only. No methodology for removing outliers was provided by CDPR for 2001 and earlier pesticide data; therefore, this information was not included in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been cancelled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide usage data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

Terrestrial Exposure Models

T-REX

For the terrestrial exposure analysis of this risk assessment, a generic bird or mammal was assumed to occupy either the treated field or adjacent areas receiving a treatment rate on the field. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the modeled treatment area.

Spray drift model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field exclusively and permanently.

Organisms consume a variety of dietary items and may exist in a variety of sizes at different life stages. For foliar applications of liquid formulations, T-REX estimates exposure for the following dietary items: short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, and seeds for granivores. Birds (used as a surrogate for amphibians and reptiles) consume all of these items. The size classes of birds represented in T-REX are the small (20 g), medium (100 g), and large (1000 g). The size classes for mammals are small (15 g), medium (35 g), and large (1000 g). EECs are calculated for the most sensitive dietary item and size class for birds (surrogate for amphibians and reptiles) and mammals. **Table 6-1** shows the percentages of the EECs and RQs of the various dietary classes for each size class as compared to the most sensitive dietary class (short grass) and size class (small mammal or bird). This information could be used to further characterize potential risk that is specific to the diet of birds and mammals. For example, if a mammal only consumes broadleaf plants and small insects and the RQ was 100 for small mammals consuming short grass, the RQ for small mammals that only consumed broadleaf plants and small insects would be 56 (100 x 0.56).

Table 6-1 Percentage of EEC or RQ for the specified dietary items and size classes as compared to the EEC or RQ for the most sensitive dietary items (short grass) and size class (small bird or small mammal).

Dietary Items	**Percentage of EECs or RQs for the Specified Dietary Items and Size Class as compared to the EEC or RQ for Small Birds[1] or Small Mammals Consuming Short Grass**					
Birds: Dose Based EECs and RQs						
Size Class	Small, 20 g		Mid, 100 g		Large, 1000 g	
	EEC	RQ	EEC	RQ	EEC	RQ
Short Grass	100%	100%	57%	45%	26%	14%
Tall Grass	46%	46%	26%	21%	12%	7%
Broadleaf plants/small Insects	56%	56%	32%	25%	14%	8%
Fruits/pods/seeds/large insects	6%	6%	4%	3%	2%	1%
Granivores	1%	1%	1%	1%	0.4%	0.2%
Mammals: Dose-Based EECs and RQs						
Size Class	Small, 15 g		Mid, 35 g		Large, 1000 g	
	EEC	RQ	EEC	RQ	EEC	RQ
Short Grass	100%	100%	69%	85%	16%	46%
Tall Grass	46%	46%	32%	39%	7%	21%
Broadleaf plants/small Insects	56%	56%	39%	48%	9%	26%
Fruits/pods/seeds/large insects	6%	6%	4%	5%	1%	3%
Granivores	1%	1%	1%	1%	0.2%	0.6%
Mammals and Birds: Dietary-based EECs and RQs for all Size Classes[2]						
Short Grass	100%					
Tall Grass	46%					
Broadleaf plants/sm Insects	56%					
Fruits/pods/seeds/lg insects	6%					

[1] The percents of the maximum RQ shown here for birds are based on the Agency's default avian scaling factor of 1.15 (Mineau *et al*. 1996).

[2] Percentages for dose-based chronic EECs and RQs for mammals are equivalent to the acute dose-based EECs and RQs.

In the risk assessment, RQs were only calculated for the most sensitive dietary class relevant to the organisms assessed. For most organisms, not enough data is available to conclude that birds or mammals may not exclusively feed on a dietary class for at least some time period. However, most birds and mammals consume a variety of dietary items and thus the RQ will overestimate risk to those organisms. For example, the CCR is estimated to consume only 15% plant material (USFWS, 2003). Additionally, some organisms will not feed on all of the dietary classes. For example, many amphibians would only consume insects and not any plant material.

T-HERPS

Uncertainties in the Mammal and Herptile Prey Item EEC

T-HERPS calculates EECs for terrestrial-phase herptiles that consume mammals and other terrestrial phase herptiles. The amount of chemical estimated to be in the prey animal, in most cases, is thought to be a conservative estimate of potential dietary exposure because T-HERPS assumes that a small prey animal is consuming its daily intake of contaminated food before being consumed by the assessed species. Depuration of the pesticide from the prey item due to excretion or metabolism was not included in the estimation. Therefore, the EECs for chemicals that are short-lived in an animal are expected to represent an over-estimate of exposure. However, for chemicals that are bioaccumulative and are not readily degraded or excreted in an animal, the resulting exposure estimates could be low-end estimates because body burdens within the prey species would be expected to increase over time for bioaccumulative chemicals, resulting in potential body burdens that exceed the estimated daily dose calculated by T-HERPS. In addition, potential residues on the surface of potential prey items (e.g. in the fur) were not estimated by T-HERPS. Additional residues would be expected to be on prey item surface as well as within the prey item. Residues could be on prey items by several pathways including direct deposition of spray drift or by contact of the prey animal with contaminated soil or foliage.

In addition, the mammal prey item assessment assumes consumption of a 35-gram mammal by the assessed species. A body weight of 35 grams was chosen because it represents a higher end body weight of deer mice (U.S. EPA, 1993). Use of larger sized prey mammals would result in higher dose-based RQs, but lower dietary-based RQs. It is uncertain if dose-based or dietary-based RQs are more appropriate for this exposure pathway.

Spray Drift Modeling

It is unlikely that the same organism would be exposed to the maximum amount of spray drift from every application made. In order for an organism to receive the maximum concentration of mancozeb from multiple applications, each application of mancozeb would have to occur under identical atmospheric conditions (e.g., same wind speed and same wind direction) and (if it is an animal) the animal being exposed would have to be located in the same location (which receives the maximum amount of spray drift) after each application. Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT model (*i.e.*, it models spray drift from ground applications in a flat area with little to no ground cover and a steady, constant wind speed and direction). Therefore, in most cases, the drift estimates from AgDRIFT may overestimate exposure, especially as the distance increases from the site of application, since the model does not account for potential obstructions (*e.g.*, large hills, berms, buildings, trees, *etc*.).

6.2. Effects Assessment Uncertainties

Age Class and Sensitivity of Effects Thresholds

It is generally recognized that test organism age may have a significant impact on the observed sensitivity to a toxicant. The acute toxicity data for fish are collected on juvenile fish between 0.1 and 5 grams. Aquatic invertebrate acute testing is performed on recommended immature age classes (e.g., first instar for daphnids, second instar for amphipods, stoneflies, mayflies, and third instar for midges).

Testing of juveniles may overestimate toxicity at older age classes for pesticide active ingredients that act directly without metabolic transformation because younger age classes may not have the enzymatic systems associated with detoxifying xenobiotics. In so far as the available toxicity data may provide ranges of sensitivity information with respect to age class, this assessment uses the most sensitive life-stage information available as measures of effect for fish and aquatic invertebrates.

Use of Surrogate Species Effects Data

Guideline toxicity tests on mancozeb are not available for aquatic-phase amphibian; therefore, freshwater fish are used as surrogate species for aquatic-phase CTS. Therefore, endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase CTS. An extrapolation of the risk conclusions from the most sensitive tested freshwater fish species to the aquatic-phase CTS is likely to overestimate the potential risks to those species.

Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency’s LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

Uncertainties associated with the Feeding Behavior of the Assessed Species

The allometric equation used to estimate daily food intake assumes a typical or constant food intake rate daily. In reality, the amount of food consumed (and, therefore, potential exposures to pesticides) may vary significantly from day to day, depending on a number of factors including availability of particular food items and energy needs.

T-HERPS estimates potential exposures for a number of food items. EECs for a particular food item are calculated with the assumption that one food item is consumed daily. Terrestrial-phase herptiles may receive 100% of their daily diet from one food item for a particular day, especially if larger prey, such as a small mammal, is available. However, many terrestrial-phase herptiles (including the CTS) may consume a variety of food items in a given day. T-HERPS estimates potential exposures resulting from consumption of a range of food items for the purpose of giving a high-end and low-end bounding estimate. All exposure values may be used in characterizing potential exposures.

Sublethal Effects

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

Sublethal effects, including behavioral effects, have been linked to mancozeb. Where quantitative data existed, these effects were considered in the assessment, and appear to occur at concentrations higher than the frank effects used as assessment endpoints. Thus, based on data available at the time of this assessment, risk conclusions in the assessment are anticipated to be adequately protective in regards to sublethal effects.

Acute LOC Assumptions

The risk characterization section of this assessment includes an evaluation of the potential for individual effects. The individual effects probability associated with the acute RQ is based on the assumption that the dose-response curve fits a probit model. It uses the mean estimate of the slope and the LC_{50} to estimate the probability of individual effects.

Residue Levels Selection

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

Extrapolation of Effects

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

Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods do not account for a potentially important aspect of food requirements. Depending upon species and dietary matrix, bird assimilation of wild diet energy ranges from 23 – 80%, and mammal's assimilation ranges from 41 – 85% (U.S. Environmental Protection Agency, 1993). If it is assumed that laboratory chow is formulated to maximize assimilative efficiency (e.g., a value of 85%), a potential for underestimation of exposure may exist by assuming that consumption of food in the wild is comparable with consumption during laboratory testing. In the screening process, exposure may be underestimated because metabolic rates are not related to food consumption.

Mixtures

The California tiger salamander and various components of their ecosystem may be exposed to multiple pesticides, introduced into its environment either via a multiple active ingredient formulated product, a tank mixture, or transport from independently applied active ingredients. Multiple pesticides may act in an additive, synergistic, or antagonistic fashion. Quantifying reasonable environmental exposures and establishing reasonable corresponding toxicological endpoints for the myriad of possible situations is beyond the scope of this document, and in some cases, beyond the current state of ecotoxicological practice. Mixtures could affect the CTS in ways not addressed in this assessment. Exposure to multiple contaminants could make organisms more or less sensitive to the effects of mancozeb, thus the directional bias associated with environmental mixtures is unknown, and may vary on a case-by-case basis.

Non-Definitive Endpoints

The current assessment on mancozeb utilized avian and terrestrial invertebrate (honey bee) endpoints that were non-definitive as a result of which there is uncertainty regarding risk conclusions. Guidance is currently being developed on how to address the uncertainty related to non-definitive endpoints.

The Agency's pesticide ecological testing guidelines allow for 'limit tests' for acute and sub-acute exposures (*e.g.*, testing a chemical up to 2,000 mg a.i./kg-bw for birds and 25 µg a.i./bee for honey bees). Because only one concentration is typically tested in a limit test, an $LC_{50}/EC_{50}/LD_{50}$ value cannot be calculated from these studies. Additionally, some acute and/or sub-acute studies fail to demonstrate a definitive endpoint because an $LC_{50}/EC_{50}/LD_{50}$ value cannot be calculated based on the effects observed at the concentrations tested. If mortality does not reach 50% at the highest concentration tested, the resulting $LC_{50}/EC_{50}/LD_{50}$ is a 'greater than' value (*e.g.,* LD_{50} >2,000 mg a.i./kg-bw), and the concentration that would result in 50% mortality is unknown. In some cases, relevant estimated environmental concentrations (EECs) for a pesticide with a non-definitive acute and/or sub-acute toxicity endpoint are higher than the highest concentrations tested.

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 mancozeb to CTS and its designated critical habitat.

Based on the best available information and the procedures summarized above, the Agency makes a May Affect, and Likely to Adversely Affect (LAA) determination for CTS (all 3 DPSs) from the currently registered uses of mancozeb (**Table 7-1**). Additionally, the Agency has determined that there is the potential for modification of designated critical habitat for CTS (all 3 DPSs) from the currently registered uses of mancozeb (**Table 7-2)**. Further information on the results of the effects determination is included as part of the Risk Description in **Section 5.2**. Given the LAA determination for the CTS (all 3 DPSs) and potential modification of designated critical habitat for CTS (all 3 DPSs), a description of the baseline status and cumulative effects for CTS is provided in **Attachment 2**.

The overall mancozeb complex LAA determination for the CTS assessment is consistent with the CRLF LAA determination for all application methods, although taxa-specific determinations differ. For non-seed treatment uses, the LAA determination is based on the likelihood of direct aquatic effects using the fish as a surrogate for the aquatic-phase CTS (in absence of data for aquatic-phase amphibians) and terrestrial effects to CTS using the bird as a surrogate for terrestrial phase CTS (in absence of data for terrestrial-phase amphibians). The LAA determination for nonseed treatment applications used to evaluate indirect effects include reduction in prey for fish (used as a surrogate for aquatic-phase amphibian prey), aquatic invertebrates, aquatic plants and a "Habitat Modification" determination based on effects on aquatic plants. There is also an LAA determination for indirect effects for reduction in terrestrial prey for birds (representing terrestrial-phase amphibians), mammals and terrestrial invertebrates. A " Habitat Modification" determination in the terrestrial habitat was based on the uncertainty due to the submitted terrestrial plant toxicity studies not being tested to the highest application rate and reported plant incidents involving mancozeb. An additional factor in the Habitat Modification" determination was based on the CTS' use of mammal burrows for shelter and the RQs indicating a reduction in the number of mammal burrows available for shelter. There is a "No Effect" (NE) determination for seed treatments from the use of mancozeb due to aquatic and terrestrial EECs being below levels of concern for listed CTS.

Species specific differences between the CTS and CRLF determinations are based on updates to the aquatic model used and additional information form ecotoxicity studies received and reviewed. The aquatic EECs were modeled from the updated PRZM EXAMS version PE_5. Information from the additional ecotoxicity studies indicated that the degradate ETU was not as toxic as the parent mancozeb. Therefore, mancozeb toxicity values were used to estimate aquatic RQs for the CTS rather than the ETU toxicity values used to estimate aquatic RQs in the CRLF assessment.

Table 7-1 Effects determination summary for effects of mancozeb on the CTS (all 3 DPS).

Species	Effects Determination	Basis for Determination
California tiger	LAA	**POTENTIAL FOR DIRECT EFFECTS** ***Aquatic-phase CTS (Eggs, Larvae, and Adults)***: *Freshwater Fish RQ*

Species	Effects Determination	Basis for Determination
salamander (CTS)		- Based on freshwater fish endpoints as surrogate for the aquatic-phase CTS, acute RQs for non-seed treatment uses exceeded the listed species risk LOC for cereal grains, corn (field), corn (sweet/Pop), cucurbits, forestry, garlic, ornamentals (residential turf), papayas, tropical fruit (Atemoya, cherimoya, custard apple, sugar apple and sweet sop), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farm) sod farms, and Christmas tree plantations mancozeb uses. Acute RQs ranged from <0.01for ornamentals (residential) to 0.41for turf (sod farms). - Based on freshwater fish, chronic RQs exceeded the chronic LOC for non-seed treatment uses with apple, asparagus, cereal grains, corn (field), corn (sweet/Pop), cotton, cucurbits, fennel, forestry, garlic, grapes, onion, ornamentals (nursery, pachysandra, residential turf), papayas, potatoes, sugar beets, tomatoes, turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farm), turf/ sod farms, and Christmas tree plantations mancozeb uses. Chronic RQs ranged from 0.06 for tropical fruit to 27.19 for turf (sod farms). *Likelihood of Individual Mortality* - The probit analysis suggested that the probability of an individual effect is ~1 in 4.18E+08 at LOC. The probability at the RQ indicated a high probability of risk. The probabilities ranged from ~1 in 27.3 to ~1 in 5.25E+26. Therefore, based on the refined probit analysis, direct effects to aquatic-phase CTS (all 3 DPSs) are likely for all uses resulting in an LAA determination from mancozeb complex exposures.
		Terrestrial-phase CTS (Juveniles and Adults): *Direct Deposition on Forage Items: Avian RQ* - - Chronic RQs for the small birds (used as a surrogate for the terrestrial-phase CTS) exceed the Agency LOC for all 10 crop exposure scenarios. Chronic RQs range from 5.53 for ornamental use to 105.73 for turf use. *Direct Deposition on Forage Items: Refined Herpetofauna Modeling* - Refined modeling was performed with chronic dietary-based toxicity values. Chronic RQs ranged from 5.55 to 96.67 for the CTS consuming small mammals. *Likelihood of Individual Mortality* The chance of individual effects (*i.e.*, mortality) for birds (surrogate for terrestrial -phase CTS) and herpetofauna based on direct deposition onto food items is as high as ~1 in 1.
		Temporal and Spatial Overlap for both Aquatic and Terrestrial Phase CTS There is spatial overlap between areas of potential pesticide application and all three distinct populations of the CTS occurrence/critical habitat based on the use patterns of mancozeb and the location of the CTS.
		POTENTIAL FOR INDIRECT EFFECTS
		CTS Aquatic Prey Items, Aquatic Habitat, Cover and/or Primary Productivity *Freshwater fish and aquatic-phase amphibians*: - Acute RQs exceed the listed species acute LOCs and there is a high likelihood of individual mortality (see above for direct effects to freshwater fish).

Species	Effects Determination	Basis for Determination
		.Freshwater Invertebrates-Water Column*:** -Acute RQs for freshwater invertebrates exceed the listed species LOC for cereal grains, corn (field), corn (sweet/Pop), cucurbits, forestry, garlic, ornamentals (nursery), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweet sop) turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farm), turf/ sod farms, and Christmas tree plantations mancozeb uses. Acute RQs ranged from 0.03for ornamentals (residential) to 0.32 for turf (sod farms). -Chronic RQs exceed the chronic LOC for cereal grains, corn (field), corn (sweet/Pop), cucurbits, forestry, garlic, ginseng, onion, ornamentals (nursery, pachysandra, residential turf), papayas, potatoes, turf (commercial/industrial/recreational area lawns, golf course and ornamental sod farm), turf/ sod farms, and Christmas tree plantations mancozeb uses. RQs ranged from 0.05for tropical fruit to 12.98 for turf (sod farms). <u>*Likelihood of Individual Mortality*</u> -The chance of individual effects (*i.e*., mortality) for freshwater invertebrates is as high as ~1 in 66.1. The probabilities range from ~1 in 2.79E+29 to ~1 in 66.1. ***Freshwater Invertebrates-Benthic*:** -The only use resulting in an endangered species LOC exceedence was for turf/sod farms. The acute RQ for freshwater invertebrates exceeded the listed species for turf/ sod farms mancozeb uses, with an acute RQ=0.05. Turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms) use had the next highest RQ, (acute RQ=0.02). <u>*Likelihood of Individual Mortality*</u> -The chance of individual effects (*i.e*., mortality) for benthic invertebrates is ~1 in 4.18E+08 at the LOC as well for the turf (sod farm) RQ. ***Freshwater Plants Due to the absence of toxicity studies for vascular plants, the algal data will be used as a surrogate to represent indirect effects for both vascular and nonvascular aquatic plants. RQs for freshwater plants exceed the listed species LOC for asparagus, cereal grains, corn (field), corn (sweet/Pop), cucurbits, fennel, forestry, garlic, ginseng, grapes, ornamentals (nursery, pachysandra and residential turf), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweet sop), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms), turf/ sod farms, and Christmas tree plantations mancozeb uses. (RQs ranged from 0.13 to 13.87)
		CTS Terrestrial Prey Items, Riparian Habitat <u>*Terrestrial-phase Amphibians*</u>: - Exceedence of acute endangered species LOCs for terrestrial-phase amphibians as described above for CTS (see **"***Potential Direct Effects; Terrestrial Phase CTS [juveniles and adults])*" <u>*Terrestrial Invertebrates*</u>: - There is potential concern for bees representing terrestrial invertebrates based on the uncertainty due to the nondefinitive endpoint from the toxicity study.

Species	Effects Determination	Basis for Determination
		The bee toxicity study reported an LD50>179µg a.i./bee. For small insects, the EECs for all uses are above the reported LD50 value. For large insects, the turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms) use EEC is the EEC above the LD50 value. In addition, a 7 day toxicity study on the mite resulted in a residual toxicity LR50=0.1 lbs/A. The LR50 value is below application rates for all uses. The study also reported an adverse reproductive effect with an endpoint of eggs laid per female. The 14 day LOAEC= 0.02 lbs/a.i./A. Use rate ranges from ornamentals (1.2 lbs/A) to turf (19.1 lbs/A) *Small Mammals: Direct Deposition on Forage Items* - Chronic diet-based RQs for small mammals foraging on food items receiving direct deposition of applied mancozeb complex exceed the chronic LOC for mammals in all of the 10 crop scenarios modeled. RQs range from 0.36for ornamental use to 110.14 for turf use. *Small Mammals: Reduction in Burrows* -Based on chronic RQ exceedence of the LOC for all 10 crop scenarios indicating a potential reduction in mammals, there is the potential for fewer mammal burrows. Therefore, there is also an LAA for mancozeb complex indirect effects. ***Terrestrial Plants*** The highest tested mancozeb concentration for the terrestrial plant toxicity studies was 1.38 lbs a.i./A. The highest application rate for mancozeb is 19.1 lbs/A. For seedling emergence, soybean and tomato are the most sensitive dicots with 4% plant dry weight inhibition; onion is the most sensitive monocot with 12% dry weight inhibition when compared to controls at the application rate of 1.38 and 0.02 lb a.i. /A for mancozeb and dimethomorph, respectively. For vegetative vigor, tomato is the most sensitive dicot with a 6% plant dry weight inhibition; corn and onion are the most sensitive monocots with 2% plant dry weight inhibition when compared to the controls at the application rate. *Plant Incidents* Five mancozeb plant incidents were reported in the United States from the Ecological Incident Information System (EIIS)[13]. Four of the five reported incidents involved the application of mancozeb mixed with other pesticides. All four of those reported incidents were classified as possible using the certainty index. The fifth incident reported an application of mancozeb and resulted in a probable classification using the certainty index. Therefore, there is an LAA based on the uncertainty due to the highest tested concentration in the toxicity test and reported plant incidents.

[13] http://www.epa.gov/oppefed1/general/databasesdescription.htm#eiis)

Table 7-2 Effects determination summary for critical habitat impact analysis.

Assessment Endpoint	Effects Determination	Basis for Determination
Aquatic Phase PCEs (Aquatic Breeding Habitat)		
Standing bodies of fresh water, including natural and man-made (e.g., stock) ponds, vernal pools, dune pools and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (i.e., 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle. FR Vol 69 No. 226 CTS, 68584, 2004	*Vascular Plants* **Habitat Modification**	Due to the absence of toxicity studies for vascular plants, the algal data is used as a surrogate to represent indirect effects for both vascular and nonvascular aquatic plants.
	Non-vascular Plants **Habitat Modification** <u>Mancozeb uses</u> Asparagus, cereal grains, corn (field and sweet/Pop), cucurbits, fennel, forestry, garlic, ginseng, grapes (wine), ornamentals (nursery, pachysandra, residential), papayas, tropical fruits (Atemoya, cherimoya, custard apple, sugar apple and sweet sop), turf (commercial/industrial/recreational area lawns, golf courses and ornamental sod farms), turf (sod farms) and christmas tree plantations	Using aquatic plant toxicity data (EC50) the RQ exceeds the listed species LOC of 1.0. RQs ranged from 0.13 for ornamentals (residential) to 13.87 for sod farms.
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend on for food, shelter and protection from the elements and predation.	**Habitat Modification** <u>Mancozeb use</u> All non-seed and dip uses	Chronic RQs for mammals exceed the chronic LOC = 1 for all non-seed uses. RQs range from 0.36 to 100.33.
Upland areas between breeding locations (PCE 1) and areas with small mammal burrow (PCE 2) that allow for dispersal among sites.	*Terrestrial plant (protection from predators)* **Habitat Modification** All mancozeb nonseed or dip uses	Although a toxicity study was submitted evaluating the effect of mancozeb on terrestrial plants, the highest tested rate (1.38 lbs a.i./A) was below the highest application rate for turf (19.1 lbs/A). *<u>Plant Incidents</u>* The five reported plant incidents for mancozeb are described in Table 1-

Assessment Endpoint	Effects Determination	Basis for Determination
		1. Therefore, there is a habitat modification determination for upland areas based on the uncertainty due to the highest tested concentration in the toxicity test and reported plant incidents.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated to seek concurrence with the LAA determinations and to determine whether there are reasonable and prudent alternatives and/or measures to reduce and/or eliminate potential incidental take.

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

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

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

8. References

A bibliography of ECOTOX references is presented in **Appendix M**, identified by the letter E followed by a number.

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