Risks of Simazine Use to Federally Threatened Delta Smelt

(*Hypomesus transpacificus*)

Pesticide Effects Determinations
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Primary Authors:
Donna R. Judkins, Ph.D., Biologist
James K. Wolf, Ph.D., Environmental Scientist

Secondary Review:
Pamela Hurley, Ph.D., Senior Toxicologist

Branch Chief, Environmental Risk Assessment Branch 3
Dana Spatz

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List of Commonly Used Abbreviations and Nomenclature

µg/kg	Symbol for "micrograms per kilogram"
µg/L	Symbol for "micrograms per liter"
ºC	Symbol for "degrees Celsius"
AAPCO	Association of American Pesticide Control Officials
a.i.	Active Ingredient
AIMS	Avian Monitoring Information System
Acc#	Accession Number
amu	Atomic Mass Unit
BCB	Bay Checkerspot Butterfly
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
CAW	California Alameda Whipsnake
CBD	Center for Biological Diversity
CCR	California Clapper Rail
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CFWS	California Freshwater Shrimp
CI	Confidence Interval
CL	Confidence Limit
CTS	California Tiger Salamander
DS	Delta Smelt
EC	Emulsifiable Concentrate
EC_{05}	5% Effect Concentration
EC_{25}	25% Effect Concentration
EC_{50}	50% (or Median) Effect Concentration
ECOTOX	EPA managed database of Ecotoxicology data
EEC	Estimated Environmental Concentration
EFED	Environmental Fate and Effects Division
e.g.	Latin *exempli gratia* ("for example")
EIM	Environmental Information Management System

EPI	Estimation Programs Interface
ESU	Evolutionarily significant unit
et al.	Latin *et alii* (“and others”)
etc.	Latin *et cetera* (“and the rest” or “and so forth”)
EXAMS	Exposure Analysis Modeling System
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FQPA	Food Quality Protection Act
ft	Feet
GENEEC	Generic Estimated Exposure Concentration model
HPLC	High Pressure Liquid Chromatography
IC_{05}	5% Inhibition Concentration
IC_{50}	50% (or median) Inhibition Concentration
i.e.	Latin for *id est* (“that is”)
IECV1.1	Individual Effect Chance Model Version 1.1
KABAM	$\underline{K}_{OW}$ (based) Aquatic BioAccumulation Model
kg	Kilogram(s)
kJ/mole	Kilojoules per mole
km	Kilometer(s)
K_{AW}	Air-water Partition Coefficient
Kd	Solid-water Distribution Coefficient
KF	Freundlich Solid-Water Distribution Coefficient
K_{OC}	Organic-carbon Partition Coefficient
K_{OW}	Octanol–water Partition Coefficient
LAA	Likely to Adversely Affect
lb a.i./A	Pound(s) of active ingredient per acre
LC_{50}	50% (or Median) Lethal Concentration
LD_{50}	50% (or Median) Lethal Dose
LOAEC	Lowest Observable Adverse Effect Concentration
LOAEL	Lowest Observable Adverse Effect Level
LOC	Level of Concern
LOD	Level of Detection
LOEC	Lowest Observable Effect Concentration
LOQ	Level of Quantitation
m	Meter(s)
MA	May Affect
MATC	Maximum Acceptable Toxicant Concentration

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

SFGS	San Francisco Garter Snake
SJKF	San Joaquine Kit Fox
SLN	Special Local Need
SMHM	Salt Marsh Harvest Mouse
TG	Tidewater Goby
T-HERPS	Terrestrial Herpetofaunal Exposure Residue Program Simulation
T-REX	Terrestrial Residue Exposure Model
UCL	Upper Confidence Limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VELB`	Valley Elderberry Longhorn Beetle
WP	Wettable Powder
wt	Weight

1. Executive Summary

1.1. Purpose of Assessment

The purpose of this assessment is to evaluate potential direct and indirect effects on the Delta smelt (*Hypomesus transpacificus,* DS) arising from FIFRA regulatory actions regarding use of simazine on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitat for the Delta smelt. 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 Norther District of California in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

The DS was listed as threatened on March 5, 1993 (58 FR 12854) by the USFWS (USFWS, 2007a). DS are mainly found in the Suisun Bay and the Sacramento-San Joaquin estuary near San Francisco Bay. During spawning DS move into freshwater.

1.2. Scope of Assessment

1.2.1. Uses Assessed

Simazine is a triazine herbicide widely used as a selective herbicide to control most annual grasses and broadleaf weeds (before they emerge or after removal of weed growth). Simazine is registered for pre-plant use or use in established fields of a variety of food and feed crops including fruit and nut crops such as apples, oranges, and almonds, in addition to corn. Simazine can also be applied on Christmas trees and on turfgrass grown commercially for sod. Nonagricultural uses for simazine include nonselective weed control in industrial sites, highway medians and shoulders, railroad rights-of-way, lumberyards, petroleum tank farms, and in noncrop areas on farms, such as around buildings, equipment and fuel storage areas, along fences, road-sides, and lanes. Simazine is also registered for residential use on turfgrass including both commercial use on recreational lawns such as golf courses and commercial or homeowner use on home lawns. There is an additional registration for simazine as an algaecide in ornamental ponds and aquariums of 1,000 gallons or less. Given that this use is limited to ponds of 1,000 gallons or less, the Agency believes that this use would pose minimal impact on the environment because labels include the following statement: "Do not apply or allow discharge to lakes, flowing water, or ponds with outflow," "Do not contaminate domestic livestock or irrigation water supply," and "Water treated with this product should not be used as a source of drinking water." Simazine can be applied as a liquid via ground sprayer, banded application, or aerial broadcast, or as granular formulation.

1.2.2. Environmental Fate Properties of Simazine

The environmental fate properties of simazine along with available monitoring data identifying its presence in surface water, air, and in precipitation in California indicate that runoff, spray drift, volatilization, atmospheric transport and subsequent deposition represent potential transport mechanisms of simazine to the aquatic habitats of the DS. In this assessment, transport of simazine from initial application sites through runoff and spray drift are considered in deriving quantitative estimates of simazine exposure to DS, its prey and its habitats. Although volatilization of simazine from treated areas resulting in atmospheric transport and eventual deposition represent relevant transport pathways leading to exposure of the DS and its habitats, it is expected that detected simazine concentrations in atmospheric monitoring data are reflective of near field spray drift and not long range transport, given simazine's low volatility and a lack of detections at higher elevations. In addition, adequate tools are not available at this time to quantify exposures through these pathways. Therefore, volatilization, and potential atmospheric transport are discussed only qualitatively in this assessment.

1.2.3. Evaluation of Degradates and Stressors of Concern

Simazine major degradates are deisopropylatrazine (DIA) and diaminochloroatrazine (DACT). Comparison of available toxicity information for DIA and DACT show lower toxicity than the parent for freshwater fish, invertebrates, and aquatic plants. Available fate data also show that DIA does not form or persist in the environment to a substantial level. Degradate toxicity data are not available for terrestrial plants. Since the toxic mode of action is thought to be similar for aquatic and terrestrial plants, toxicity from degradates is expected to be similar.

1.3. Assessment Procedures

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

1.3.1. Exposure Assessment

1.3.1.a. Aquatic Exposures

Tier-II aquatic exposure models are used to estimate high-end exposures of simazine in aquatic habitats resulting from runoff and spray drift from different uses. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). AgDRIFT and AGDISP model may be used to refine the estimated deposition of simazine on aquatic habitats from spray drift. EFED's default spray drift fractions were used for estimates of aquatic exposure. Peak model-estimated environmental concentrations resulting from different simazine uses range from 5.6 to 130.2 µg/L. These estimates are supplemented with analysis of available California surface water monitoring data from U. S. Geological Survey's National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation. The maximum concentration of simazine reported by NAWQA from 2000-2005 for California surface waters with agricultural watersheds is 64.5 µg/L. This value is approximately two times less than the maximum model-estimated environmental concentration, but is within the range of environmental concentrations estimated for different uses. The maximum concentration of simazine reported by the California Department of Pesticide Regulation surface water database from 2000-2005 (36.1 µg/L) is roughly 3.5 times lower and the NAWQA data from 2000-2005 (64.5 µg/L) is about 2 times lower than the highest peak model-estimated environmental concentration.

1.3.1.b. Terrestrial Exposures

Terrestrial plants are an important component in all four PCEs of DS critical habitat, particulary for providing shade, and thus, temperature control, and in mitigating runoff and sedimentation, which also affects water quality. The AgDRIFT (and sometimes, AGDISP) model is used to estimate deposition of simazine on terrestrial habitats from spray drift. The TerrPlant model is used to estimate simazine exposures to plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar and granular simazine applications

1.3.2. Toxicity Assessment

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

Section 4 summarizes the ecotoxicity data available on simazine. Simazine is moderately to highly toxic to freshwater and estuarine/marine fish and invertebrates on an acute exposure basis and very highly toxic to aquatic and terrestrial plants.

1.3.3. Measures of Risk

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

1.4. Summary of Conclusions

Based on the best available information, the Agency makes a **Likely to Adversely Affect** determination for the DS from the use of simazine. Additionally, the Agency has determined that there **is** the potential for modification of designated critical habitat for the DS from the use of simazine. This is based on effects to DS food source and critical habitat components. A summary of the risk conclusions and effects determinations for the DS and their designated critical habitat is presented in **Table 1.1** and **Table 1.2**. Use-specific determinations are provided in **Table 1.3**. Further information on the results of the effects determination is included as part of the Risk Description in **Section 5.2**. Given the LAA determination for the DS and potential modification of designated critical habitat for DS, a description of the baseline status and cumulative effects for the DS is provided in **Attachment 3**.

Table 1.1. Effects Determination Summary for Effects of Simazine on the Delta Smelt

Species	Effects Determination	Basis for Determination
Delta smelt (*Hypomesus transpacificus*)	**LAA[1]**	**Potential for Direct Effects**
		Freshwater Life Stages (Eggs, Larvae, and Breeding Adults): No acute or chronic LOCs are exceeded for fish..
		Saltwater Life Stage (Juveniles and Adults): No acute or chronic LOCs were exceeded for fish
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity The acute and chronic LOCs for aquatic invertebrates are exceeded for uses on Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. There is overlap of the delta smelt habitat with these uses. The LOC for aquatic nonvascular plants is exceeded for uses on Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular uses on berries and non-bearing fruit. There is overlap of the delta smelt habitat with these uses. The LOC for aquatic vascular plants is not exceeded for any uses. Field study and incident data support a scenario of indirect effects to the DS through aquatic plant kills resulting in low dissolved oxygen from plant decomposition, and possibly through lowered food supply.
		Riparian habitat Riparian vegetation may be affected because terrestrial plant RQs are above the terrestrial plant LOC for all uses. There is overlap of delta smelt habitat with these uses. Risk to plants is limited to grassy, herbaceous, riparian vegetation (woody plants are not sensitive to simazine); therefore, impacts to flow (runoff) and sedimentation are the most likely effects.

[1]LAA=likely to adversely affect.

Table 1.2. Effects Determination Summary for the Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination	Basis for Determination
Modification of aquatic PCEs	**HM**[1]	As summarized in **Table 1.1**, simazine may affect sensitive freshwater invertebrates that are food to the DS; and as such, part of their critical habitat. This applies to liquid simazine uses on: Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. Simazine may affect sensitive saltwater invertebrates that are food to the DS, and as such, part of their critical habitat. Invertebrates that inhabit isohaline (2 ppt) estuarine habitat are especially important and both freshwater and saltwater invertebrate data are used to estimate risk.. The aquatic plant LOC is exceeded for non-vascular plants. Non-vascular plants are the chief food source for DS larvae and so this is especially important for areas used by the DS as spawning grounds and rearing habitat. This applies to liquid simazine uses on: Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. Water quality can also be compromised due to low dissolved oxygen resulting from plant mortality and decomposition. The LOC for terrestrial plants is exceeded for all simazine uses. Riparian plants are a component of all four PCEs for the DS. Alterations in riparian vegetation can affect runoff/flow, water quality and sedimentation. Risk to plants is limited to grassy, herbaceous, riparian vegetation. Woody plants are not sensitive to simazine; therefore, temperature and shading impacts are unlikely

[1]**Habitat Modification**

Table 1.3. Simazine Use-specific Risk Summary for Delta smelt

Uses	Potential for Effects to Identified Taxa Found in the Aquatic Environment							
	AquaticVertebrates (Direct Effect to DS)		Aquatic Invertebrates (Indirect Effect to DS/Food)		Aquatic Plants (Indirect Effect to DS/ Food and Habitat)		Terrestrial Plants (Indirect Effect to DS/ Habitat)	
	Acute	Chronic	Acute	Chronic	Vascular	Non-vascular	Monocots	Dicots
Christmas trees	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Berries	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Tree plantations	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Tree nurseries	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Non-cropland	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Non-bearing fruit	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Avocados	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Olives	No	No	No	No	No	No	**Yes**	**Yes**
Nuts (high rate)	No	No	No	No	No	No	**Yes**	**Yes**
Grapes	No	No	No	No	No	No	**Yes**	**Yes**
Nuts (low rate)	No	No	No	No	No	No	**Yes**	**Yes**
Corn	No	No	No	No	No	No	**Yes**	**Yes**
Shelterbelts	No	No	No	No	No	No	**Yes**	**Yes**
Fruit (low and high rates)	No	No	No	No	No	No	**Yes**	**Yes**
Citrus	No	No	No	No	No	No	**Yes**	**Yes**
Turf (residential, recreational, and sod farm)	No	No	No	No	No	No	**Yes**	**Yes**

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

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (*i.e.*, food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift 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 Delta smelt 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 federally threatened Delta smelt (*Hypomesus transpacificus*, DS) arising from FIFRA regulatory actions regarding use of simazine on agricultural and non-agricultural sites. In addition, this assessment evaluates whether use on these sites is expected to result in modification of the species' designated critical habitat. This ecological risk assessment has been prepared) consistent with a stipulated injunction ordered by the Federal District Court for the Norther District of California in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS).

The DS was listed as threatened on March 5, 1993 (58 FR 12854) by the USFWS (USFWS, 2007a). DS are mainly found in the Suisun Bay and the Sacramento-San Joaquin estuary near San Francisco Bay. During spawning DS move into freshwater.

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 simazine 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 simazine 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 DS 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 in the lawsuits regarding the potential use of simazine 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. Descriptions of the routine procedures for evaluating risk to the San Francisco Bay Species are 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 simazine in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment.

Currently registered non-agricultural uses of simazine in California include dormant fruit, tree plantations and nurseries, shelterbelts, Christmas trees, turf (residential, recreational, and sod farm), and non-cropland areas defined as industrial sites, highway medians, rights-of-way, lumberyards, tank farms, fuel storage areas, and fence lines. Agricultural uses include fruit and nut crops such as apples, oranges, grapes, berries, peaches, nectarines, avocados, olives, almonds, macadamia nuts, and walnuts in addition to corn.

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

2.2.1. Evaluation of Degradates

Degradates of simazine include deisopropyl-atrazine (DIA), diamino-chlorotriazine (DACT), and hydroxysimazine (HS). Comparison of available toxicity information for degradates of simazine indicates lesser toxicity than the parent for fish, aquatic invertebrates, and aquatic plants. Acute toxicity values for DIA are approximately 2.6-fold less sensitive than acute toxicity values for simazine in freshwater fish. In addition, no adverse effects were observed in fish and daphnids for DACT and in daphnids for DIA at the limit of simazine's solubility. Available aquatic plant degradate toxicity data for DIA and DACT report EC_{50} values at concentrations that are at least 69 times higher than the lowest reported aquatic plant EC_{50} value for parent simazine. Although toxicity information is not available for hydroxysimazine, this degradate is also likely to be less toxic than parent simazine, given that the more toxic chloro group is replaced by a less toxic hydroxyl group during its formation. Degradate toxicity data are also not available for terrestrial plants; however, lesser toxicity is assumed, given the available ecotoxicological information for other taxonomic groups including aquatic plants, where the toxic mode of action is similar, and the likelihood that degradates may lose efficacy as an herbicide. Although other taxonomic groups appear to be more sensitive to simazine than its degradates, acute oral toxicity data for mammals indicates that DIA is more toxic than parent simazine, with a corresponding LD_{50} value of 1,240 mg/kg-bw, as compared to > 5,000 mg/kg-bw for simazine.

Given the lesser aquatic toxicity of degradates, as compared to the parent, concentrations of the simazine degradates are not assessed for direct and/or indirect effects to the DS. Although the degradate toxicity data indicates that DIA is more toxic to mammals than parent simazine, the available fate data show that DIA does not form and persist in the environment at any substantial level. Additional details on available simazine degradate toxicity are included in **Section 4**.

2.2.2. Evaluation of Mixtures

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

Simazine has registered products that contain multiple active ingredients. Analysis of the available open literature for multiple active ingredient products relative to the single active ingredient is provided in **Appendix A**. The results of this analysis show that an assessment based on the toxicity of the single active ingredient of simazine is appropriate. Other triazine herbicides may combine with simazine to produce additive toxic effects on aquatic plants. The variety of chemical interactions presented in the available data set suggest that the toxic effect of simazine, in combination with other pesticides used in the environment, can be a function of many factors including but not necessarily limited to: (1) the exposed species, (2) the co-contaminants in the mixture, (3) the ratio of simazine and co-contaminant concentrations, (4) differences in the pattern and duration of exposure among contaminants, and (5) the differential effects of other physical/chemical characteristics of the receiving waters (*e.g.* organic matter present in sediment and suspended water). Quantitatively predicting the combined effects of all these variables on mixture toxicity to any given taxa with confidence is beyond the capabilities of the available data. However, a qualitative discussion of implications of the available pesticide mixture effects data involving simazine on the confidence of risk assessment conclusions for the DS is addressed as part of the uncertainty analysis for this effects determination.

2.3. Previous Assessments

An Interim Reregistration Eligibility Decision (IRED)[1] for simazine was completed on March 3, 2005 and a Reregistration Eligibility Decision (RED) on April 6, 2006 (U.S. EPA, 2006)[2]. The results of the Agency's ecological risk assessment for simazine suggest the potential for adverse acute effects to non-target terrestrial and aquatic plants, and direct chronic effects to birds and mammals. In addition, a number of the granular uses resulted in potential direct adverse effects to freshwater invertebrates and fish, although there was a high degree of uncertainty associated with the freshwater fish data set because exposure concentrations were not verified in the available acute toxicity tests.

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[1] http://www.epa.gov/pesticides/reregistration/simazine/
[2] http://www.epa.gov/oppsrrd1/reregistration/REDs/simazine_red.pdf

The Agency has completed effects determinations for the Barton Springs salamander for simazine (U.S. EPA, 2007a)[3] as part of the settlement for the court case *Center for Biological Diversity and Save Our Springs Alliance v. Leavitt, No. 1:04CV00126-CKK* (filed January 26, 2004). The results of this endangered species risk assessment concluded that simazine has no effect on the Barton Springs salamander by direct toxic effects and/or indirect effects resulting from effects to aquatic invertebrates and plants.

The Agency also completed effects determinations for the California red-legged frog (CRLF) for simazine[4] in 2007, as part of the settlement agreement in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)), settlement entered in Federal District Court for the Northern District of California on October 20, 2006. This assessment concluded that simazine is Likely to Adversely Affect, "LAA" the aquatic-phase CRLF, based on indirect effects from a reduction in algal food items for the tadpole, and on aquatic non-vascular plants and sensitive herbaceous terrestrial plants that comprise its habitat (sedimentation and runoff control). For the terrestrial-phase CRLF, an "LAA" determination was also concluded for chronic direct effects and indirect effects from a reduction in mammals and terrestrial-phase frogs as food items, and herbaceous terrestrial plants as habitat. Modification of critical habitat was also determined for both aquatic and terrestrial primary constituent elements (PCEs).

The outcomes of ecoassessments for the frog and salamander were very different, mostly due to their respective action areas. The Barton Springs salamander has a much more limited area and agriculture happens to be very low (only one orchard) in their action area. Another important difference is that the salamander relies much more heavily on sub-surface water while the CRLF is more affected by surface water. Toxicity of simazine to the two organisms was assumed to be very similar, but exposure very different.

2.4. Environmental Fate Properties

Simazine is moderately soluble in water at 20°C with a solubility of 3.5 mg/L. Based on laboratory studies, simazine could persist for several months ($t_{1/2}$ = 91 days; aerobic soil metabolism) in the environment and maybe for years in oxygen deprived aquatic systems ($t_{1/2}$ = 664 days; anaerobic aquatic metabolism), as it is not easily degraded by soil microbial organisms. If released on soil surface and under direct sunlight, it will undergo relatively faster degradation ($t_{½} \approx 22$ days). Simazine is also quite resistant to aqueous abiotic reactions (stable to hydrolysis at pH 5, 7, and 9 and to photolysis in buffered solution at pH 7), thus increasing its likelihood to runoff and contaminate surface water. However, it must be noted that a supplemental aqueous photolysis study showed simazine degrading with a half-life of 16 hours in the presence of acetone as a sensitizer.

Laboratory adsorption data show low water/soil partitioning for simazine. The Freundlich $K_{d\text{-}ads}$ constants for the adsorption phase were below 5 for all soils tested. Organic matter (OM) seems to affect the sorption efficiency of simazine as the adsorption coefficient was shown to be strongest in a high organic matter clay soil ($K_{d\text{-}ads}$ 4.31, OM 4.8%) and weakest in a low organic matter loam soil ($K_{d\text{-}ads}$ 0.48, OM 0.8%). These data indicate that simazine is highly mobile, thus

[3] http://www.epa.gov/espp/litstatus/effects/simazine/effects-determ.pdf
[4] http://www.epa.gov/espp/litstatus/effects/redleg-frog/simazine/determination.pdf

having strong potential to leach to ground water systems, especially in OM poor soil systems, such as loam and sand soils.

Based on its low vapor pressure (6.1 x 10^{-9} mm Hg at 20°C) and Henry's Law Constant (3.2 x 10^{-10} atm·m^3/mol at 25°C), volatilization loss of simazine from soil and water systems is expected to be insignificant compared to dissipation by chemical degradation and metabolism. Based on laboratory bioaccumulation in rainbow trout, simazine is not expected to bioaccumulate in fish, which is in concurrence with simazine's low K_{ow} value of 122. The BCF in all tissue tested ranged from 0.9 (viscera) to 2.3 (muscle). Elimination of accumulated residues by day 28 of depuration was 52% in viscera and 98% in muscle.

Based on its persistence and mobility, as demonstrated by the laboratory data, simazine is expected to reach surface water via transport from soil surfaces during runoff events and ground water via vertical movement through soil (leaching). Aside from monitoring data, terrestrial field and aquatic dissipation studies were also submitted for simazine. Unfortunately, most of the terrestrial field studies did not follow the Subdivision N Guidelines and were deemed not acceptable to provide information on the behavior of simazine under actual terrestrial field conditions. Two supplemental studies, however, indicated that simazine could persist in the fields for over one month to several years depending on soil texture and soil temperature. In addition, a non-guideline study on simazine persistence in soil as a function of temperature and soil moisture (MRID 00027881) also indicated that although decreasing soil moisture slows simazine's metabolism rate in soil, soil temperature exerted the greatest influence in the breakdown of simazine by microbes: a decrease in soil temperature from 25 to 15^{o}C (with other factors remaining constant) could increase simazine's half-life by up to 250 to 300%. As for aquatic field studies, dissipation of simazine is variable, with half lives ranging from 12 days in swimming pool water, to 53 days in surface water man-made ponds, and up to 700 days in a lake in Missouri. The fast degradation of simazine in the swimming pool water study could be attributed partially to photodegradation, which was seen in laboratory studies to accelerate in the presence of photosensitizers or chemical species (such as hydroxyl radicals) capable of inducing photoreactions.

There are three types of degradates/metabolites for simazine. The first type of degradate is formed via dealkylation of the amino groups, for which mono- and fully dealkylated degradates are known (G-28279 or DIA and G-28273 or DACT). The second type is formed by substitution of the chloro group by a hydroxyl group (G-30414 or hyrdroxysimazine, HA). The third type is formed by substitution of the chloro group by a hydroxyl group together with partial or complete dealkylation (GS-17791 and GS-17792). From limited laboratory data, the relative concentrations of the degradates in soil were generally DIA>DACT~Hydroxysimazine, except for one aerobic soil metabolism study and one aerobic aquatic metabolism study, where the concentration of hydroxysimazine was higher than that of DIA towards the end of the studies. The highest detected concentration of DIA in the laboratory studies was approximately 10% of total applied radioactivity (aerobic soil metabolism study) and less than 5% on soil surfaces of two supplemental terrestrial field studies, which indicates that DIA, and subsequently DACT and hydroxysimazine, may not form and persist in the environment at any substantial levels.

Like parent simazine, the dealkylated degradates are very mobile in the sand soil and the loam soil, as shown by their low (<2) adsorption coefficients (K_{ads}). Mobility for these dealkylated degradates, however, appears to decrease in soil with higher clay content (K_{ads} in clay soil range from 1.56 to 4.3). Therefore, although laboratory studies indicate that the dealkylated degradates are as likely (or even more likely) to leach to ground water as parent simazine, as with simazine, soil characteristics must be taken into account when assessing the leaching potential of these degradates in a specific region. Hydroxysimazine, on the other hand, shows the strongest adsorption to soil, with K_{ads} values of 8 in sand to 480 in clay soil, thus possessing lower leaching potential than its parent. Acceptable field dissipation studies are not currently available to confirm the laboratory findings on the mobility of these degradates.

In summary, simazine is somewhat persistent and mobile in soils and has the potential to reach surface water and ground water via run off and leaching, respectively. When present in ground water and in surface water, simazine will further persist, especially in systems with relatively long hydrologic residence times (such as in some reservoirs), mostly due to its resistance to abiotic hydrolysis and to direct aqueous photolysis, its susceptibility to biodegradation, and its limited volatilization potential. For simazine degradates such as DIA and DACT, laboratory and field studies indicate that their concentrations in the environment are likely to be insignificant compared to parent simazine.

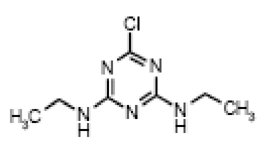
The relatively low soil/water partitioning of simazine and its chloro degradates indicates that the concentrations of the degradates in/on suspended and bottom sediment in equilibrium with the water column will be somewhat comparable to their parent. In contrast, hydroxysimazine concentration would be much higher. **Table 2.1** lists the environmental fate properties of simazine, along with the major and minor degradates detected in the submitted environmental fate and transport studies. Structures of simazine and its principal degradates are included in **Figure 2.1**.

Table 2.1 Summary of Simazine Environmental Fate Properties

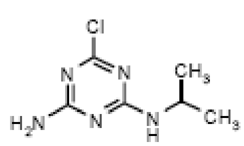
Study	Half-lives, Days	Major Degradates *Minor Degradates*	MRID #	Study Status
Hydrolysis	stable at pH 4, 7 , and 9 @ 20C	none	00027856	Acceptable
Direct Aqueous Photolysis	stable (t ½ >30 days - duration of study) in sterile, unbuffered water irradiated with a mercury vapor lamp. t ½ ~ 16 hrs in sterile, unbuffered 1% aqueous acetone solution irradiated with artificial light stable (t ½ ~ 382 days) in sterile buffered solution, irradiated with xenon lamp	G-28273 (max 11% TAT at study end) G-28279 (max 82 % after 98 hr) *G-28273, G-30414 and GS-17792* none	00143171 42503708	Supplemental Acceptable
Soil Photolysis	22 days (corrected for dark control, 12-hr irradiation)	none *G-30414, G-28279, G-28273, and GS-17792.*	40614410	Supplemental/ Unacceptable

Study	Half-lives, Days	Major Degradates *Minor Degradates*	MRID #	Study Status
Aerobic Soil Metabolism	110 days (silt loam) 91 days (sandy loam)	G-28279 (max 10% at day 60) *G-30414, G-28273, GS-17792, G-28516, GS-17791, and CO_2* GS-30414 (max 62% at study end) *GS-17792 and GS-28279*	00158638 43004501	Supplemental Supplemental
Anaerobic Soil Metabolism	56 days (sandy loam)	none *G-28279, G-30414, G-28273, and GS-17792*	00027857	Supplemental
Anaerobic Aquatic Metabolism	664 days (sandy clay)	none *G-30414, G-28279, and G-28273*	40614411	Acceptable
Aerobic Aquatic Metabolism	61 (sediment), 109 (water), and 71 days (total system)	G-30414 (max 12% day 30) *G-28279, G-30044, and G-31709*	43004502	Acceptable
$K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g) $K_{oc\text{-}ads}$ / $K_{oc\text{-}des}$ (mL/g)	4.3/9.3 (clay), 0.7/2.3 (sand), 1.3/6.2 (sandy loam), and 0.5/0.8 (loam) 153 / 331 (clay), 123/426 (sand), 114/555 (sandy loam), and 103/167(loam)	NA	41442903 41257903	Acceptable
Aquatic Field Dissipation	60 to 700 days in lakes 12 days in GA swimming pool water 53 days in IA man-made pond water	G-28279 G-28279 and G-30414 G-28279 and G-30414	00027829 40614420 40614422	Supplemental Supplemental Supplemental

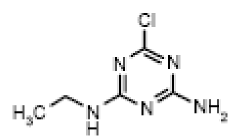
G-28279 = DIA/CEAT; G-28273 = DACT; G-30414 = Hydroxysimazine



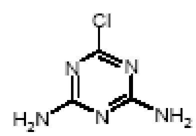
simazine



Desethyl-s-atrazine (DEA)



Desisiporpyl-s-atrazine (DIA)



Diaminochlorotriazine (DACT)

Figure 2.1 Simazine and Degradate Structures

2.4.1. Environmental Transport Mechanisms

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

A number of studies have documented atmospheric transport and re-deposition of pesticides from the Central Valley to the Sierra Nevada Mountains (Fellers *et al.*, 2004; LeNoir *et al.*, 1999; McConnell *et al.*, 1998; Sparling *et al.*, 2001). Prevailing winds blow across the Central Valley eastward to the Sierra Nevada Mountains, transporting airborne industrial and agricultural pollutants into the Sierra Nevada ecosystems (Fellers *et al.*, 2004; LeNoir *et al.*, 1999) (McConnell *et al.*, 1998). Several sections of the range and critical habitat for the DS are located east of the Central Valley. The magnitude of transport via secondary drift depends on the simazine'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 simazine that describe its potential to enter the air from water or soil (*e.g.,* Henry's Law constant and vapor pressure), pesticide use data, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevadas are considered in evaluating the potential for atmospheric transport of simazine to locations where it could impact the DS.

In general, deposition of drifting or volatilized pesticides is expected to be greatest close to the site of application. Computer models of spray drift (AgDRIFT and AgDISP) may be used to determine potential exposures to aquatic and terrestrial organisms. Vegetative vigor toxicity studies show that simazine is equally toxic to monocot and dicot terrestrial plants, thus the distance of potential impact away from the use sites (action area) is determined by the distance required to fall below the LOC for these non-target plants

2.4.2. Mechanism of Action

Simazine is part of the triazine herbicide family (including atrazine, cyanazine, propazine) and is very effective at inhibiting the photosynthetic process in susceptible plants by binding to specific sites within the plant's chloroplasts. Specifically, simazine inhibits photosynthesis via competition with plastoquinone II at its binding site in the process of electron transport in photosystem II.

2.4.3 Use Characterization

Currently, Syngenta Crop Protection, Inc. is the primary manufacturer of simazine; however, there are an additional 13 registrants with active registrations. Syngenta Crop Protection, Inc. supports the majority of the uses (Princep Caliber 90®, Princep®). Other registrants and products include Atanor S.A. (Simazina Atanor), Chem-Real Investment Corp., Ciba, Ltd. (Gesastop®, Princep®), Drexel Chemical Co. (Drexel® simazine), Helm AG, Makhteshim-Agan (Simanex®), Micro-Flo Co., OXON Italia S.P.A., Platte Chemical Co., Sanachem (Pty) Ltd., Sanonda Co. Ltd., Sostram Corp. (Sim-Trol®), Terra International, Inc., and Tecomag (Nezitec®).

Table 2.2 presents the simazine application rates and management practices relevant to the 2010 growing season in California. Environmental exposures are estimated for assessed uses of simazine according to the label for the 2010 growing season in order to be conservative; however, several uses will be cancelled (*i.e.*, all non-residential granular uses and aerial applications) once the mitigation practices resulting from the 2006 RED are fully implemented in 2010.

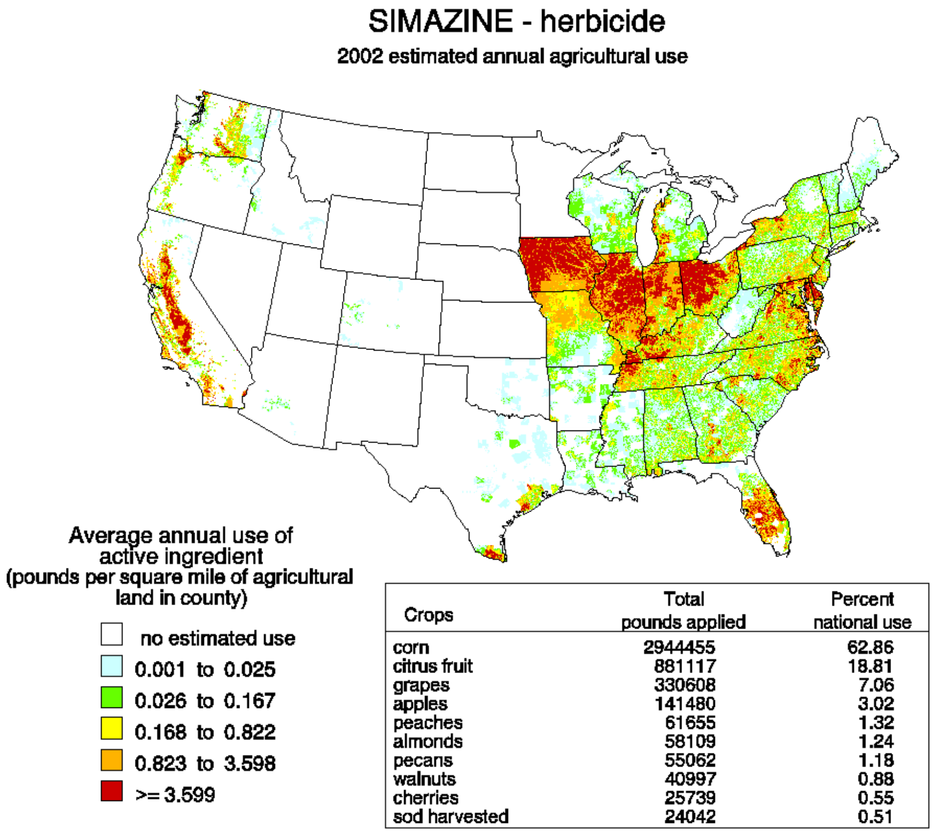
Table 2.2 Simazine Uses Assessed for the DS

Use[1,2]	Max. Single Appl. Rate (lb ai/A)	Max. Number of Application per Year
Almonds and Nectarines	2	1
Apples, Pears, and Sour Cherries	4	1
Avocados	4	1
Blueberries and (blackberries, boysenberries, loganberries, and raspberries) (liquid and granular)	4 or 2 + 2[3]	1 2
Citrus - Grapefruit, Lemon, and Orange	4 or 2 + 2[3]	1 2
Cranberry	4	1

Use[1,2]	Max. Single Appl. Rate (lb ai/A)	Max. Number of Application per Year
Filberts or Hazlenut	4 or 2 + 2[3]	1 2
Grapes	4.8	1
Macadamia Nuts	4	1
Olives	4	1
Peaches	2	1
Walnuts	4	1
Corn	2 (sand, silt, and loam w/ low OM)	1
Apple, Sour Cherry, Peach, and Pear Trees (non bearing or young trees only) (Granular only)	8	1
Christmas Tree Plantation for Lumber	5.94	1
Non-Cropland (Aerial application)	5	1
Tree Plantations	4	1
Tree Nurseries	4	1
Shelterbelts (Granular)	3	1
Turfgrass (Residential) (Granular and Liquid)	2 or 1 + 1	2
Turfgrass on Golf courses (Fairways) (Granular and Liquid)	2 or 1 + 1	2

[1] All applications are tank mixed, except as noted
[2] All formulations are liquid ground applications unless otherwise noted as granular or aerial
[3] Second notation corresponds to two applications

A national map (**Figure 2.2**) showing the estimated poundage of simazine uses across the United States is provided below. The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website. On the county level, simazine use is heaviest in the Central Valley of CA, where mostly almonds, nuts, fruits, and citrus are grown, and in Florida on turf and citrus.



Crops	Total pounds applied	Percent national use
corn	2944455	62.86
citrus fruit	881117	18.81
grapes	330608	7.06
apples	141480	3.02
peaches	61655	1.32
almonds	58109	1.24
pecans	55062	1.18
walnuts	40997	0.88
cherries	25739	0.55
sod harvested	24042	0.51

Figure 2.2 Simazine Use in Total Pounds per County[5]

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006; Biscoe et. al., 2010) using state-level usage data obtained from USDA-NASS[6], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature), and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[7] . CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases; therefore, CDPR PUR data were used to obtain county-level simazine usage data for this California-specific assessment. Nine years (1999-2007) of usage data were included in this analysis. Data

5 http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1981

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

7 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.

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 nine years. The units of area treated are also provided where available.

Between 1999 and 2007, simazine was reportedly used in 55 counties in California. The principal use was on orchard vineyard crops including oranges, grapes, almonds, and walnuts. The greatest usage of simazine in California is to oranges at an average of approximately 190,000 lbs annually, followed by wine grapes at approximately 119,000 lbs annually, table grapes at an approximate average of 116,000 lbs annually, almonds at 60,000 lbs annually, walnuts at approximately 55,000 lbs annually, rights-of-way at 39,000 lbs annually, avocados at 15,000 lbs annually, lemons at 15,000 lbs annually, olives at 16,000 lbs annually, and peaches at 10,000 lbs annually. All remaining crops had less than 10,000 lbs applied annually and several uses had less than 10 lbs annually (some with only one reported application). A summary of simazine usage for all California use sites is provided below in **Table 2.3**.

The uses considered in this risk assessment represent all currently registered uses according to a review of all current labels. No other uses are relevant to this assessment. Any other reported use, such as may be seen in the CDPR PUR database, represent either historic uses that have been cancelled, misreported uses, or misuse. Historical uses, misreported uses, and misuse are not considered part of the federal action and, therefore, are not considered in this assessment.

Table 2.3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2007 for Currently Registered Simazine Uses[1].

	Application				
	lbs a.i./yr	Rate (lbs a.i./Acre)			
Site Name	Average Annual lbs applied	Average	95th %	99th %	Maximum[2]
ORANGE	189,819.2	2.1	3.6	4.5	21.8
GRAPE, WINE	118,391.9	1.5	4.0	4.8	41.7
GRAPE	116,110.6	1.0	2.7	3.7	27.5
ALMOND	55,409.6	0.7	1.8	2.4	12.5
WALNUT	42,638.8	1.7	3.6	5.7	37.8
OLIVE	15,997.6	1.9	3.6	4.0	36.0
AVOCADO	14,855.9	2.0	4.0	5.1	40.1
LEMON	14,728.4	2.7	4.5	6.8	40.0
PEACH	10,288.6	0.7	1.8	2.4	15.9
NECTARINE	7,528.5	0.7	1.8	2.7	20.0
GRAPEFRUIT	5,594.6	2.1	3.4	4.5	11.3
PEAR	3,496.3	1.8	4.0	5.6	26.6

Site Name	Application				
	lbs a.i./yr	Rate (lbs a.i./Acre)			
	Average Annual lbs applied	Average	95th %	99th %	Maximum[2]
APPLE	2,435.6	1.5	4.0	4.0	39.8
UNCULTIVATED NON-AG	976.5	2.5	6.0	9.0	13.5
N-OUTDR PLANTS IN CONTAINERS	543.3	2.7	6.4	25.6	76.8
CITRUS	522.9	2.0	3.6	4.0	5.5
PLUM	426.6	0.8	2.0	4.5	7.3
UNCULTIVATED AG	410.1	2.1	4.5	9.0	13.6
TANGERINE	407.6	2.1	3.6	5.0	9.5
RIGHTS OF WAY	322.9	4.6	9.0	45.0	45.0
BLUEBERRY	243.4	1.4	3.0	4.0	4.0
FOREST, TIMBERLAND	192.4	2.8	8.6	9.5	9.5
CHERRY	178.8	1.0	2.7	2.8	3.1
PECAN	178.4	1.1	2.0	3.6	3.6
N-OUTDOOR FLOWER	133.6	1.9	6.0	7.2	8.5
N-GREEN HOUSE FLOWER	130.5	2.2	4.0	5.4	5.4
ASPARAGUS	92.5	2.2	2.3	2.3	2.3
ARTICHOKE, GLOBE	89.2	0.6	1.3	1.3	1.3
CHRISTMAS TREE	56.6	1.9	3.6	4.0	4.0
LETTUCE, LEAF	54.6	15.5	99.9	99.9	99.9
INDUSTRIAL SITE	53.5	1.9	4.5	4.5	4.5
APRICOT	53.3	0.8	2.0	3.6	3.6
TANGELO	46.5	2.2	3.6	3.6	3.6
PRUNE	41.3	1.4	3.4	3.4	3.4
CORN, HUMAN CONSUMPTION	39.4	2.3	2.5	20.0	20.0
CORN (FORAGE - FODDER)	35.8	0.7	2.0	2.0	2.0
LETTUCE, HEAD	35.1	2.1	13.8	13.8	13.8
ALFALFA	33.4	0.6	2.7	4.0	4.0
N-GRNHS PLANTS IN CONTAINERS	29.8	4.1	21.6	21.6	21.6
N-OUTDR TRANSPLANTS	28.9	1.4	3.9	4.0	4.0
PISTACHIO	27.9	0.7	1.1	1.1	1.1
BOYSENBERRY	25.5	1.0	1.8	2.7	2.7
RANGELAND	21.5	2.1	3.0	3.0	3.0
SOIL FUMIGATION/PREPLANT	21.2	1.7	3.0	3.0	3.0
DITCH BANK	16.6	2.6	4.0	4.0	4.0
ANIMAL PREMISE	14.0	1.7	5.4	5.4	5.4
PASTURELAND	13.1	1.5	4.5	4.5	4.5
WHEAT	11.1	1.3	2.7	2.7	2.7

Site Name	Application				
	lbs a.i./yr	Rate (lbs a.i./Acre)			
	Average Annual lbs applied	Average	95th %	99th %	Maximum[2]
UNKNOWN	10.5	1.9	4.0	4.0	4.0
COTTON	7.9	1.3	1.8	1.8	1.8
KIWI	7.6	0.7	0.9	0.9	0.9
STRAWBERRY	7.5	1.9	1.9	1.9	1.9
LANDSCAPE MAINTENANCE	6.8	1.7	3.1	3.1	3.1
PERSIMMON	5.3	1.7	4.0	4.0	4.0
WATER AREA	5.0	2.7	4.5	4.5	4.5
REGULATORY PEST CONTROL	4.0	6.0	6.0	6.0	6.0
BEAN, UNSPECIFIED	4.0	0.6	0.6	0.6	0.6
RESEARCH COMMODITY	3.7	4.7	10.0	10.0	10.0
MINT	3.5	1.8	1.8	1.8	1.8
POMEGRANATE	3.2	2.5	4.0	4.0	4.0
RECREATION AREA	3.0	0.6	0.6	0.6	0.6
SMALL FRUITS/BERRY	2.2	2.2	2.2	2.2	2.2
OAT	1.9	2.2	4.0	4.0	4.0
LIME	1.9	7.8	12.0	12.0	12.0
N-GRNHS TRANSPLANTS	1.9	1.3	2.6	2.6	2.6
CAULIFLOWER	1.8	1.6	1.6	1.6	1.6
RASPBERRY	1.5	1.6	2.7	2.7	2.7
TROPICAL/SUBTROPICAL FRUIT	1.5	1.1	1.5	1.5	1.5
BLACKBERRY	1.3	1.6	2.7	2.7	2.7
POULTRY	1.2	2.7	2.7	2.7	2.7
BUILDINGS/NON-AG OUTDROOR	1.2	1.2	1.8	1.8	1.8
QUINCE	0.9	0.9	0.9	0.9	0.9
STONE FRUIT	0.9	0.7	0.7	0.7	0.7
COMMODITY FUMIGATION	0.7	0.1	0.1	0.1	0.1
NUTS	0.6	3.6	3.6	3.6	3.6
KUMQUAT	0.3	0.1	0.1	0.1	0.1
BARLEY	0.1	0.6	0.6	0.6	0.6
TURKEY	0.1	1.5	1.5	1.5	1.5
TURF/SOD	0.0	1.5	1.5	1.5	1.5
CELERY	0.0	0.0	0.0	0.0	0.0
SPINACH	0.0	0.0	0.0	0.0	0.0

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

The counties with the highest nine year use averages (in lbs a.i. per year) of simazine were Tulare (158,000), Fresno (116,000), Kern (67,000), Madera (45,000), San Joaquin (40,000), Stanislaus (28,000), Sonoma (18,000), and Merced (17,000). The average use in lbs a.i. per year for each county are summarized in **Table 2.4.**

Table 2.4 Summary of Nine Year Average Simazine Use per County from the California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2007[1].

County	total lb a.i. per year	County	total lb a.i. per year
TULARE	157,856.8	SOLANO	1,299.7
FRESNO	115,754.4	COLUSA	1,194.8
KERN	66,755.0	ORANGE	973.1
MADERA	45,487.2	YUBA	847.0
SAN JOAQUIN	40,242.6	AMADOR	709.8
STANISLAUS	27,713.4	ALAMEDA	595.2
SONOMA	17,539.1	SAN BENITO	580.9
MERCED	16,599.3	CONTRA COSTA	424.5
MONTEREY	14,876.5	EL DORADO	310.5
SACRAMENTO	10,452.0	SHASTA	205.1
BUTTE	10,212.2	TUOLUMNE	188.0
RIVERSIDE	9,712.8	CALAVERAS	150.9
SAN DIEGO	8,094.1	SANTA CLARA	142.0
SAN LUIS OBISPO	6,787.1	SANTA CRUZ	112.2
SANTA BARBARA	6,559.5	LOS ANGELES	97.3
NAPA	6,473.1	NEVADA	87.2
VENTURA	6,301.6	PLACER	56.0
KINGS	5,751.6	MARIPOSA	20.4
TEHAMA	4,827.5	SAN MATEO	19.8
GLENN	4,117.7	LASSEN	13.5
YOLO	3,965.2	MARIN	10.8
MENDOCINO	2,918.5	SISKIYOU	6.7
SUTTER	2,162.2	PLUMAS	4.0
LAKE	2,004.1	HUMBOLDT	0.1
SAN BERNARDINO	1,683.0		

[1] Based upon data supplied by BEAD (USEPA, 2009).

2.5. Assessed Species

Table 2.5**Table 2.5** provides a summary of the current distribution, habitat requirements, and life history parameters for the Delta smelt (DS). More detailed life-history and distribution information can be found in **Attachment 2**. See **Figure 2.3** for a map of the current range and designated critical habitat of the DS. The DS was listed as threatened on March 5, 1993 (58 FR 12854) by the USFWS (USFWS, 2007a). DS are mainly found in the Suisun Bay and the Sacramento-San Joaquin estuary near San Francisco Bay. During spawning DS move into freshwater.

Table 2.5 Summary of Current Distribution, Habitat Requirements, and Life History Information for the Delta smelt

Assessed Species	Size	Current Range	Habitat Type	Designated Critical Habitat?	Reproductive Cycle	Diet
Delta Smelt [1] *Hypomesus transpacificus*	Up to 120 mm in length	Suisun Bay and the Sacramento-San Joaquin estuary (known as the Delta) near San Francisco Bay, CA	The species is adapted to living in fresh and brackish water. They typically occupy estuarine areas with salinities below 2 parts per thousand (although they have been found in areas up to 18ppt). They live along the freshwater edge of the mixing zone (saltwater-freshwater interface).	Yes	They spawn in fresh or slightly brackish water upstream of the mixing zone. Spawning season usually takes place from late March through mid-May, although it may occur from late winter (Dec.) to early summer (July-August). Eggs hatch in 9 – 14 days.	They primarily planktonic copepods, cladocerans, amphipods, and insect larvae. Larvae feed on phytoplankton; juveniles feed on zooplankton.

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

Delta Smelt Habitat

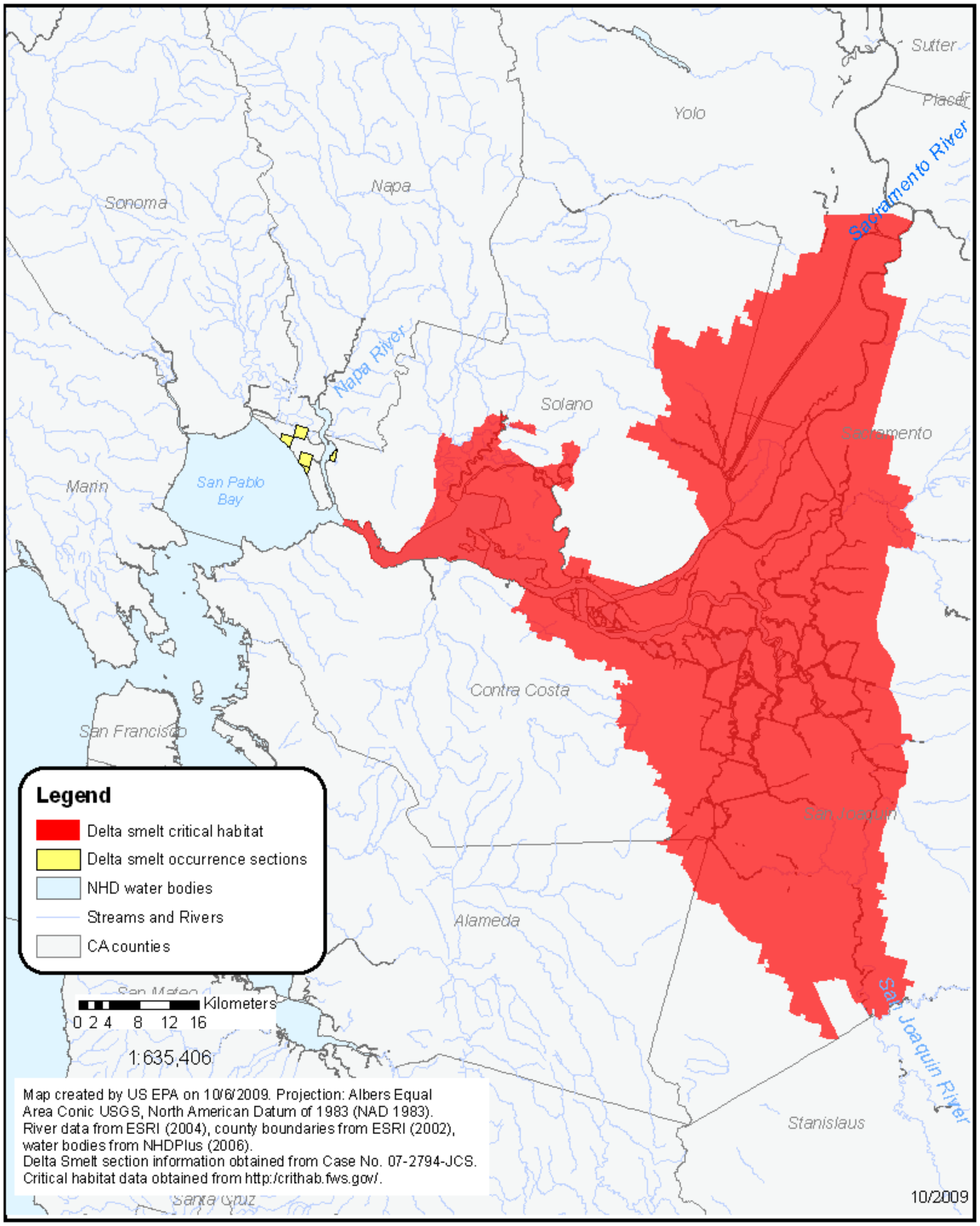


Figure 2.3 Delta Smelt Critical Habitat and Occurrence Sections identified in Case No. 07-2794-JCS.[8]

[8] Critical habitat maps (Delta Smelt, Calif. Tiger Salamander, Valley Elderberry Longhorn Beetle, Bay Checkerspot Butterfly, Alameda Whipsnake, Tidewater Goby) from crithab.fws.gov, Delta Smelt Recovery Plan, 1996. ecos.fws.gov

2.6. Designated Critical Habitat

Critical habitat has been designated for the Delta smelt. 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 2.6** describes the PCEs for the critical habitats designated for the Delta smelt.

Table 2.6. Designated Critical Habitat PCEs for the Delta smelt

PCEs[1,2,3]
PCE 1: Spawning Habitat—shallow, fresh or slightly brackish backwater sloughs and edgewaters to ensure egg hatching and larval viability. Spawning areas also must provide suitable water quality (i.e., low "concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emergent vegetation).
PCE 2: Larval and Juvenile Transport—Sacramento and San Joaquin Rivers and their tributary channels must be protected from physical disturbance and flow disruption. Adequate river flow is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Suitable water quality must be provided so that maturation is not impaired by pollutant concentrations.
PCE 3: Rearing Habitat—Maintenance of the 2 ppt isohaline and suitable water quality (low concentrations of pollutants) within the Estuary is necessary to provide delta smelt larvae and juveniles a shallow protective, food-rich environment in which to mature to adulthood.
PCE 4: Adult Migration— Unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods.

[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.
[3] 59 FR 65256 65279, 1994.

More detail on the designated critical habitat applicable to this assessment can be found in **Attachment 2**. Activities that may destroy or modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of simazine that may alter the PCEs of the designated critical habitat for the Delta smelt 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 simazine is expected to directly impact living organisms within the action area, critical habitat analysis for simazine is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7. Action Area and LAA Effects Determination Area

2.7.1. Action Area

The action area is used to identify areas that could be affected by the Federal action. The Federal action is the authorization or registration of pesticide use or uses as described on the label(s) of pesticide products containing a particular active ingredient. The action area is defined by the Endangered Species Act as, "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR §402.2). Based on an analysis of the Federal action, the action area is defined by the actual and potential use of the pesticide and areas where that use could result in effects. Specific measures of ecological effect for the assessed species that define the action area include any direct and indirect toxic effect to the assessed species and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature. It is recognized that the overall action area for the national registration of simazine 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 DS and its designated critical habitat within the state of California.

For this assessment, the entire state of California is considered the action area. The purpose of defining the action area as the entire state of California is to ensure that the initial area of consideration encompasses all areas where the pesticide may be used now and in the future, including the potential for off-site transport via spray drift and downstream dilution that could influence the San Francisco Bay Species. Additionally, the concept of a state-wide action area takes into account the potential for direct and indirect effects and any potential modification to critical habitat based on ecological effect measures associated with reduction in survival, growth, and reproduction, as well as the full suite of sublethal effects available in the effects literature.

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

2.7.2. LAA Effects Determination Area

A stepwise approach is used to define the Likely to Adversely Affect (LAA) Effects Determination Area. An LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the species and/or modify its designated critical habitat using EFED's standard assessment procedures (see **Attachment I**) and effects endpoints related to survival, growth, and reproduction. This is the area where the "Potential Area of LAA Effects" (initial area of concern + drift distance 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 simazine. An analysis of labeled uses and review of available product labels was completed. Several of the currently labeled uses are special local needs (SLN) uses or are restricted to specific states and are excluded from this assessment. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the DS, the analysis indicates that, for simazine, the following agricultural uses are considered as part of the federal action evaluated in this assessment:

- Almonds
- Nectarines
- Apples
- Pears
- Sour cherries
- Avocados
- Blueberries
- Blackberries
- Boysenberries
- Loganberries
- Raspberries
- Citrus
- Cranberry
- Filbert
- Hazelnut
- Grapes
- Macadamia nuts
- Olives
- Peaches
- Walnuts
- Corn

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

- Non-bearing apple, cherry, peach, and pear trees
- Christmas tree plantations
- Non-cropland (*i.e.*, commercial/industrial/institutional premises/highways)
- Tree plantations
- Tree nurseries
- Shelterbelt plantings
- Turfgrass on sod farms
- Turfgrass on golf courses
- Homeowner turf

Following a determination of the assessed uses, an evaluation of the potential “footprint” of simazine use patterns is determined. This “footprint” represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types that represent the labeled uses described above. A map representing all the land cover types that make up the initial area of concern for simazine is presented in **Figure 2.4**.

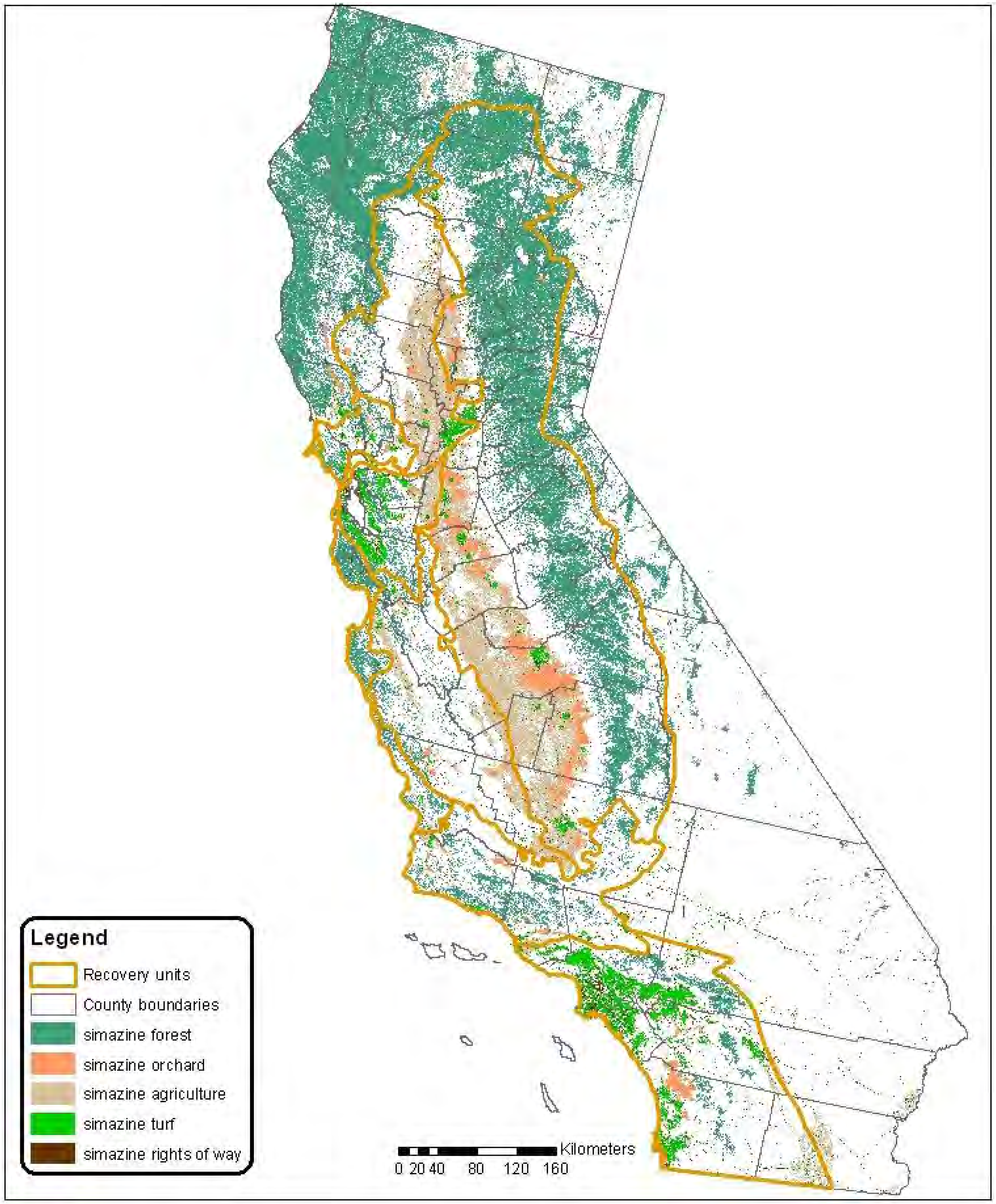


Figure 2.4. Initial area of concern, or “footprint” of potential use, for simazine.

Once the initial area of concern is defined, the next step is to define the potential boundaries of the Potential Area of LAA Effects. This can be defined by determining the extent of offsite transport via spray drift and runoff where exposure to the pesticide will result in exceedances of the LOCs. For this assessment, since the action area has been defined as the whole State of California, the Potential Area of LAA Effects is also defined as the whole State.

An evaluation of usage information was conducted to determine the area where use of simazine 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 simazine has historically been used on a wide variety of agricultural and non-agricultural uses.

2.8. Assessment Endpoints and Measures of Ecological Effect

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

2.8.1. Assessment Endpoints

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in **Section 4** of this document. **Table 2.7** identifies the taxa used to assess the potential for direct and indirect effects from the uses of simazine for the DS. The specific assessment endpoints used to assess the potential for direct and indirect effects are provided in **Table 2.8**. For more information on the assessment endpoints, see **Attachment 1**.

Table 2.7 Taxa Used in the Analyses of Direct and Indirect Effects for the Delta Smelt

Listed Species	Terr. Plants	FW Fish	FW Inverts.	Estuarine/Marine Fish	Estuarine/Marine Inverts.	Aquatic Plants
Delta smelt	Indirect (habitat)	Direct*	Indirect (prey)	Direct*	Indirect (prey)	Indirect (food/ habitat)

Abbreviations: n/a = Not applicable; Terr. = Terrestrial; Invert. = Invertebrate; FW = Freshwater
*The most sensitive fish species across freshwater and estuarine/marine environments is generally used to assess effects for these species because they may be found in freshwater or estuarine/marine environments. In this case both freshwater and saltwater acute test results were very similar.

Table 2.8 Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Simazine to Result in Direct and Indirect Effects to the Delta Smelt or Modification of Critical Habitat

Taxa Used to Assess Direct and Indirect Effects to the Delta smelt and/or Modification to Critical Habitat or Habitat	Direct or Indirect Effect to the Delta smelt	Assessment Endpoints	Measures of Ecological Effects
1. Freshwater or Estuarine/Marine Fish	**Direct Effect** [1]	Survival, growth, and reproduction of individuals via direct effects	**1a.** Most sensitive fish acute LC_{50} **1b.** Most sensitive fish chronic NOAEC **1c.** Most sensitive fish early-life stage NOAEC:
2. Freshwater or Estuarine/Marine Invertebrates	**Indirect Effect (prey)**	Survival, growth, and reproduction of individuals or modification of critical habitat via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	**2a.** Most sensitive aquatic invertebrate EC_{50} **2b**. Most sensitive aquatic invertebrate chronic NOAEC
3. Aquatic Plants (freshwater/marine)	**Indirect Effect (food/habitat)**	Survival, growth, and reproduction of individuals or modification of critical habitat via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	**3a.** Vascular plant acute EC_{50} **3b.** Non-vascular plant acute EC_{50}
4. Terrestrial Plants	**Indirect Effect (habitat)**	Survival, growth, and reproduction of individuals or modification of critical habitat via indirect effects on food and habitat (*i.e.*, riparian vegetation)	**4a.** Distribution of EC_{25} for monocots (seedling emergence and vegetative vigor) **4b.** Distribution of EC_{25} for dicots (seedling emergence and vegetative vigor)

Abbreviations: SF=San Francisco

[1]The most sensitive fish species across freshwater and estuarine/marine environments is generally used to assess effects for these species because they may be found in freshwater or estuarine/marine environments. In this case both freshwater and saltwater acute test results were very similar.

[2] The most sensitive endpoint was used in calculations and is displayed in bold font.

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions resulting from the use of simazine 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 simazine effects data are available.

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

2.9. Conceptual Model

2.9.1. Risk Hypotheses

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

The labeled use of simazine within the action area may:

- directly affect DS by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect DS and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect DS 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, larval food supply and cover/egg attachment substrate;
- indirectly affect DS 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); and
- indirectly affect DS and/or modify their habitat by reducing or changing the composition of the terrestrial plant community in riparian zones and, thus, affecting sedimentation and runoff/flow.

2.9.2. Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the simazine release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual model for the Delta smelt and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in **Figure 2.5** and **Figure 2.6**. Although the conceptual models for direct/indirect effects and modification of designated critical habitat PCEs are shown on the same diagrams, the potential for direct/indirect effects and modification of PCEs will be evaluated separately in this assessment. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the Delta smelt and modification to designated critical habitat is expected to be negligible.

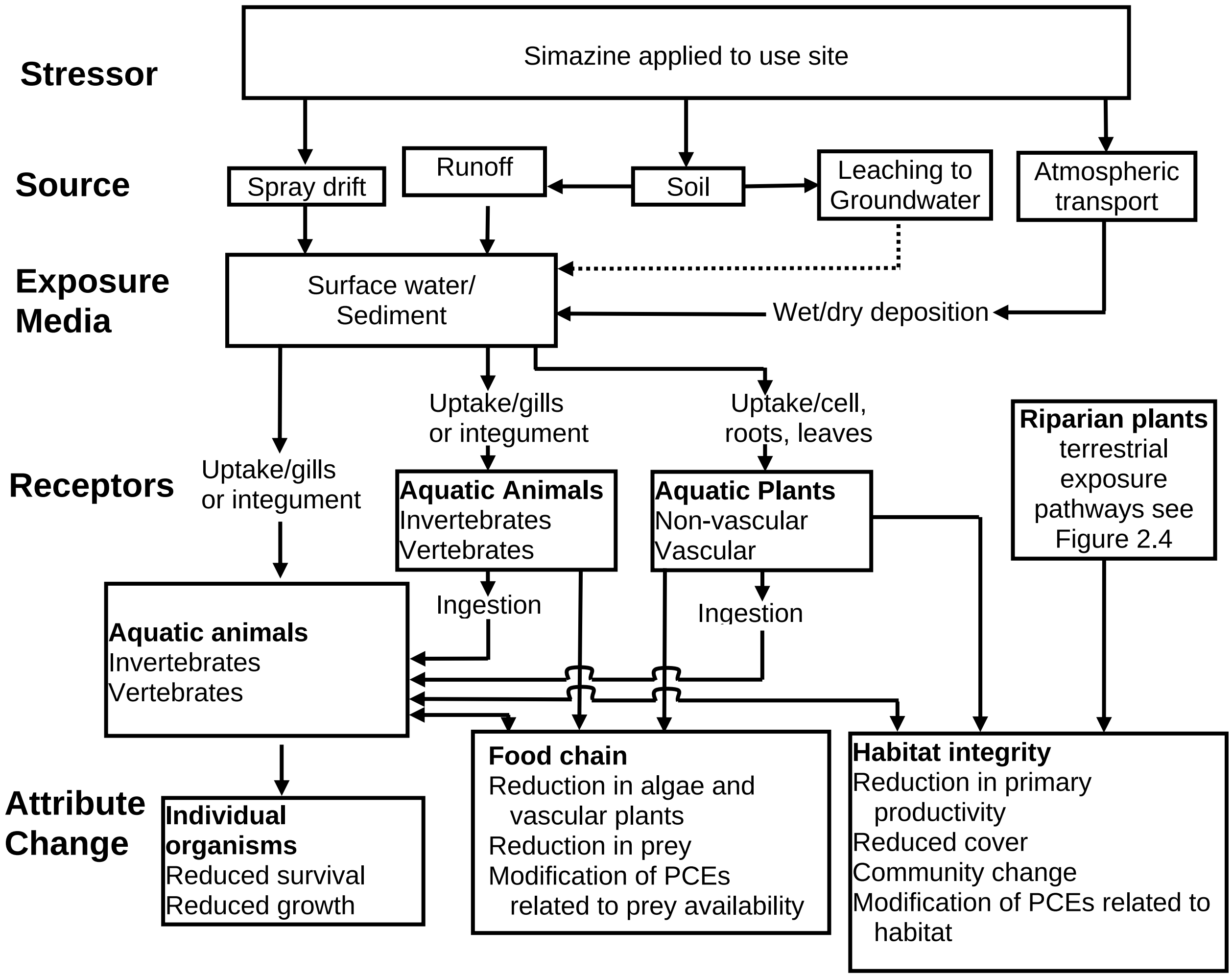


Figure 2.5. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Aquatic Organisms from the Use of Simazine.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

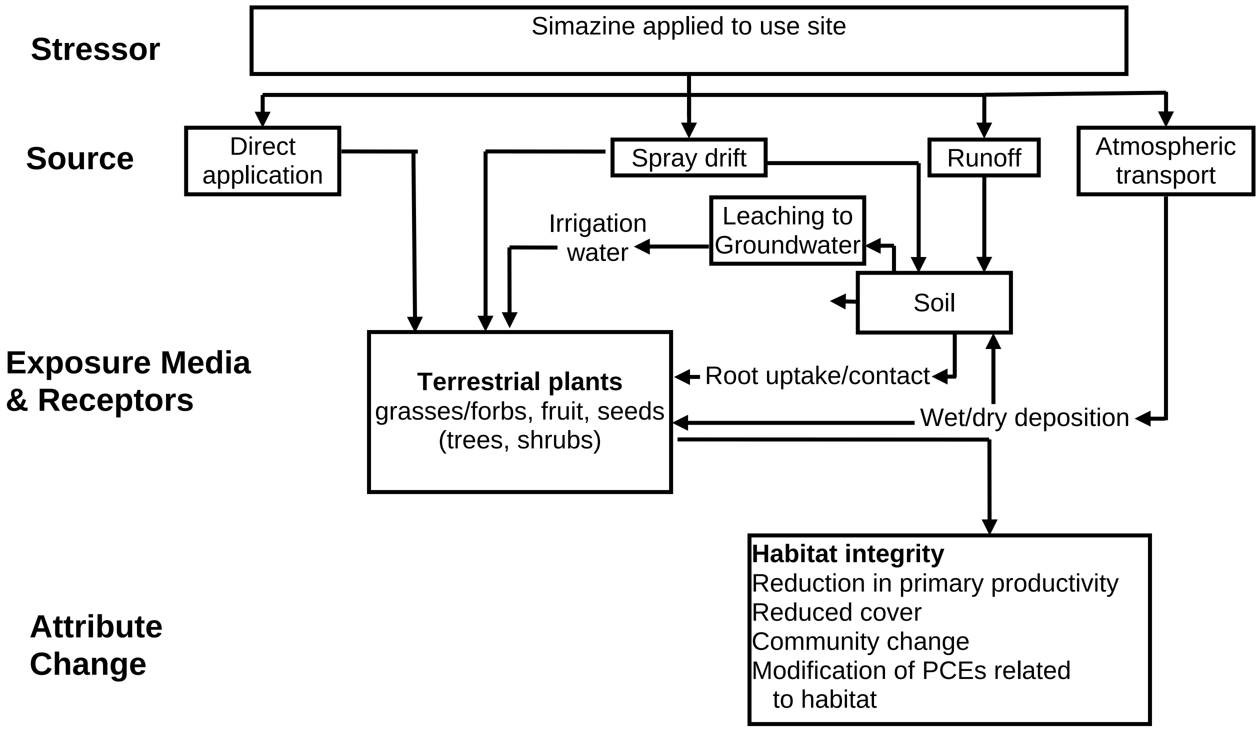


Figure 2.6. Conceptual model depicting stressors, exposure pathways, and potential effects to terrestrial organisms from the use of Simazine.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

2.10. Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the assessed species, prey items, and habitat is estimated based on a taxon-level approach. In the following sections, the use, environmental fate, and ecological effects of simazine 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 simazine is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

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

2.10.1. Measures of Exposure

The environmental fate properties of simazine along with available monitoring data indicate that water and sediment runoff and spray drift are the principle potential transport mechanisms of simazine to the aquatic and terrestrial habitats. In this assessment, transport of simazine through runoff and spray drift is considered in deriving quantitative estimates of simazine exposure to

DS, its prey and its habitat. Although simazine has been detected at low concentrations in air monitoring samples, the available data suggest that detections are related to nearby sources and are more likely due to spray drift than long-range transport. In addition, the vapor pressure of simazine suggests that volatilization leading to long-range transport is unlikely.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of simazine using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. Two spray drift models, AgDISP and AgDRIFT may be used to assess exposures of terrestrial plants to simazine deposited on terrestrial habitats by spray drift. More information on these models is available in **Attachment 1**.

2.10.2. Measures of Effect

Data identified in **Section 2.8** are used as measures of effect for direct and indirect effects. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. More information on the ecotoxicology (ECOTOX) database and how toxicological data are used in assessments is available in **Attachment 1**.

2.10.2.a. Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from agricultural and non-agricultural uses of simazine, 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; see **Appendix B**). More information on standard assessment procedures is available in **Attachment 1**.

2.10.3. Data Gaps

The main data gaps for this assessment were chronic toxicity data for freshwater inverebrates and estuarine/marine fish and invertebrates. In the absence of data risk must be presumed.

One endpoint was calculated, however, using a freshwater fish acute to chronic ratio (ACR) for simazine for saltwater fish. No saltwater chronic invertebrate data were available for simazine and no ACR was found for oysters, collembolans or corals among data from other triazine herbicides.

3. Exposure Assessment

Simazine is formulated as liquid, water dispersible granules, wettable powder, emulsifiable concentrate, and granular formulations. Application equipment for the agricultural uses includes ground application (the most common application method), aerial application, band treatment, incorporated treatment, various sprayers (low-volume, hand held, directed), and spreaders for granular applications. Risks from ground boom and aerial applications are considered in this assessment because they are expected to result in the highest off-target levels of simazine due to generally higher spray drift levels. Ground boom and aerial modes of application tend to use lower volumes of application applied in finer sprays than applications coincident with sprayers and spreaders and thus have a higher potential for off-target movement via spray drift.

3.1. Label Application Rates and Intervals

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

In the April 2006 RED EPA stipulated a number of changes to the use of simazine including label restrictions and other mitigation measures designed to reduce risk to human health and the environment. The label changes include: cancellation of aerial and non-residential granular uses of simazine. In addition, a number of other mitigation measures, including rate reductions, cancellations of certain uses, added spray drift language, and buffer restrictions near streams, rivers, lakes, and reservoirs are proposed. These proposed mitigation measures are expected to become final later in 2010. Of the proposed mitigation measures relevant to this assessment that are expected to become final in later in 2010, all aerial applications and non-residential granular uses will be cancelled California and spray drift and buffer restriction language will be added to the labels. The proposed spray drift language includes specific application restrictions for wind speed (< 10 mph), droplet size (coarse or coarser ASAE standard 572 spray), and release height (nozzle height no more than 4 feet above ground or crop canopy). The proposed buffer restrictions prohibit application of simazine within 66 feet of streams and rivers and 200 feet of lakes and reservoirs.

Currently registered non-agricultural uses of simazine within the DS action area include dormant fruit, tree plantations and nurseries, shelterbelts, Christmas trees, turf (residential, recreational, and sod farm), and non-cropland areas defined as industrial sites, highway medians, rights-of-way, lumberyards, tank farms, fuel storage areas, and fence lines. Agricultural uses within the DS action area include fruit and nut crops such as apples, oranges, grapes, berries, peaches, nectarines, avocados, olives, almonds, macadamia nuts, and walnuts in addition to corn. The uses being assessed are summarized in **Table 3.1**.

Table 3.1 Simazine Uses, Scenarios, and Application Information for the DS Risk Assessment

Scenario	Uses[1] Represented by Scenario	Application Rate [2]	Number of Applications	Application Interval
CA almond	Filbert Hazelnut Macadamia nut Walnut	4 lbs	1	NA
CA almond	Almond	2 lbs	1	NA
CA fruit	Apple Cherry Pear	4 lbs	1	NA
CA fruit	Nectarine Peach	2 lbs	1	NA
CA fruit	Non-food on Apple Cherry Peach Pear	8 lbs (granular only) (0 lbs Post-RED)	1	NA
CA strawberry or CA wine grapes	Blueberry Blackberry Boysenberry Longanberry Raspberry Cranberry	4 lbs (liquid and granular) (0 lbs for granular Post-RED)	1	NA
CA avocado	Avocado	4 lbs	1	NA
CA citrus	Grapefruit Lemon Orange	4 lbs	1	NA
CA grapes	Grapes	4.8 lbs (4.0 lbs Post-RED)	1	NA
CA olives	Olives	4 lbs	1	NA
CA corn	Corn	2 lbs	1	NA
CA forestry	Tree plantations	4 lbs	1	NA
CA nursery	Tree nurseries	4 lbs	1	NA
CA forestry	Christmas trees	5.94 lbs (4 lbs Post-RED)	1 (2 apps Post-RED)	
CA fruit	Shelterbelts	3 lbs (granular only) (0 lbs Post-RED)	1	NA
CA turf	Sod farm Golf course	1 lbs (liquid and granular) 1 lbs (liquid and granular)	2	Assumed 30 days between applications
CA residential	Homeowner turf	1 lbs (liquid and granular) 1 lbs (liquid and granular)	2	Assumed 30 days between applications
CA right of way	Non-cropland	5 lbs (aerial) (0 lbs Post-RED)	1	NA

1 Uses assessed based on memorandum from SRRD dated August 27, 2007 (**Appendix C**).
2 All uses modeled by ground applications unless otherwise noted as granular or aerial.

3.2. 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., 1998) used was PRZM 3.12 beta, dated May 24, 2001. The water body is simulated with EXAMS version 2.98, dated July 18, 2002 (Burns, 1997). Tier 2 simulations are run for multiple (usually 30) years and the reported EECs are the concentrations that are expected once every ten years based on the thirty years of daily values generated by the simulation. PRZM and EXAMS were run using the PE4 shell, dated May 14, 2003, which also summarizes the output. Spray drift was simulated using the AgDRIFT model version 2.01 dated May 24, 2001.

3.2.1. Modeling Approach

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

All of the modeled scenarios assume 100% of the watershed is treated simultaneously, with the exception of the residential turf uses. In modeling the residential turf scenario, it is assumed that no more than 50% of a typical residential site is covered in turf; therefore, the modeled EECs for these uses are reduced by a factor of 50%. Further details on the rationale for the residential turf modeling assumptions has been described in several previously conducted assessments (U.S. EPA, 2007a and b).

Crop-specific management practices for all of the assessed uses of simazine were used for modeling, including application rates, number of applications per year, application intervals, buffer widths and resulting spray drift values modeled from AgDRIFT, and the first application date for each crop. The date of first application was developed based on several sources of information including data provided by BEAD, a summary of individual applications from the CDPR PUR data, and crop profiles maintained by the USDA. A sample of the distribution of simazine applications to grapes from the CDPR PUR data for 2005 used to pick a March 1 application date is shown in **Figure 3.1.**

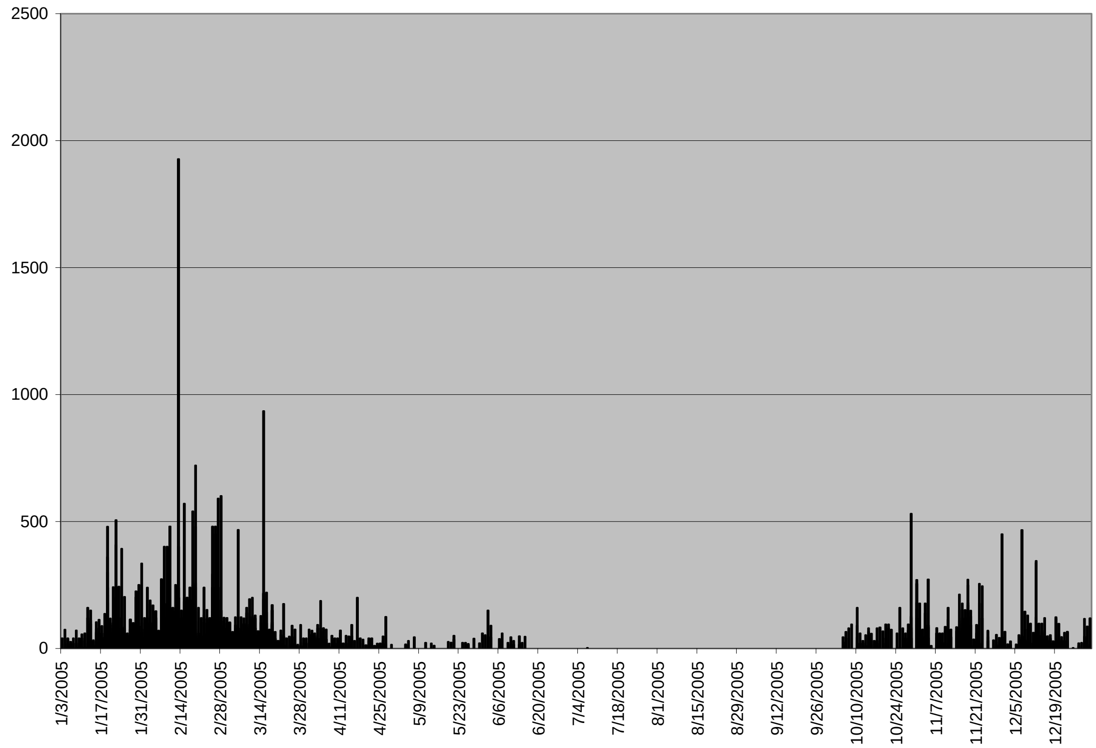


Figure 3.1 Summary of Applications of Simazine to Grapes in 2005 from CDPR PUR data.

More detail on the crop profiles and the previous assessments may be found at:

http://www.ipmcenters.org/CropProfiles/

3.2.2. Model Inputs

Simazine is a triazine herbicide used on a wide variety of food and non-food crops. Physical and chemical properties relevant to assess the behavior of simazine and related compounds in the environment are presented in **Table 2.1** and **Table 2.2**. Application information from the label is in **Table 2.3** and **Table 3.1**. The input parameters for PRZM and EXAMS are in **Table 3.2**.

Appendix D contains example model output files and tables showing the data used to calculate input values.

Table 3.2. Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Simazine Endangered Species Assessment

Fate Property[1]	Value	MRID (or source)
Molecular Weight	202 g/mole	Product Chemistry
Henry's constant	3.2x 10^{-10} atm m^3 / mole	Product Chemistry
Vapor Pressure	6.1 x 10^{-9} torr	Product Chemistry
Solubility in Water	3.5 ppm	Product Chemistry
Photolysis in Water	stable	00143171 42503708
Aerobic Soil Metabolism Half-lives	$t_{1/2}$ = 130 days (upper 90th percentile confidence bound on mean half-life of 110 and 91 days)	00158638 43004501
Hydrolysis	stable	00027856
Aerobic Aquatic Metabolism (water column)	$t_{1/2}$ = 213 days (input value is three times the single laboratory aerobic aquatic metabolism half-life of 71 days)	43004502
Anaerobic Aquatic Metabolism (benthic)	$t_{1/2}$ = 168 days (input value is three times the single laboratory anaerobic aquatic metabolism half-life of 56 days or 168 days – anaerobic aquatic is 664 days)	40614411
Koc	123 (average of 152.5, 123.3, 114, and 102.7)	41442903 41257903
Application Efficiency	95 % for aerial 99 % for ground	default value[2]
Spray Drift Fraction[1]	5 % for aerial 1 % for ground	default value[2]

1 – Spray drift not included in final EEC due to edge-of-field estimation approach
2 – Inputs determined in accordance with EFED "*Guidance for Chemistry and Management Practice Input Parameters for Use in Modeling the Environmental Fate and Transport of Pesticides*" dated February 28, 2002. , assumed anaerobic aquatic metabolism was 3 times the aerobic soil metabolism rate which may overestimate anaerobic degradation.

3.2.3. Results

The aquatic EECs for the various scenarios and application practices are listed in **Table 3.3.** Estimated aquatic exposures are highest for simazine use on Christmas trees with peak EEC of 130.2 µg/L. The use with the next highest peak exposure concentration is based on liquid applications on berries with peak EEC of 108.4 µg/L, followed by granular use on berries, tree plantations, tree nurseries, non-cropland, dormant fruit, and avocados with 103 µg/L, 88.0 µg/L, 68.2 µg/L, 66.0 µg/L, 61.5 µg/L, and 53.5 µg/L respectively. All other modeled simazine uses yield peak exposure concentrations below 50 µg/L. The output/example output from PRZM-EXAMS is provided in **Appendix D.**

Table 3.3. Aquatic EECs (µg/L) for Simazine Uses in California

Scenario[1]	Application Rate[2]	Date of First Application	Crops Represented	Peak EEC	4-day average EEC	21-day average EEC	60-day average EEC	90-day average EEC
CA almond (high rate)	4 lbs	December 1	Filbert Hazelnut Macadamia nut Walnut	25.6	25.5	25.0	20.6	20.2
CA almond (low rate)	2 lbs	December 1	Almond	12.8	12.7	12.5	10.3	10.1
CA fruit (high rate)	4 lbs	March 1	Apple Cherry Pear	11.1	11.1	10.9	10.5	10.2
CA fruit (low rate)	2 lbs	March 1	Nectarine Peach	5.6	5.5	5.4	5.3	5.1
CA fruit (dormant)	8 lbs (granular) (0 lbs Post-RED)	December 1	Non-food on Apple Cherry Peach Pear	61.5	61.2	59.8	51.5	50.6
CA strawberry	4 lbs (granular) (0 lbs Post-RED)	December 1	Blueberry Blackberry Boysenberry Longanberry Raspberry Cranberry	103.4	102.5	100.5	81.9	79.4
CA strawberry	4 lbs (liquid)	December 1	Blueberry Blackberry Boysenberry Longanberry Raspberry Cranberry	108.4	107.4	105.4	86.3	83.7
CA avocado	4 lbs	December 1	Avocado	53.5	53.1	51.9	33.5	32.5
CA citrus	4 lbs	December 1	Grapefruit Lemon Orange	7.1	7.0	6.9	6.5	6.4
CA grapes	4.8 lbs (4.0 lbs Post-RED)	March 1	Grapes	18.2	18.1	17.6	16.7	16.0
CA olives	4 lbs	December 1	Olives	33.9	33.7	29.9	28.9	28.0
CA corn	2 lbs	April 1	Corn	12.3	12.2	11.9	11.3	10.8
CA forestry	4 lbs	December 1	Tree Plantations	88.0	87.5	85.6	61.6	60.0
CA forestry	5.94 lbs (4 lbs Post-RED w/2 apps)	December 1	Christmas trees	130.2	130.1	127.2	91.4	89.1
CA nursery	4 lbs	December 1	Tree nurseries	68.2	67.9	66.3	39.7	38.6

Scenario[1]	Application Rate[2]	Date of First Application	Crops Represented	Peak EEC	4-day average EEC	21-day average EEC	60-day average EEC	90-day average EEC
CA fruit	3 lbs (granular) (0 lbs Post-RED)	December 1	Shelterbelts	12.0	11.9	9.3	8.9	8.6
CA turf	1 lbs (2 liquid apps w/ 30 day interval)	March 1	Sod farm Golf course	8.8	8.7	8.6	8.4	8.3
CA turf	1 lbs (2 granular apps w/ 30 day interval)	March 1	Sod farm Golf course	6.6	6.6	6.5	6.4	6.2
CA residential	1 lbs (2 liquid apps w/ 30 day interval)	March 1	Homeowner turf	5.2	5.2	5.2	5.0	4.9
CA residential	1 lbs (2 granular apps w/ 30 day interval)	March 1	Homeowner turf	4.3	4.2	4.2	4.1	4.0
CA right of way	5 lbs (aerial) (0 lbs Post-RED)	March 1	Non-cropland (commercial, industrial, institutional premises, equipment, highways)	66.04	65.41	64.59	62.12	60.57

[1] All uses modeled with ground application (unless otherwise noted) based on current labels and do not include post-RED mitigations
[2] All uses modeled with one application unless otherwise noted

3.2.4. Existing Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. Simazine has a limited set of surface water monitoring data relevant to the DS assessment. Most of this data is non-targeted (*i.e.*, study was not specifically designed to capture simazine concentrations in high use areas). Included in this assessment are simazine data from the USGS NAWQA program (http://water.usgs.gov.nawqa) and data from the California Department of Pesticide Regulation (CDPR). In addition, air monitoring data for simazine are summarized.

These monitoring data are characterized in terms of general statistics including number of samples, frequency of detection, maximum concentration, and mean from all detections, where that level of detail is available.

3.2.4.a. USGS NAWQA Surface Water Data

Surface water monitoring data from the United States Geological Survey (USGS) NAWQA program was accessed on June 15, 2010 and all data for the state of California were downloaded.

A total of 2,291 water samples were analyzed for simazine. Of these samples, simazine was detected in 2,001 samples (196 were estimated either above or below the range of quantitation) with a frequency of detection of 87%. The maximum concentration detected was 64.5 μg/L in Mustang Creek near Montpelier in Merced County in 2004. Two additional samples from the same site (also from the same runoff event in 2004) were above 50 μg/L, while a total of 35 samples (6 sites, all but one sample collected since 2000) were above 10 μg/L, and 120 samples were above 1 μg/L. No clear pattern in simazine detections from different use sites is evident because simazine was detected in a number of different types of watersheds (agricultural, urban, mixed and other) as classified by the USGS land use information. The average concentration of all samples was 0.59 μg/L while the average concentration of all detections was 0.68 μg/L.

3.2.4.b. USGS NAWQA Groundwater Data

Groundwater monitoring data from the United States Geological Survey (USGS) NAWQA program were accessed on June 15, 2010 and all data for the state of California was downloaded. A total of 901 water samples were analyzed for simazine. Of these samples, simazine was detected in 364 samples (69 were estimated either above or below the range of quantitation) with a frequency of detection of 40%. The maximum concentration detected was 0.5 μg/L from a groundwater well in Merced County. As with the surface water data, there was no clear pattern associated with use sites as the NAWQA detections were from different types of watersheds (agricultural, urban, mixed and other) as classified by the USGS land use information. The average concentration of all samples was 0.021 μg/L while the average concentration of all detections was 0.044 μg/L

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

Surface water monitoring data was accessed from the California Department of Pesticide regulation (CDPR) on June 16, 2010 and all data (1990-2006) with analysis for simazine were extracted. A total of 5,360 samples were available. Of these samples, simazine was detected in 2,255 samples for a frequency of detection of 42%. The maximum concentration was 57.9 μg/L in 2004 from the USGS site at Mustang Creek (this is the same site as the peak concentration from the USGS NAWQA data). The maximum concentration from a site not included in the USGS data was 22.7 μg/L from the Highline Spillway in Merced County from 2002. Of all samples, only 128 were detected at concentrations above 1 μg/L and most of these were from Merced, San Joaquin, and Stanislaus Counties. There was no monitoring data for degradates of simazine from the CDPR data. CPDR Data can be found at: http://www.cdpr.ca.gov/docs/emon/surfwtr /surfcont.htm.

3.2.4.d. Atmospheric Monitoring Data

Available monitoring data for simazine in air and rainfall were evaluated to provide context to the evaluation of the extent of action area and estimated concentrations in surface water. Based on the available information (Majewski et al., 2000; Majewski and Capel, 1995; Dubus et al., 2000, Foreman et al., 2000, McConnell et al., 2004, and Usenko et al., 2005), simazine has been detected in rainwater and snow and air samples across the United States. In general, simazine has been detected in some studies at variable frequency of detections but in general, detections in rainfall have generally been below 1 µg/L, but higher values have been measured (**Table 3.4**). Often there is a lack of ancillary data in these studies to determine whether these detections are due to spray drift or longer-range transport due to volatilization. However, given that most of the studies focus on major agricultural locations, that simazine has not been detected in any of the studies conducted at higher elevations, coupled with the relatively low volatility of simazine, it is expected that many of these detections are reflective of near field (spray drift) exposure and are not indicative of long-range transport. The concentrations detected in the reviewed studies suggest that transport of simazine via atmospheric transport will yield exposures well below those predicted by modeling. Western Contaminants Assessment Project publication can be found at: http://www.nature.nps.gov/air/studies/air_toxics/wacap.cfm

An air monitoring study conducted for the CDPR and California Air Resources Board (Law et. al. 1999) reported the results of application and ambient air monitoring for simazine. Application monitoring was conducted in Tulare County around the use of simazine as a herbicide applied to oranges from December 18 to December 22, 1998. Ambient monitoring was conducted to coincide with the use of simazine on grapes in Fresno County from February 18 to April 1, 1998. The highest concentration in the application monitoring was 190 ng/m^3; detectable levels of simazine were observed in 22 of 32 samples (69%). The highest concentration of simazine in the ambient air monitoring samples was 18 ng/m^3; detectable levels of simazine were observed in 48 of 120 sample (40%).

Atmospheric transport of pesticides, including simazine, was conducted in the Sacramento California Metropolitan Area (Majewski and Baston, 2002). Weekly composite, bulk air was sampled by wind speed and direction for two years at three sites (1 urban, 2 agricultural) in Sacramento County, California. One sample from two of the sites contained detectable levels of simazine, Franklin Field (0.36 ng/m^3) and Sacramento Metro-Area (0.25 ng/m^3).

Data from outside of California was also noted. Dorfler and Scheunert (1997) collected rainwater in Germany, the highest concentrations was 8.1 µg/L near the source of application and 0.088 µg/L away from the area of application.

Table 3.4 Detections of Simazine in Air, Precipitation, and Snow Samples Taken in California

Location	Years	Sample type	Maximum Conc.	Detection frequency	Source
California Data					
Central San Joaquin Valley, CA	2001- 2004	Rain (wet)/Air (dry)	6.74 µg/L	99% (n = 137)	Majewski et al., 2005
Tulare and Fresno Counties, CA	1998	Air - application Air - ambient	190 ng/m^3 18 ng/m^3	69% (n = 32) 40% (n = 120)	Law et al, 1999
Franklin Field, Sacramento, CA Sacramento Metro area	1997-1998	Air Air	0.36 ng/m^3 0.25 ng/m^3	1.4% (n ≈ 100) 1.4% (n ≈ 100)	Majewski and Baston, 2002
German Data					
Conodoguinet Creek	1991	Rain	0.15 µg/L		Shertzer et al., 1998
Germany		Rain	8.1 µg/L	0.088 to 8.1 µg/L	Dorfler and Scheunert, 1997

Exposure to simazine through long range atmospheric transport may also occur. Prevailing winds blow across the Central Valley eastward to the Sierra Nevada Mountains, transporting airborne industrial and agricultural pollutants into the Sierra Nevada ecosystems (Fellers *et al.,* 2004, LeNoir *et al.,* 1999, and McConnell *et al.,* 1998). Simazine can be present in air or precipitation due to spray drift, volatilization and/or wind erosion of soil containing residues (Majewski et al., 2005). Precipitation and dry particulate matter can contribute to simazine deposits in aquatic systems (LeNoir *et al*, 1999). Therefore, deposition of simazine could potentially be transported to the habitats of DS. No approved model currently exists for estimating atmospheric transport of pesticides and the resulting exposures to organisms in areas receiving pesticide deposition. Therefore, potential mechanisms of atmospheric transport for simazine such as volatilization, wind erosion of soil and spray drift can only be discussed qualitatively. Given the presence of simazine in air and precipitation in California monitoring data, exposure to DS habitat through atmospheric transport of simazine cannot be precluded. Although it is not possible to quantify simazine exposure via long-range transport, the amount of simazine deposition into DS habitat based on measured simazine concentrations in rain samples are considered in combination with California precipitation data.

A number of long-range mechanisms transport simazine from an initial application site to the atmosphere via wet or dry deposition of simazine to distant locales. The mechanisms are: 1) volatilization from soil and plant surfaces in treated areas, 2) wind erosion of soil containing sorbed simazine, and 3) spray drift of simazine during application.

Factors influencing volatilization of simazine from a treated area are: vapor pressure, adsorption to soil, incorporation depth, and Henry's law constant. The vapor pressure (6.1×10^{-9} mm Hg @ 20 ºC) and Henry's law constant of 3.2×10^{-10} atm-m^3/mol @ 25 ºC (measured) and 4.62×10^{-10} atm-m^3/mol @ 25 ºC (calculated) indicates that simazine has a low potential to volatilize from soil and water.

3.3. Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.2.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method (**Table 3.5**). A runoff value of 0.01 is utilized based on simazine's solubility, which is classified by TerrPlant as <10 mg/L. For aerial, ground, and granular application methods, drift is assumed to be 5%, 1% and 0%, respectively. Soil incorporation is assumed to be 1 for both ground and granular applications. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 3.5**. An example output from TerrPlant is available in **Appendix F**.

Table 3.5 TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Simazine via Runoff and Drift

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift EEC (lbs a.i./A)	Dry area EEC (lbs a.i./A)	Semi-aquatic area EEC (lbs a.i./A)
Christmas trees	5.94	Foliar – ground	1	0.059	0.119	0.653
Non-cropland	5	Foliar – aerial	5	0.25	0.3	0.75
Grapes	4.8	Foliar - ground	1	0.048	0.096	0.528
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries	4	Foliar - ground	1	0.04	0.08	0.44
Almonds, Nectarines, Peaches, Corn, and Turf[1]	2	Foliar - ground	1	0.02	0.04	0.22
Non-bearing Fruit	8	Granular	0	0	0.08	0.8
Berries	4	Granular	0	0	0.04	0.4
Shelterbelts	3	Granular	0	0	0.03	0.3
Turf[1]	2	Granular	0	0	0.02	0.2

[1] The TerrPlant model considers only exposures to plants from single pesticide applications. Although simazine use on turf is usually applied as two separate applications of 1 lb ai/A, terrestrial plant EECs were derived using a conservative assumption of one application at 2 lb ai/A.

4. Effects Assessment

This assessment evaluates the potential for simazine to directly or indirectly affect the DS or modify their designated critical habitat. Assessment endpoints for the effects determination for each assessed species include direct toxic effects on the survival, reproduction, and growth, as well as indirect effects, such as reduction of the prey base or modification of its habitat. In addition, potential modification of critical habitat is assessed by evaluating effects to the PCEs, which are components of the critical habitat areas that provide essential life cycle needs of each assessed species.

As described in the Agency's Overview Document (USEPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater fish, freshwater invertebrates, estuarine/marine fish, estuarine/marine invertebrates, aquatic plants and terrestrial plants. Acute (short-term) and chronic (long-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on simazine.

4.1. Ecotoxicity Study Data Sources

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant (**Appendix G**), and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD)

(USEPA, 2004). Open literature data presented in this assessment were obtained from other simazine risk assessments, including the 2005 IRED, 2006 RED and 2007 CRLF risk assessments (all previously cited), as well as ECOTOX information obtained in February, 2010. In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

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

Open literature toxicity data for 'target' terrestrial plant species, which include efficacy studies, are not currently considered in deriving the most sensitive endpoint for terrestrial plants. The list of citations including toxicological and/or efficacy data on target plant species not considered in this assessment is provided in **Appendix H**. Efficacy studies do not typically provide endpoint values that are useful for risk assessment (*e.g.*, NOAEC, EC_{50}, etc.), but rather are intended to identify a dose that maximizes a particular effect (*e.g.,* EC_{100}). Therefore, efficacy data and non-efficacy toxicological target data are not included in the ECOTOX open literature summary table provided in **Appendix I**.

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

Citations of all open literature not considered as part of this assessment because they were either rejected by the ECOTOX screen or accepted by ECOTOX but not used (*e.g.*, the endpoint is less sensitive) are included in **Appendix H. Appendix H** also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment.

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

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

Simazine degradates, deisopropylatrazine (DIA) and diaminochloroatrazine (DACT), are assumed to be less toxic than the parent compound for aquatic receptors. As shown in **Table 4.1**, comparison of available toxicity information for DIA and DACT indicates lesser aquatic toxicity than parent for freshwater fish, invertebrates, and aquatic plants. In the 2007 CRLF risk assessment authors presented information showing that DIA is more toxic to mammals than parent simazine, but that DIA does not form and persist in the environment at any substantial level. Although degradate toxicity data are not available for terrestrial plants, lesser toxicity is assumed, given the available ecotoxicological information for other taxonomic groups including aquatic plants, where the toxic mode of action is similar, and the likelihood that the simazine degradates are expected to lose efficacy as an herbicide.

Table 4.1 Comparison of Acute Toxicity Values for Simazine and Degradates

Substance Tested	Fish LC_{50} (μg/L)	Daphnid EC_{50} (μg/L)	Aquatic Nonvascular Plant EC_{50} (μg/L)	MRIDs
Simazine	6,400	1000	36	00033309, 45088221, 42662401
DACT	>100,000	>100,000	7,000	47046104, 47046101, 45087401
DIA	17,000	126,000	2,500	47046103, 47046102, 45087401

Therefore, given the lesser aquatic toxicity and fate characteristics of the degradates, as compared to the parent, concentrations of the simazine degradates are not assessed for direct and/or indirect effects to the DS. The available information also indicates that aquatic organisms are more sensitive to the technical grade (TGAI) than the formulated products of simazine; however, chronic toxicity data for freshwater fish and invertebrates are not available for the technical grade of simazine. Therefore, available chronic toxicity data for the formulated product (adjusted to account for the percentage of active ingredient) are used as measures of chronic effects for freshwater fish and invertebrates. A detailed summary of the available ecotoxicity information for all simazine degradates and formulated products is presented in **Appendix G**.

The results of available toxicity data for mixtures of simazine with other pesticides are presented in **Appendix A**. Based on the available information, other triazine herbicides, such as atrazine, may combine with simazine to produce additive toxic effects on aquatic plants. The variety of chemical interactions presented in the available data set suggest that the toxic effect of simazine, in combination with other pesticides used in the environment, can be a function of many factors including but not necessarily limited to: (1) the exposed species, (2) the co-contaminants in the mixture, (3) the ratio of simazine and co-contaminant concentrations, (4) differences in the pattern and duration of exposure among contaminants, and (5) the differential effects of other physical/chemical characteristics of the receiving waters (*e.g.* organic matter present in sediment and suspended water). Quantitatively predicting the combined effects of all these variables on mixture toxicity to any given taxa with confidence is beyond the capabilities of the available data. However, a qualitative discussion of implications of the available pesticide mixture effects data involving simazine on the confidence of risk assessment conclusions for the DS is addressed as part of the uncertainty analysis for this effects determination.

4.2. Toxicity of Simazine to Aquatic Organisms

Table 4.2 summarizes the most sensitive aquatic toxicity endpoints, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the DS is presented below. Additional information is provided in **Appendix G**. All endpoints are expressed in terms of the active ingredient (a.i.) unless otherwise specified.

Table 4.2. Aquatic Toxicity Profile for Simazine

Assessment Endpoint	Acute/ Chronic	Species TGAI/TEP % a.i.	Toxicity Value Used in Risk Assessment	Classification	Citation or MRID Number[1]	Comment
Freshwater fish	Acute	Fathead Minnow, *Pimephales promelas* (TGAI)	96-hour LC_{50} = 6,400 µg a.i./L	Moderately Toxic	MRID 00033309	**Supplemental**: Nominal concentrations; no raw data provided
	Chronic	Fathead Minnow, *P. promelas* (80% formulated product)	NOAEC = 960 µg[2] a.i./L LOAEC = 2000 µg a.i./L	NA	MRID 00043676	**Acceptable**: 12% reduction in fry growth at 2,000 µg/L
Freshwater invertebrates	Acute	Daphnid, *Daphnia magna* (TGAI)	**48-hour TL_{50}[3] = 1,000 µg a.i./L**	Highly Toxic	MRID 45088221	**Supplemental**: Nominal concentrations; no raw data provided.
	Chronic	Daphnid, *D. magna* (80% formulated product)	NOAEC = 2,000 µg a.i./L LOAEC = >2,000 µg a.i./L Calculated **NOAEC = 40 µg a.i./L**	NA	MRID 00043676	**Acceptable**: No adverse effects at the highest test concentration; 12% reduction in fry growth at 2,000 µg/L, concentration adjusted for ai. **Calculated** from *D. magna* ACR[4] from atrazine data, using the *D. magna* acute endpoint of 1000 µg a.i./L.

Assessment Endpoint	Acute/ Chronic	Species TGAI/TEP % a.i.	Toxicity Value Used in Risk Assessment	Classification	Citation or MRID Number[1]	Comment
Estuarine/ marine fish	Acute	Seabream (*Sparus aurata*) yolk-sac larvae Sheepshead minnow, *Cyprinodon varieagatus* (TGAI)	**72- hour LC_{50} = 4,190 µg a.i./L** 96-hr LC_{50} = >4300 µg ai/L	 Moderately Toxic	E76270 Arufe *et al*., 2004 MRID 42503702	**Qualitative**: Nominal concentrations; no raw data provided; no way to confirm that simazine stayed in solution **Acceptable**: No mortality or sublethal effects at highest test concentration
	Chronic	Seabream (*Sparus aurata* Calculated using Fathead minnow ACR (6.7[5])	**NOAEC = 625 µg a.i./L**	NA	--	Calculated data based on acute to chronic ratio from freshwater data. [5]
Estuarine/ marine invertebrates	Acute	Eastern oyster, Crassostrea *virginicana* (TGAI)	96-hr EC_{50} = >3700 µg ai/L	Moderately Toxic	MRID 42503703	**Acceptable**: 6.8% reduction in shell growth at the highest test concentration
	Chronic	--	No Data	NA	--	--
Aquatic plants	Vascular	Duckweed, *Lemna stagitalis* (TGAI)	**14-day EC_{50} = 140 µg a.i./L NOAEC = 54 µg a.i./L**	NA	MRID 42503704	**Acceptable:** LOAEC of 110 µg/L based on reduction in frond number
	Non-vascular	Blue-green algae (TGAI)	**5-day EC_{50} = 36 µg a.i./L** **EC_{05} = 5.4 µg/L**	NA	MRID 42662401	**Supplemental/ Qualitative**: A NOAEC could not be determined based on cell density. Existing cell density data was used to calculate an EC_{05} for use as an NOAEC.

[1] ECOTOX references are designated with an E followed by the ECOTOX reference number.
[2] Endpoints presented in **Bold font** were used in risk calculations.

[3] TL=Threshold Limit, term used by authors to identify the threshold concentration in which immobility was observed at a certain level, in this case, 50% immobilization which is for our purpose, the same as an EC_{50} and used in calculations in the same way.. .
[4]ACR calculations from atrazine data: data from MRIDs 45087413 and 00024377 showed atrazine acute and chronic toxicity endpoints for *D. magna* of 3500 and 140, respectively; therefore, 3500/140 = 25.
[5]ACR calculations for fathead minnow simazine toxicity data above: 6400/960 = 6.7.

A considerable number of aquatic toxicity and field studies are available for simazine. Reported acute toxicity values generally exceed the water solubility limit of simazine (approximately 3.5 mg/L at 20^{o} C). While simazine concentrations in water would appear to be stable to hydrolysis and photolysis for the duration of the acute static studies, the actual exposure levels are uncertain because mean-measured concentrations are not available, and precipitation is frequently reported in the acute studies. Test concentrations are rarely measured to verify exposure levels; therefore, a high degree of uncertainty exists for the freshwater toxicity data for simazine. As such, studies with LC_{50} values > 100 mg/L are highly uncertain. It appears that simazine is acutely toxic to some freshwater fish and aquatic invertebrates in the range of 1 to 10 mg/L.

Toxicity to fish and aquatic invertebrates is categorized using the system shown in **Table 4.3** (USEPA, 2004). Toxicity categories for aquatic plants have not been defined.

Table 4.3. Categories of Acute Toxicity for Fish and Aquatic Invertebrates

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

4.2.1. Toxicity to Fish

A summary of acute and chronic fish data, including data from the open literature, is provided below in **Sections 4.2.1.a** through **4.2.1.c**.

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

As shown in **Appendix G**, submitted acute toxicity values for technical grade simazine exceed its expected water solubility (~3500 µg ai/L), with values ranging from 6400 to >32000 µg ai/L. Reported acute LC_{50} values for fathead minnow (MRID 00033309) and bluegill sunfish (MRID 00025438) are 6,400 and 16,000 µg ai/L, respectively. While both of these LC_{50} values exceed the predicted limit of simazine's solubility in water, a co-solvent was used to increase the limit of simazine's water solubility, and no observation of precipitate were noted in the test chambers. The fathead minnow LC_{50} value of 6,400 µg ai/L was the lowest acute freshwater fish toxicity endpoint. This test was categorized as supplemental because no raw data or test concentrations were provided in the study. A no effect level of 2,500 µg ai/L was established in the 96-hour fathead minnow study, which is consistent with the results of a 28-day subacute rainbow trout study (MRID 00043668), that also had a no-effect concentration of 2,500 µg ai/L.

Uncertainty was present in all available acute freshwater studies on the TGAI regarding dissolved levels of simazine in water because mean-measured test concentrations were not analyzed. Reported nominal concentration results reflect the concentration after the application and not necessarily the concentration of simazine in water during or at the end of the 96-hour test. A number of the acute studies on both the TGAI and formulated product are classified as invalid because precipitation of the test substance in the test chambers was reported and LC_{50} values exceed the water solubility of simazine by a large margin.

Acute effects data for freshwater fish are available for a number of simazine's formulated products including Aquazine (80% WP) and a 50% formulation. All ai-adjusted LC_{50} values for Aquazine (>72,600 µg/L) and the 50% formulation (13,500 to 55,000 µg/L) exceed the lowest LC_{50} value for the TGAI (6,400 µg/L). The available data suggests that Aquazine and the 50% formulation are less toxic to freshwater fish than the TGAI.

Toxicity data for saltwater fish are not as plentiful as for freshwater fish. Submitted studies had 96-h LC_{50}s for fish ranging from >2,400 to >4,300 µg ai/L for striped bass (*Morone saxatilis*) and sheepshead minnows (*Cyprinodon variegatus*), respectively. One additional study found in the open literature search had a lower acute endpoint than submitted studies, with a 72-h LC_{50} = 4,190 µg a.i./L for the seabream *(Sparus aurata;* Arufe *et al*., 2004, E76270). Since the DS inhabits both saltwater and freshwater, the most conservate endpoint in either salinity is used for risk calculations. Therefore, the seabream study, classified as quantitative, was used in risk calculations. It was the most sensitive endpoint. This endpoint is very close to the sheepshead endpoint (> 4300 µg a.i./L) used in calculations in the 2007 CRLF risk assessment, but since it is an actual number, rather than a greater-than number, it is a better endpoint for risk calculations.

Based on the available data, simazine is categorized as moderately toxic to fish on an acute basis.

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

No freshwater fish early life-stage test using the TGAI was submitted for simazine. Two fish life-cycle tests with fathead minnow were submitted for Aquazine, an 80% formulation that is typically applied directly to the water (MRID 00043676). One test was conducted with steady concentrations via continuous flow. In the second test, the chemical was applied at the beginning of the test and allowed to decrease at normal degradation rates. Both tests were conducted at the same initial test concentrations. The static test where concentrations decrease over time is intended to be representative of typical use-pattern exposures of Aquazine. The lowest endpoint values in the continuous and usage-pattern exposures were increase in percent hatched fry (NOAEC = 130 µg/L ai) and increased fry growth (length) (NOAEC = 25 µg/L ai), respectively. However, neither of these endpoints are considered as toxicologically relevant for the risk assessment. Therefore, a NOAEC value of 960 µg/L ai was selected, based on 12% reduction in growth (length) to 30-day old fry at a continuous exposure treatment level of 2,000 µg/L ai. The corresponding LOAEC value, based on reduction in fry growth, is 2,000 µg/L ai. Freshwater fish life-cycle studies for the 80% formulation are summarized in **Appendix G**.

No saltwater fish early life-stage or life cycle tests have been submitted for simazine and no such studies were found in the open literature. An acute to chronic ratio (ACR) from fathead minnow

(*Pimephales promelas*) data for simazine was used to calculate an estimated chronic saltwater fish endpoint. The acute and chronic endpoints of 6,400 and 960 µg ai/L (MRIDs 00033309 and 00043676; **Appendix G**) produced an ACR of 6.7 (6400/960 = 6.7). Applied to the most sensitive saltwater fish acute data, the seabream, the chronic NOAEC = 625 µg a.i./L.

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

In addition to submitted studies, data available from the open literature show sensitive sublethal effects to freshwater fish at lower concentrations than those used in calculations (MRID 00043676), **Table 4.2**. Although these studies (see **Appendix G)** report potentially sensitive endpoints (olfactory detection of female priming pheromone and priming response of male), effects on survival, growth, or reproduction were not observed in the available full life-cycle studies, and so they could not be used in calculations, but were useful for risk characterization, see **Section 5.1.1.a**. These studies raise questions about the potential effects of simazine on endocrine-mediated functions in anadromous fish; however, it is not possible to quantitatively link these sublethal effects to the selected assessment endpoints for the DS (*i.e.*, survival, growth, and reproduction of individuals and modification to designated critical habitat). In one study with male Atlantic salmon (*Salmo salar* L.; Moore and Lower, 2001), simazine inhibited *in vitro* olfactory function in male Atlantic salmon parr. The results of this study are summarized in Appendix A. Following a 5 day exposure period, the reproductive priming effect of the female pheromone prostaglandin $F_{2\alpha}$ on the levels of expressible milt in males was reduced after exposure to simazine at concentrations as low as 0.1 µg/L. Although the hypothesis was not tested, the study authors suggest that exposure of smelts to simazine during the freshwater stage may potentially affect olfactory imprinting to the natal river and subsequent homing of adults. Although this study produced a NOAEC that is lower than the fish full life-cycle test of 960 ppb, this study was not considered appropriate for RQ calculation for the following reasons:

- A negative control was not used; therefore, potential solvent effects cannot be evaluated;
- The study did not determine whether the decreased response of olfactory epithelium to specific chemical stimuli would likely impair similar responses in intact fish; and
- A quantitative relationship between the magnitude of reduced olfactory response of male epithelial tissue to the female priming hormone observed in the laboratory and reduction in salmon reproduction (*i.e.*, the ability of male salmon to detect, respond to, and mate with ovulating females) in the wild is not established.

4.2.2. Toxicity to Aquatic Invertebrates

Freshwater aquatic invertebrate toxicity data were used to assess potential indirect effects of simazine to the DS. Direct effects to freshwater invertebrates resulting from exposure to simazine may indirectly affect the DS via reduction in available food items. As discussed in **Section 2.5**, the main food sources of the DS are aquatic invertebrates (except larvae which feed mainly on algae).

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

4.2.2.a. Aquatic Invertebrates: Acute Exposure Studies

Acute toxicity data for simazine are available for daphnids (*Daphnia magna)*, seed shrimp (*Cypridopsis vidua*), scuds (*Gammarus lacustris* and *G. fasciatus*), stoneflies (*Pteronarcys californica*), sowbugs (*Asellus brevicaudus*), glass shrimp (*Palaemonetes kadiakensis*) and crayfish (*Orconectes nais*). Results of acute toxicity tests are found in **Appendix G**; 48-h EC_{50}'s ranged from 1 mg/L for daphnids to >100 mg/L for three of the crustacean taxa, though the higher endpoints were accompanied by a great deal of uncertainty because test concentrations were far above solubility and confirmation of the concentrations was not possible.

Submitted studies showed Eastern oyster (*Crassostrea virginica*) 96-h EC_{50}'s ranging from >1.0 to >3.7 mg ai/L from shell deposition studies (see **Appendix G**). No mysid shrimp data were available. One study (Park and Lees, 2005) from the open literature had a very different LC_{50} of >1000 mg/L for the collembolan (*Proisotoma minuta*). This study was classified as supplemental largely because test concentrations were not confirmed. The oyster endpoint of >3.7 mg ai/L was from an acceptable study and was chosen as the endpoint to use in calculations (MRID 42503703). Simazine is classified as practically non-toxic to moderately toxic to saltwater invertebrates.

4.2.2.b. Aquatic Invertebrates: Chronic Exposure Studies

No freshwater invertebrate life-cycle test using the TGAI was submitted for simazine. A freshwater aquatic invertebrate life-cycle test using the formulated product Aquazine (80% formulation) was submitted for simazine (MRID 00043676). The results of this test are summarized in **Appendix G**. No treatment-related adverse effects to *D. magna,* including parental mortality and offspring production, occurred during the 21-day study at the highest test concentration tested, 2,000 µg ai/L This NOAEC, >2000 µg ai/L, was used for risk calculations in the 2007 CRLF risk assessment.

This chronic endpoint, however, is actually higher than the acute endpoint described above. This inversion of expected results emphasizes the uncertainty of testing near the saturation limit. Concentrations were confirmed in the chronic test but not the acute test. In the acute test technical grade simazine was used along with ethanol as a carrier solvent; in the chronic test, an 80% formulated product was used and results adjusted for concentration of ai.

No chronic saltwater invertebrate toxicity data were available for simazine. No ACR was found for oysters, collembolans or corals among data from other triazine herbicides, to use with the acute saltwater toxicity data for these taxa available for simazine.

4.2.2.c. Aquatic Invertebrates: Open Literature Data

The most sensitive endpoint, a *D. magna* 48-h TL_{50} (threshold level for 50% of test organisms, used the same as an EC_{50} in risk calculations) of 1000 ug ai/L, was used in calculations (MRID

45088221). Based on available data, simazine is categorized as highly to slightly toxic to freshwater invertebrates on an acute basis.

One paper (Owen *et al*, 1993) found in the open literature linked sublethal effects in three coral species (*Madracis mirabilis, Diplora strigos* and, *Favia fragum*) to reduced production in their symbiotic zooxanthallae from acute (6-h) exposures to 100 ug/L simazine. This study did not link the measured effects to mortality, reproduction or growth, nor was purity of the test substance given; therefore, it could not be used for risk calculation but is useful for risk characterization.

One additional chronic toxicity study from the open literature showed that *Daphnia pulex* fed a diet of green alga were less sensitive to the effects of simazine than those fed mixed bacterial cultures, but results were erratic and not dose-dependant. Therefore, data from this study are addressed qualitatively, see **Appendix G.**

4.2.2.d. Aquatic Invertebrates: Calculated Data

A conservative approach is to use the most sensitive endpoint, the acute endpoint of EC_{50} = 1000 µg ai/L, along with an ACR from a closely related chlorotriazine herbicide to calculate a chronic endpoint. Using atrazine *D. magna* toxicity data (MRIDs 45087413 and 00024377) an ACR of 25 is calculated (3500/140, respectively) Applying this ACR to *D. magna* acute data for simazine, a chronic endpoint of 40 µg ai/L is calculated. This is the most conservative chronic endpoint available and is therefore used in risk calculations in this assessment. Since this ACR is much larger than the simazine ACR calculated for fish (6.7), an evaluation of these calculations is included in the risk description (**Section 5.1.1.b**).

4.2.3. Toxicity to Aquatic Plants

Toxicity of simazine to aquatic plants is used to estimate effects to primary production, food for DS larvae, and critical habitat PCEs. Both laboratory and field studies were used to determine whether simazine may indirectly affect the DS through effects to aquatic plants, see **Sections 4.2.3.a** through **4.2.5.**

4.2.3.a. Aquatic Plants: Laboratory Data

A summary of acute toxicity of simazine to aquatic plants is provided in **Appendix G**. Tier II toxicity data for technical grade simazine is available for vascular duckweed (*Lemna gibba*) and the following non-vascular plants: blue-green algae (*Anabaena flos-aquae*), marine diatom (*Skeletonema costatum* and *Phaeodactylum tricornutum*), freshwater alga (*Selenastrum capricornutum*), freshwater diatom (*Navicula pelliculosa*), marine algae (*Isochrysis galbana*), and marine green algae (*Chlorococcum* sp. and *Dunaliella tertiolecta*).

One Tier II study of the freshwater aquatic vascular plant, duckweed, was completed using the TGAI of simazine (MRID 42503704). Frond number was the most sensitive endpoint with an EC_{50} value of 140 µg/L. NOAEC and LOAEC values, based on reduction in frond number and growth rate inhibition were 54 and 110 µg/L, respectively. Growth was reduced by 9.1% in plants in the 110 μg/L treatment group. By days 6-9 and onward, there was an increase in colony breakup, smallness of frond, and root destruction in test solutions of $\geq$ 230 μg/L.

The Tier II results indicate that freshwater blue-green algae (*Anabaena*) is the most sensitive non-vascular plant to simazine (MRID 42662401). The EC_{50} for *Anabaena* is 36 μg/L, as compared to EC_{50} values ranging from 90 to 100 μg/L for other freshwater non-vascular plants. The Tier II aquatic plant study with the freshwater alga, *Anabaena*, was scientifically valid, but could not be classified as acceptable because a NOAEC value was not determined. In an Agency 1993 memo, dated October 18, 1993, EPA agreed that existing growth data be used to derive an EC_{10} value for use as the NOAEC. However, current Agency policy specifies that the EC_{05} be used to derive the NOAEC in order to protect listed species that have obligate relationships with non-vascular plants. The resulting NOAEC value based on the EC_{05} is 5.4 μg/L. Reduction in growth rates of 36.8, 80.1, 97.6, and 107% were observed by day 5 at respective test concentrations of 78, 170, 320, and 660 μg/L. In addition, a 28% reduction in cell density was observed at the lowest test concentration of 20 μg/L.

4.2.4. Freshwater Field Studies

A number of field studies are available in the open literature that evaluate adverse effects to freshwater organisms resulting from single and multiple applications of simazine to freshwater ponds to remove noxious growths of aquatic macrophytes. Generally, direct application of simazine to ponds results in a die-off of macrophytes, which consequently results in a decrease of dissolved oxygen (DO). In many of the studies, adverse effects to freshwater fish in field studies following simazine application are attributed to indirect effects including a combination of low DO and reduced food resources, rather than direct toxicity of simazine. Available data from aquatic field studies are inadequate to determine whether simazine applications to aquatic habitats at levels of approximately 1,000 μg/L (1 ppm) result in adverse effects to non-target aquatic organisms either by direct toxicity or indirect effects such as low DO, lost food/habitat resources, and/or decreased ecosystem productivity in the absence of macrophytes. The available field data indicate that benthic macroinvertebrates are generally not adversely impacted by simazine concentrations of 1,000 μg/L, although one study reported a reduction in zooplankton biomass in the post-treatment period. In most of the studies, the fish are older life stages such as fingerlings and/or adults, which are not normally as sensitive to pesticides as larval and fry stages. In addition to indirect effects associated with low DO, the results of one field study suggest a possible direct effect of simazine on the feeding response of channel catfish, following direct application of 1,300 μg/L to earthen channel catfish ponds infested with stonewort. The reviewed field studies are qualitatively evaluated in this risk assessment because observed adverse effects associated with simazine exposure are likely the result of a complex interaction of several parameters rather than simazine concentration alone. Further discussion of the open literature field studies for freshwater fish and invertebrates is provided in **Appendix G**.

The open literature contains a large amount of information on the toxicity of simazine to aquatic plants; however, the majority of data report toxicity values that are higher (*i.e.*, not as sensitive) than the endpoints reported in the submitted studies. A number of open literature papers, which characterize unique endpoints to aquatic plants, present data with endpoint values that are more sensitive than the submitted endpoints, or discuss aquatic plant succession and recovery following simazine application are discussed below. **Appendix G** provides a summary of the open literature laboratory and *in situ* studies, respectively, on the effects of simazine to aquatic plants. Based on the results of the *in situ* and laboratory studies, it appears that simazine results in a reduction of chlorophyll *a* in periphyton and phytoplankton at simazine levels between 500 and 1,000 μg/L. Other studies show increased chlorophyll *a* production at simazine concentrations of $\leq$0.05 ug/L. In addition, despite the apparent sensitivity of the blue-green algae *Anabaena flosaquae* to simazine, the results of one open literature study suggest possible resistance and shifts in the aquatic periphytic plant community to blue-green alga at the higher simazine treatment levels of 5,000 μg/L. Simazine resistance has also been reported in seeds and tubers of *Potamogeton foliosus*. There is evidence to suggest that recovery occurs in algae upon removal of simazine from the site of action, with the recovery inversely proportional to the prior exposure level. In one study, recovery of macrophytes was noted within two to three months following application of simazine granules at 25 lb doses (% ai was not reported). Further detail on the open literature data for aquatic plants is discussed in **Appendix G**.

4.2.5. Aquatic Field/Mesocosm Studies

A number of freshwater microcosm, mesocosm, and field studies are available for simazine, although the lowest concentration of simazine tested in these studies was 1,000 μg/L, well above environmentally relevant concentrations. In many of the studies (summarized in **Appendix G**) , adverse effects to freshwater fish in field studies following simazine application are attributed to indirect effects including a combination of low DO and reduced food resources, rather than direct toxicity of simazine. Therefore, the available field study data are inadequate to determine whether simazine applications to aquatic habitats at levels of approximately 1,000 μg/L result in adverse effects to freshwater fish either by direct toxicity or indirect effects such as low DO, lost food/habitat resources, and/or decreased ecosystem productivity in the absence of macrophytes. In addition to indirect effects associated with low DO, the results of a field study by Tucker and Boyd (1978) suggest a possible direct effect of simazine on the feeding response of channel catfish, following direct application of 1,300 μg/L to earthen channel catfish ponds infested with stonewort. However, the application rate of simazine used in this study is approximately three times higher than current labels allow and direct applications to water are restricted to ornamental ponds and aquariums of 1,000 gallons or less.

4.3. Toxicity of Simazine to Terrestrial Plants

Table 4.4 summarizes the most sensitive terrestrial toxicity endpoints, based on an evaluation of both the submitted studies and the open literature. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment is presented below. Additional information is provided in **Appendix G.**

Table 4.4. Terrestrial Toxicity Profile for Simazine

Type of Test	Species	Toxicity Value Used in Risk Assessment	Citation MRID/ ECOTOX reference No.	Comment
Seedling Emergence Monocots	Onions	EC_{25} = 0.02 lb ai/A	MRID 42634603	**Acceptable**: Onion shoot height
Seedling Emergence Dicots	Lettuce	EC_{25} = 0.009 lb ai/A	MRID 42634603	**Acceptable**: Lettuce dry weight
Vegetative Vigor Monocots	Oats	EC_{25} = 0.033 lb ai/A	MRID 42634604	**Acceptable**: Oats dry weight
Vegetative Vigor Dicots	Lettuce	EC_{25} = 0.033 lb ai/A	MRID 42634604	**Acceptable**: Lettuce dry weight

Plant toxicity data from both registrant-submitted studies and studies in the scientific literature were reviewed for this assessment. Registrant-submitted studies are conducted under conditions and with species defined in EPA toxicity test guidelines. Sublethal endpoints such as plant growth, dry weight, and biomass are evaluated for both monocots and dicots, and effects are evaluated at both seedling emergence and vegetative life stages. Guideline studies generally evaluate toxicity to ten crop species. These tests are conducted on herbaceous crop species only, and extrapolation of effects to other species, such as the woody shrubs and trees and wild herbaceous species, contributes uncertainty to risk conclusions.

Commercial crop species have been selectively bred, and may be more or less resistant to particular stressors than wild herbs and forbs. The direction of this uncertainty for specific plants and stressors, including simazine, is largely unknown. Homogenous test plant seed lots also lack the genetic variation that occurs in natural populations, so the range of effects seen from tests is likely to be smaller than would be expected from wild populations.

Terrestrial plant toxicity data are used to evaluate the potential for simazine to affect riparian zone vegetation within the action area for the DS. Impacts to riparian (*i.e.*, grassy or herbaceous streambank) vegetation may result in indirect effects to the DS through changes in runoff/flow and sedimention. These changes can also modify designated critical habitat PCEs via increased sedimentation, and alteration in flow and water quality. Since woody plants are not sensitive to simazine, temperature and shading impacts are unlikely

Based on the results of the tests, it appears that emerged seedlings are more sensitive to simazine via soil/root uptake exposure than emerged plants via foliar routes of exposure. However, all tested plants, with the exception of corn, exhibited adverse effects in both the seedling emergence and vegetative vigor toxicity tests, following exposure to Princep 4L at 4 lb ai/A. The results of the Tier II seedling emergence and vegetative vigor toxicity tests on non-target plants are summarized below in
Table 4.5 and also in **Appendix G**.

In Tier II seedling emergence toxicity tests, the most sensitive monocot and dicot species are onion and lettuce, respectively. EC_{25} values for lettuce and onions, which are based on a reduction in dry weight, are 0.009 lb ai/A and 0.02 lb ai/A, respectively. In the Tier II vegetative vigor test, lettuce (a dicot) and oat (a monocot) were determined to be equally sensitive to treatment, based on dry weight, with an EC_{25} of 0.033 lb ai/A for both species; the NOAEC for both was 0.016 lb ai/A.

Based on a review of the open literature, no additional information is available that indicates greater non-target terrestrial plant sensitivity to simazine than the registrant-submitted studies discussed above.

Table 4.5 Non-target Terrestrial Plant Seedling Emergence and Vegetative Vigor Toxicity (Tier II) Data

Crop	Type of Study Species	NOAEC (lb ai/A)	EC_{25} (lb ai/A)	Most sensitive parameter	Slope
Seedling Emergence					
Monocots	Corn	4.0	>4.0	None	NA
	Oats	0.016	0.031	Dry Weight	3.82
	Onion	**0.0017**	**0.02**	Shoot Height	0.901
	Ryegrass	0.15	0.045	Dry Weight	3.18
Dicots	Radish	0.049	>0.049	Dry Weight	0.344
	Soybean	<0.049	0.057	Dry Weight	1.92
	Lettuce	**0.0018**	**0.009**	Dry Weight	1.88
	Tomato	0.016	0.038	Dry Weight	3.85
	Cucumber	0.016	0.046	Dry Weight	2.56
	Cabbage	0.049	0.034	Dry Weight	1.95
Vegetative Vigor					
Monocots	Corn	4.0	>4.0	None	NA
	Oats	**0.016**	**0.033**	Dry Weight	3.75
	Onion	0.016	0.039		2.19
	Ryegrass	0.049	0.26	Shoot Height	3.36
Dicots	Radish	0.049	0.063	Dry Weight	2.19
	Soybean	0.049	0.085	Dry Weight	2.86
	Lettuce	**0.016**	**0.033**	Dry Weight	3.08
	Tomato	0.031	0.037	Dry Weight	4.18
	Cucumber	0.016	0.036	Dry Weight	1.38
	Cabbage	0.016	0.041	Dry Weight	1.89

In addition, a report on the toxicity of simazine to woody plants (Wall, 2007) was reviewed by the Agency. A total of 79 species were tested at application rates ranging from 0.5 to 12 lb ai/A. The species were exposed to simazine in a direct application, which represents a worst case exposure scenario. It is expected that woody plant species adjacent to treated areas would not be exposed to simazine at the tested rates. Simazine is labeled for use around numerous woody species including citrus, tree nuts, grapes, and woody shrubs and vines. Based on the available data, it is unlikely that simazine will cause adverse effects to non-target woody plant species. A summary of the woody plant data is provided in **Appendix G**.

4.4. Toxicity of Chemical Mixture

As previously discussed, the results of available toxicity data for mixtures of simazine with other pesticides are presented in **Appendix A**. Based on the available information, other triazine herbicides, such as atrazine, may combine with simazine to produce additive toxic effects on aquatic plants. The variety of chemical interactions presented in the available data set suggest that the toxic effect of simazine, in combination with other pesticides used in the environment, can be a function of many factors including but not necessarily limited to: (1) the exposed species, (2) the co-contaminants in the mixture, (3) the ratio of simazine and co-contaminant concentrations, (4) differences in the pattern and duration of exposure among contaminants, and (5) the differential effects of other physical/chemical characteristics of the receiving waters (*e.g.* organic matter present in sediment and suspended water). Quantitatively predicting the combined effects of all these variables on mixture toxicity to any given taxa with confidence is beyond the capabilities of the available data. However, a qualitative discussion of implications of the available pesticide mixture effects data involving simazine on the confidence of risk assessment conclusions for the DS is addressed as part of the uncertainty analysis for this effects determination.

4.5. Incident Database Review

A review of the Ecological Incident Information System (EIIS, version 2.1), the 'Aggregate Incident Reports' (v. 1.0) database was completed on May 22, 2006 and another on May 13, 2010. The results of these reviews for terrestrial, plant, and aquatic incidents are discussed below in **Sections 4.5.1** through **4.5.3**. A complete list of the incidents involving simazine including associated uncertainties is included as **Appendix K**

4.5.1. Terrestrial Incidents

At the time that the simazine CRLF risk assessment was completed in 2007, only two simazine incidents had been reported involving terrestrial animals. Since the 2007, two additional terrestrial incidents involving simazine were reported (#'s I020023-001 and I020943-001) in the EIIS. Details are not given here since this risk assessment only covers aquatic organisms and terrestrial plants.

4.5.2. Plant Incidents

Three simazine incidents had been reported for terrestrial plants at the time of the simazine CRLF risk assessment (2007). In the first incident, water from a simazine-treated swimming pool affected a section of lawn grass. The certainty index for the lawn incident (# I003567-001) is "highly probable." Both of the remaining two incidents occurred on May 9, 2000, in a corn field in Virginia (#I012366-022 and #I12366-023). Following aerial broadcast application of simazine and atrazine, plant damage was observed to approximately 130 acres of corn. Reported observations of corn plant damage included shortened internodes, and reduced root structure, plant height and ear production, which led to a reduction in the final yield of corn. The certainty index for both incidents was reported as "unlikely."

One new plant incident was found in the 2010 EIIS query involving damage to corn and hay (#I016790-007) in New York after aerial spray. The acreage damaged was not reported and the certainty index reported as "possible."

4.5.3. Aquatic Incidents

Although a number of freshwater aquatic incidents involving fish kills were reported for simazine between the years of 1980 and 1995, the majority of these incidents were the result of direct application of simazine to water bodies not in accordance with the current label restrictions for direct applications to ornamental ponds and aquaria less than 1,000 gallons. Nine freshwater aquatic incidents involving fish kills have been reported for simazine between the years of 1976 and 1995 (#'s B0000-216-18, B0000-300-31, B0000-502-10, I000598-011, I000598-015, I003249-010, I003567-001, I005754-015, I005895-026, I005895-027 and I005895-402). Six incidents have a certainty index of "highly probable" or "probable," and the other three have certainty indices of "possible" and "unlikely." Six incidents resulted from treatment of a lake, pond, or lagoon; two incidents were associated with simazine use on corn and from simazine use along railroad tracks; and the treatment site for the other incident was not reported. In a number of the incidents involving direct application of simazine to lakes, ponds, and lagoons, the legality of use was listed as "misuse" or "undetermined." For those incidents where the legality of use is reported as "registered use," the volume of the water bodies is not provided; therefore, it is unclear whether simazine was applied in accordance with its intended use. The six incidents involving direct application of simazine to water are summarized in **Appendix K**. All occurred prior to 1996, when label language was clarified to restrict direct applications to ornamental ponds and aquaria greater than 1,000 gallons. It is important to note that in a number of the incidents involving direct application of simazine to water, low DO, caused by decaying aquatic vegetation, is attributed as an indirect effect related to the fish kills. The certainty index associated with the remaining three incidents (those resulting from use on corn, railroad tracks, and an unspecified treatment site) was reported as "unlikely."

Of the nine reported incidents, three were reported in California, two were reported in Nebraska, two were reported in South Carolina and one was reported in Michigan and in Tennessee. Fish species listed in these kills include smelt, bullheads, stickleback, striped bass, bluegills, channel catfish, croaker, menhaden, mullet, northern pike, pinfish, yellow perch, sea trout, black bullhead, and fathead minnows. A complete list of the aquatic incidents involving simazine is included as **Appendix K**.

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

The Agency uses the probit dose response relationship as a tool for providing additional information on the potential for acute direct effects to individual listed species and aquatic animals that may indirectly affect the listed species of concern (USEPA, 2004). As part of the risk characterization, an interpretation of acute RQs for the DS 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 simazine 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. Based on a review of the acute toxicity for simazine, no dose response information is available to estimate a slope for this analysis; therefore, a default slope assumption of 4.5 (with lower and upper bounds of 2 to 9) (Urban and Cook, 1986) is used.

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

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to the DS or for modification to their designated critical habitat from the use of simazine 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 B**). For acute exposures to the aquatic animals the LOC is 0.05. The LOC for chronic exposures to DS and its prey, and acute exposures to plants, is 1.0.

Acute and chronic risks to aquatic organisms are estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs in **Table 3.3** based on the label-recommended simazine usage scenarios summarized in **Table 3.1** and the appropriate aquatic toxicity endpoint from **Table 4.2.** Exposures are also derived for terrestrial plants, as discussed in Section **Table 3.3** and summarized in **Table 2.3**, based on the highest application rates of simazine use within the action area.

5.1.1. Exposures in the Aquatic Habitat

Since DS habitat encompasses both freshwater and saltwater, the most sensitive aquatic endpoints from either freshwater or estuarine/marine toxicity tests are used to calculate RQs for both fish and aquatic invertebrates (see bolded endpoints in **Table 4.2**). The highest screening-level aquatic EEC (based on non-granular use of simazine on Christmas trees at 5.94 lbs ai/A) was initially used to derive risk quotients. In cases where LOCs were not exceeded based on this use pattern, additional RQs were not derived because it was assumed that RQs for lower EECs would also not exceed LOCs. However, if LOCs were exceeded based on the highest EECs, use-specific RQs were also derived.

5.1.1.a. Fish

Acute risk to fish is based on 1 in 10 year peak EECs in the standard pond and the lowest acute toxicity value for fish. Chronic risk is based on the 1 in 10 year 60-day EECs and the lowest chronic toxicity value for fish. Risk quotients for freshwater fish are shown in **Table 5.1**.

Table 5.1. Acute and Chronic RQs for Fish - Summary of Direct Effect RQs for the Delta Smelt

Uses/Application Rate	Species	Peak EEC (µg/L)	60-day EEC (µg/L)	Acute			Chronic RQ*
				RQ*	Probability[1] of individual effect at LOC	Probability[1] of individual effect at RQ	
Christmas trees/5.94 lb a.i./acre (liquid)	Seabream	130.2	91.4	0.03	1 in 4.18E+08 (1 in 216 to 1 in 1.75E+31)	1 in 2.76E+11 (1 in 862 to 1 in 2.14E+42)	0.14

* = LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0) are bolded and shaded. Acute RQ = use-specific peak EEC / [Seabream LC50= 4190 µg a.i./L]. Chronic RQ = use-specific 60-day EEC / [calculated seabream NOAEC = 625 µg a.i./L].

[1] A probit slope value for the acute seabream toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).

Based on acute toxicity data for the seabream (*Sparus aurata*), as well as chronic toxicity data calculated by applying an ACR from fathead minnow data (6400/960=6.7; ACR=6.7; MRIDs 00033309 and 00043676) to acute seabream data, simazine **does not** have the potential to directly affect the DS (**Table 5.1**). Probabilities are also quite low for individual effects at the LOC or RQ (ranging from 1 in 216 to 1 in 2.14E=42). RQs were calculated only for the use that resulted in the highest EEC (foliar use on Christmas trees at 5.94 lb ai/A) because none of the acute or chronic LOCs were exceeded. These RQs are further characterized in **Section 5.2.1.**

5.1.1.b. Aquatic Invertebrates

Acute risk to aquatic invertebrates is based on 1 in 10 year peak EECs in the standard pond and the lowest acute toxicity value for aquatic invertebrates. Chronic risk is based on 1 in 10 year

21-day EECs and the lowest chronic toxicity value for aquatic invertebrates. Risk quotients for the most sensitive aquatic invertebrates (freshwater and saltwater) are shown in **Table 5.2**.

Table 5.2. Summary of Acute and Chronic RQs for Aquatic Invertebrates.

Uses	Application rate (lb ai/A) and type*	Peak EEC (µg/L)	21-day EEC (µg/L)	Acute		Indirect Effects Chronic RQ**
				Indirect Effects Acute RQ**	% Expected Effect on Prey Population at RQ***	
Christmas trees	5.94 (liquid)	130.2	127.2	**0.13**	<0.01 (<0.01-3.8)	**3.18**
Berries[1]	4 (liquid)	108.4	105.4	**0.11**	<0.01 (<0.01-2.8)	**2.64**
	4 (granular)	103.4	100.5	**0.10**	<0.01 (<0.01-2.3)	**2.51**
Tree plantations	4 (liquid)	88.0	85.6	**0.09**	<0.01 (<0.01-1.8)	**2.14**
Tree nurseries	4 (liquid)	68.2	66.3	**0.07**	<0.01(<0.01-1.0)	**1.66**
Non-cropland[2]	5 (liquid)	66.0	64.6	**0.07**	<0.01 (<0.01-1.0)	**1.62**
Non-bearing fruit[3]	8 (granular)	61.5	59.8	**0.06**	<0. 01 (<0.01-0.7)	**1.50**
Avocados	4 (liquid)	53.5	51.9	**0.05**	<0. 01 (<0.01-0.5)	**1.30**
Olives	4 (liquid)	33.9	29.9	0.03	<0. 01 (<0.01-0.1)	0.75
Nuts (high rate)[4]	4 (liquid)	25.6	25.0	0.03	<0. 01 (<0.01-0.1)	0.63
Grapes	4.8 (liquid)	18.2	17.6	0.02	<0. 01 (<0.01-0.03)	0.44
Nuts (low rate)[5]	2 (liquid)	12.8	12.5	0.01	<0. 01	0.31
Corn	2 (liquid)	12.3	11.9	0.01	<0. 01	0.30
Shelterbelts	3 (granular)	12.0	9.3	0.01	<0. 01	0.23
Fruit (low and high rates)[6]	2 and 4 (liquid)	5.6 - 11.1	5.4 – 10.9	0.01	<0. 01	0.14-0.27
Citrus[7]	4 (liquid)	7.1	6.9	0.01	<0. 01	0.17
Turf (residential, recreational, and sod farm)	1 (2 liquid and granular applications w/30 day interval)	4.3 – 8.8	4.2 – 8.6	≤0.01	<0. 01	0.11-0.22

* Simazine is applied once/season via ground application, unless otherwise noted.
** = LOC exceedances (acute RQ for endangered species ≥ 0.05; chronic RQ ≥ 1.0) are bolded and shaded. Acute RQ = use-specific peak EEC / daphnia TL_{50} value of 1,000 µg/L (MRID 00043676). Chronic RQ = use-specific 21-day EEC / daphnia NOAEC value of 40 µg ai/L (calculated endpoint).
***The probit dose-response slope value for the water flea is not available; therefore, the % expected effect on prey population was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).
[1] Specifically: blueberries, blackberries, boysenberries, loganberries, raspberries, and cranberries
[2] Specifically: commercial, industrial, institutional premises, equipment, highways, and rights-of-way
[3] Specifically: apples, cherries, peaches, and pears
[4] Specifically: filberts, hazelnuts, macadamia nuts, and walnuts
[5] Specifically: almonds
[6] Specifically: apples, cherries, pears, nectarines, and peaches
[7] Specifically: grapefruits, lemons, and oranges

Indirect acute and chronic effects to the DS via effects to prey (invertebrates) in aquatic habitats are expected. For chronic risks, 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive RQs. A summary of the acute and chronic RQ values for exposure to aquatic invertebrates (as prey items of the DS) is provided in **Table 5.2**. Chronic RQs exceed the LOCs (RQ $\geq$ 1.0) for liquid applications of simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), and berries, tree plantations, tree nurseries, and avocados (4 lb ai/A); LOCs are also exceed for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A). Acute RQs from 0.05 to 0.13 exceed the LOC for endangered species (0.05) but the probabilities are low (<0.01 to 3.8%); all acute RQs are less than LOCs for non-listed species (RQ = 0.5).

As previously mentioned in the effects section, an ACR of 25 was used to calculate the chronic daphnid endpoint. This ACR was from atrazine toxicity data for *D. magna*. For comparison, if the ACR from simazine fish toxicity data (6.7) is applied, then the chronic endpoint would be 149 µg/L and no exceedences of the chronic LOC would be found. The chronic endpoint of 40 µg/L is used in this risk assessment because of the uncertainties involved and the fact that this value is the most conservative available. Even though it is two orders of magnitude below submitted chronic toxicity data (2000 µg/L) it is based on the acute endpoint of 1000 µg/L which has been determined to be an appropriate endpoint per EPA response to comments a previous risk assessment (D313255). EPA considered arguments against the use of the 1000 µg/L EC_{50} chronic endpoint for *D. magna*, cited in Sanders (1970), and decided that it is indeed an appropriate value for use in risk assessments, but acknowledged uncertainties due to an absence of measured test substance concentrations. Therefore, until data is submitted with mean measured concentrations to reduce uncertainty this endpoint will be used.

Indirect effects to DS **are** possible based on a reduction of freshwater invertebrates as prey (via chronic toxicity to freshwater invertebrates). Based on chronic exceedences, simazine **does** have the potential to indirectly affect the DS.

5.1.1.c. Aquatic Plants

Acute risk to aquatic vascular and non-vascular plants is based on 1 in 10 year peak EECs in the standard pond and the lowest acute toxicity value. Risk quotients are shown in **Table 5.3**.

Table 5.3. Summary of Acute RQs for Vascular and Non-Vascular Aquatic Plants.

Uses	Application rate (lb ai/A) and type*	Peak EEC (µg/L)	Aquatic Plant RQs** (food and habitat for DS)	
			Vascular	Non-vascular
Christmas trees	5.94 (liquid)	130.2	0.93	**3.62**
Berries[1]	4 (liquid)	108.4	0.77	**3.01**
	4 (granular)	103.4	0.74	**2.87**
Tree plantations	4 (liquid)	88.0	0.63	**2.44**
Tree nurseries	4 (liquid)	68.2	0.49	**1.89**
Non-cropland[2]	5 (liquid)	66.04	0.47	**1.83**
Non-bearing fruit[3]	8 (granular)	61.5	0.44	**1.71**
Avocados	4 (liquid)	53.5	0.38	**1.49**
Olives	4 (liquid)	33.9	0.24	0.94
Nuts (high rate)[4]	4 (liquid)	25.6	0.18	0.71
Grapes	4.8 (liquid)	18.2	0.13	0.51
Nuts (low rate)[5]	2 (liquid)	12.8	0.09	0.36
Corn	2 (liquid)	12.3	0.09	0.34
Shelterbelts	3 (granular)	12.0	0.09	0.33
Fruit (low and high rates)[6]	2 and 4 (liquid)	5.6 - 11.1	0.08	0.04 - 0.31
Citrus[7]	4 (liquid)	7.1	0.05	0.20
Turf (residential, recreational, and sod farm)	1 (2 liquid and granular applications w/30 day interval)	4.3 – 8.8	0.03 – 0.06	0.03 – 0.06

* Simazine is applied once/season via ground application, unless otherwise noted.
** LOC exceedances (RQ $\geq$ 1) are bolded and shaded. Vascular RQ = use-specific peak EEC / duckweed EC_{50} value of 140 µg/L (MRID 42503704). Non-vascular RQ = use-specific peak EEC / blue green algae EC_{50} value of 36 µg/L (MRID 42662401).
[1] Specifically: blueberries, blackberries, boysenberries, loganberries, raspberries, and cranberries
[2] Specifically: commercial, industrial, institutional premises, equipment, highways, and rights-of-way
[3] Specifically: apples, cherries, peaches, and pears
[4] Specifically: filberts, hazelnuts, macadamia nuts, and walnuts
[5] Specifically: almonds
[6] Specifically: apples, cherries, pears, nectarines, and peaches
[7] Specifically: grapefruits, lemons, and oranges

Indirect effects of simazine to the DS via reduction in vascular and non-vascular aquatic plants in the diet of DS larvae, as well as habitat for all age groups of DS, are based on peak EECs and the lowest acute toxicity value for aquatic vascular and non-vascular plants. As shown in **Table 5.3,** RQs exceed the acute risk LOC (RQ $\geq$1.0) for aquatic non-vascular plants for liquid applications of simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), berries, tree plantations, tree nurseries, and avocados (4 lb ai/A), and granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) with RQ values ranging from 1.49 to 3.62. Since the acute RQs are exceeded, there **is** a potential for indirect effects to the DS. The preliminary effects determination is “may effect”, based on indirect effects to the DS from a reduction in non-vascular aquatic plants as food items.

5.1.2. Exposures in the Terrestrial Habitat

5.1.2.a. Terrestrial Plants

Potential indirect effects to the DS resulting from direct effects on riparian vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. Risk quotients are shown in **Table 5.4** and **Table 5.5.** Based on the results of the submitted terrestrial plant toxicity tests, it appears that dicot plants are more sensitive in the emerged seedling test than the vegetative vigor test. However, all tested plants, with the exception of corn, exhibited adverse effects in both the seedling emergence and vegetative vigor test, following exposure to simazine. The results of these tests indicate that a variety of terrestrial plants that may inhabit riparian zones may be sensitive to simazine exposure.

Table 5.4. RQs for Monocots Inhabiting Dry and Semi-Aquatic Areas Exposed to Simazine via Runoff and Drift.

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ*	Dry area RQ	Semi-aquatic area RQ
Christmas trees	5.94	Foliar - ground	1	**2.97**	**5.94**	**32.67**
Non-cropland	5	Foliar - aerial	5	**12.5**	**15**	**37.5**
Grapes	4.8	Foliar - ground	1	**2.40**	**4.80**	**26.40**
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries	4	Foliar - ground	1	**2.0**	**4.0**	**22.0**
Almonds, Nectarines, Peaches, Corn, and Turf	2	Foliar - ground	1	**1.0**	**2.0**	**11.0**
Rights-of-Way and Non-bearing Fruit	8	Granular	0	NA	**4.0**	**40.0**
Berries	4	Granular	0	NA	**2.0**	**20.0**
Shelterbelts	3	Granular	0	NA	**1.5**	**15.0**
Turf	2	Granular	0	NA	**1.0**	**10.0**
* = LOC exceedances (RQ $\geq$ 1) are bolded and shaded.						

Table 5.5. RQs for Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Simazine via Runoff and Drift.

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ*	Dry area RQ	Semi-aquatic area RQ
Christmas trees	5.94	Foliar - ground	1	**6.60**	**13.20**	**72.60**
Non-cropland	5	Foliar - aerial	5	**27.78**	**33.33**	**83.33**
Grapes	4.8	Foliar - ground	1	**5.33**	**10.67**	**58.67**
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries	4	Foliar - ground	1	**4.44**	**8.89**	**48.89**
Almonds, Nectarines, Peaches, Corn, and Turf	2	Foliar - ground	1	**2.22**	**4.44**	**24.44**
Rights-of-Way and Non-bearing Fruit	8	Granular	0	NA	**8.89**	**88.89**
Berries	4	Granular	0	NA	**4.44**	**44.44**
Shelterbelts	3	Granular	0	NA	**3.33**	**33.33**
Turf	2	Granular	0	NA	**2.22**	**22.22**
* = LOC exceedances (RQ $\geq$ 1) are bolded and shaded.						

For monocot and dicot plants inhabiting dry and semi-aquatic areas, the LOC (RQ $\geq$ 1.0) is exceeded for exposures resulting from single applications of all non-granular and granular uses of simazine (**Table 5.4** and **Table 5.5)**. In addition, spray drift RQs exceed LOCs for all non-granular uses of simazine for both monocot and dicot plants. Example output from TerrPlant v.1.2.2 is provided in **Appendix F.** The preliminary effects determination for indirect effects to DS via reduction in the terrestrial plant community is "**may affect**".

Based on these results since the non-listed plant RQs are exceeded, there **is** a potential for indirect effects to the DS via habitat alteration (mostly due to runoff and sedimentation changes, which can also affect water quality).

5.1.3. Primary Constituent Elements of Designated Critical Habitat

For simazine use, the assessment endpoints for designated critical habitat PCEs involve the same endpoints as those being assessed for potential direct and indirect effects to the DS. 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.

All four assessment endpoints for the primary constituent elements (PCEs, **Table 2.6**) of designated critical habitat for the DS (spawning habitat, juvenile hatching and transport, rearing habitat and adult migration) involve potential effects to aquatic and/or terrestrial plants and one involves potential effects to aquatic invertebrates:

- Simazine may affect sensitive freshwater invertebrates that are food to the DS (PCE 3); and as such, part of their critical habitat. This applies to liquid simazine uses on: Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. Simazine may affect sensitive saltwater invertebrates that are food to the DS, and as such, part of their critical habitat. Invertebrates that inhabit isohaline (2 ppt) estuarine habitat are especially important; both freshwater and saltwater invertebrate data are used to estimate risk.
- The aquatic plant LOC is exceeded for non-vascular plants. Non-vascular plants are the chief food source for DS larvae and so this is especially important for areas used by the DS as spawning grounds and rearing (or growth and development) habitat (PCEs 1 and 3). This applies to liquid simazine uses on: Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit.
- The LOC for terrestrial plants is exceeded for all simazine uses. Riparian plants are a component of all four PCEs for the DS. Alterations in riparian vegetation can affect runoff/flow, water quality and sedimentation. Risk to plants is limited to grassy, herbaceous, riparian vegetation. Woody plants are not sensitive to simazine; therefore, temperature and shading impacts are unlikely.

PCEs include alteration of water quality characteristics necessary for normal growth and viability of DS and their food source, especially in the rearing habitat. To assess the impact of simazine on this PCE, acute and chronic freshwater and saltwater fish and invertebrate toxicity endpoints, as well as endpoints for aquatic and terrestrial plants, are used as measures of effects. RQs for these endpoints were calculated in **Sections 5.1.1** through **5.1.2**.

The preliminary effects determination for all four DS PCEs of designated habitat is "**habitat modification**" based on the risk estimation provided in **Sections 5.1.2** and **5.1.3.**

5.2. Risk Description

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

If the RQs presented in the Risk Estimation (**Section 5.1**) show no direct or indirect effects for the assessed species, and no modification to PCEs of the designated critical habitat, a "no effect" determination is made, based on simazine'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 simazine. A preliminary effects determination for effects to the DS from simazine use is "**may affect**." A summary of the risk estimation results are provided in

Table 5.6 for direct and indirect effects to the DS and in **Table 5.6** for the PCEs of their designated critical habitat.

Table 5.6. Risk Estimation Summary for Simazine - Direct and Indirect Effects

Taxa	LOC Exceedances (Yes/No) for the Delta Smelt	Description of Results of Risk Estimation	Estimated Outcome for the DS
Freshwater Fish	Listed Species **No**	Acute and chronic endangered species freshwater fish LOCs **not exceeded** for any use.	No Effect
Freshwater Invertebrates	Non-listed Species **Yes**	Acute freshwater invertebrate LOC **not exceeded** for any use. Chronic LOC **exceeded** for Christmas trees, berries, tree plantations, tree nurseries, non-cropland, non-bearing fruit and avocados uses.	**Indirect Effects**
Estuarine/Marine Fish	Listed Species **No**	Acute and chronic endangered species saltwater fish LOCs **not exceeded** for any use.	No Effect
Estuarine/Marine Invertebrates	Non-listed Species **No**	Acute saltwater invertebrate LOCs **not exceeded** for any use. Chronic risk **could not be precluded for any uses**.	**Indirect Effects**
Vascular Aquatic Plants	Non-listed Species **No**	Aquatic vascular plant **LOC not exceeded** for any use.	No Effect
Non-Vascular Aquatic Plants	Non-listed Species **Yes**	Acute non-vascular plant LOC **not exceeded** for any use. Chronic LOC **exceeded** for Christmas trees, berries, tree plantations, tree nurseries, non-cropland, non-bearing fruit and avocados uses.	**Indirect Effects**
Terrestrial Plants - Monocots	Non-listed Species **Yes**	Terrestrial plant LOC **exceeded** for ALL uses	**Indirect Effects**
Terrestrial Plants - Dicots	Non-listed Species **Yes**	Terrestrial plant LOC **exceeded** for ALL uses	**Indirect Effects**

Table 5.7. Risk Estimation Summary for Simazine – Effects to Designated Critical Habitat. (PCEs)

Taxa	LOC Exceedances (Yes/No) for the Delta Smelt	Description of Results of Risk Estimation
Freshwater Fish	Listed Species **No**	Acute and chronic endangered species freshwater fish LOCs **not exceeded** for any use.
Freshwater Invertebrates	Non-listed Species[1] **Yes**	Acute freshwater invertebrate LOC **not exceeded** for any use. Chronic LOC **exceeded** for Christmas trees, berries, tree plantations, tree nurseries, non-cropland, non-bearing fruit and avocados uses.
Estuarine/Marine Fish	Listed Species **No**	Acute and chronic endangered species saltwater fish LOCs **not exceeded** for any use.
Estuarine/Marine Invertebrates	Non-listed Species[1] **Yes**	Acute saltwater invertebrate LOCs **not exceeded** for any use. Chronic risk to saltwater invertebrates **could not be precluded** due to lack of data.
Vascular Aquatic Plants	Non-listed Species[1] **No**	Aquatic vascular plant **LOC not exceeded** for any use.
Non-Vascular Aquatic Plants	Non-listed Species[1] **Yes**	Acute non-vascular plant LOC **not exceeded** for any use. Chronic LOC **exceeded** for Christmas trees, berries, tree plantations, tree nurseries, non-cropland, non-bearing fruit and avocados uses.
Terrestrial Plants - Monocots	Non-listed Species[1] **Yes**	Terrestrial plant LOC **exceeded** for ALL uses
Terrestrial Plants - Dicots	Non-listed Species[1] **Yes**	Terrestrial plant LOC **exceeded** for ALL uses

[1] Only non-listed LOCs were evaluated because the Delta smelt does not have an obligate relationship with this taxonomic group

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

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

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

A description of the risk and effects determination for each of the established assessment endpoints for the DS and their designated critical habitat is provided in **Sections 5.2.1** through **5.2.3**. The risk description begins with a discussion of the potential for direct effects, followed by a discussion of the potential for indirect effects, and ends with a discussion on the potential for modification to the critical habitat from the use of simazine. A discussion of any potential overlap between areas of concern and the species (including any designated critical habitat) assessed here is presented in the spatial analysis section (**Section 5.2.4**). If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects a No Effect determination is made.

5.2.1. Direct Effects to the Delta Smelt

Delta smelt must spend part of their life-cycle in both freshwater and saltwater. Larvae feed on freshwater algae and juveniles and adults feed mainly on zooplankton. These waterbodies can receive runoff and spray drift containing simazine and/or be affected by simazine effects to terrestrial plants which influence water temperature, water quality, shade, sedimentation and runoff. As shown in **Table 5.1**, acute and chronic RQs based on the highest modeled EECs for simazine use on Christmas trees (5.94 lb ai/A) and the most sensitive freshwater fish data are well below the Agency's acute and chronic risk LOCs. Comparison of the highest modeled surface water EEC (peak = 130 µg/L) with available NAWQA surface water monitoring data from California indicates that the peak modeled EEC is approximately two times higher than the maximum concentration of simazine (64.5 µg/L) detected in Mustang Creek in Merced County. Therefore, use of modeled EECs is assumed to provide a conservative measure of simazine exposures for DS.

Since DS inhabit both freshwater and saltwater, the most sensitive toxicity endpoints among freshwater and saltwater fish toxicity data are used to assess risk to DS from direct effects of simazine. Acute and chronic RQs (**Table 5.2**) based on the highest modeled EECs for simazine use on Christmas trees (5.94 lb ai/A) and the most sensitive fish data (seabream LC_{50} = 4190 µg a.i./L and NOAEC = 625 µg a.i./L, **Table 4.2**) are well below the Agency's acute and chronic risk LOCs. Comparison of the highest modeled surface water EEC (peak = 130 µg/L) with available NAWQA surface water monitoring data from California indicates that the peak modeled EEC is approximately two times higher than the maximum concentration of simazine (64.5 µg/L) detected in Mustang Creek in Merced County. Therefore, use of modeled EECs is assumed to provide a conservative measure of simazine exposures for DS.

Because raw data was not provided as part of the acute toxicity study for the seabream used as a surrogate for the DS, information is unavailable to estimate a slope for the dose response curve. Therefore, the probability of an individual effect to DS was calculated based on a default assumption of 4.5 (with lower and upper bounds of 2 and 9) (Urban and Cook, 1986). The corresponding estimated chance of an individual acute mortality to the DS at an RQ level of 0.03 is 1 in 2.76E+11 (with respective upper and lower bounds of 1 in 862 to 1 in 2.14E+42). Given the low probability of an individual mortality occurrence and acute and chronic RQs that are well below LOCs, simazine is not likely to cause direct adverse effects to DS.

As discussed in greater detail in **Section 4.2.1.b**, one open literature study raises questions about sublethal effects of simazine on endocrine-mediated olfactory functions in anadromous fish. Consideration of the sublethal data indicates that effects associated with endocrine-mediated olfactory functions may occur in anadromous fish including salmon at simazine concentrations as low as 0.1 µg/L (Moore and Lower, 2001). However, there are a number of limitations in the design of this study, which are addressed in detail in **Appendix G,** that preclude quantitative use of the data in this risk assessment. Authors did not quantitatively link the sublethal effects to the selected endpoints for the DS (*i.e.*, survival, growth, and reproduction of individuals).

A number of freshwater microcosm, mesocosm, and field studies are available for simazine, although the lowest concentration of simazine tested in these studies was 1,000 µg/L, well above environmentally relevant concentrations. In many of the studies (summarized in **Appendix G**) , adverse effects to freshwater fish following simazine application are attributed to indirect effects including a combination of low DO and reduced food resources, rather than direct toxicity of simazine, which is not surprising given simazine's toxicity to aquatic plants, and exceedence of LOCs for non-vascular aquatic plants. Unfortunately, the available field study data are inadequate to determine whether simazine applications to aquatic habitats at levels of approximately 1,000 µg/L affect freshwater fish by direct toxicity or indirect effects such as low DO, lost food/habitat resources, and/or decreased ecosystem productivity in the absence of macrophytes. In addition to indirect effects associated with low DO, the results of a field study by Tucker and Boyd (1978) suggest a possible direct effect of simazine on the feeding response of channel catfish, following direct application of 1,300 µg/L to earthen channel catfish ponds infested with stonewort. However, the application rate of simazine used in this study is approximately three times higher than current labels allow and direct applications to water are restricted to ornamental ponds and aquariums of 1,000 gallons or less.

Although a number of freshwater aquatic incidents involving fish kills were reported for simazine between the years of 1980 and 1995, the majority of these incidents were the result of direct application of simazine to water bodies not in accordance with the current label restrictions for direct applications to ornamental ponds and aquaria less than 1,000 gallons. Notably, in most cases fish mortality was attributed to low dissolved oxygen from rotting vegetation, similar to the field study results, just described. A complete list of all the aquatic incidents involving simazine is included in **Appendix K.**

Using a weight-of-evidence approach, the following pieces of evidence were weighed:

- The LOC is not exceeded for fish (peak EECs range from 4.3 to 130.2 and the highest 60-d EEC was 91.4; lowest toxicity endpoints were seabream LC_{50} = 4190 µg a.i./L and NOAEC = 625 µg a.i./L); and
- NAWQA monitoring data do not show concentrations of simazine in the environment in a range toxic to aquatic animals.

From these lines of evidence, there **is not** a potential for direct effects to the Delta smelt from registered uses of simazine.

5.2.2. Indirect Effects to the Delta Smelt

5.2.2.a. Potential Loss of Food

Algae (Aquatic Non-Vascular Plants)

As discussed in Section 2.5, the diet of DS larvae is composed primarily of unicellular aquatic plants (i.e., algae and diatoms) and detritus. Based on RQs for algae (**Table 5.3**) liquid applications of simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), berries, tree plantations, tree nurseries, and avocados (4 lb ai/A), and granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) may affect this food source. RQs for non-vascular plants were based on the most sensitive EC_{50} value of 36 µg/L for freshwater blue-green algae (*Anabaena*). Further examination of toxicity data for other freshwater non-vascular plants (diatoms and *Selenastrum*) indicates that they are approximately three times less sensitive to simazine than blue-green algae with EC_{50} values ranging from 90 to 100 µg/L. However, the range of toxic endpoints for freshwater non-vascular plants falls within the range of peak modeled simazine concentrations for the use patterns mentioned above (48 to 130 µg/L), as well as peak measured concentrations of simazine in available monitoring data ($\leq$ 65 µg/L). The concentration of simazine in water would have to be < 36 µg/L to achieve RQ values for freshwater non-vascular aquatic plants that are less than LOCs.

Based on liquid applications of simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), berries, tree plantations, tree nurseries, and avocados (4 lb ai/A), and granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) simazine **does** have the potential to indirectly affect the delta smelt by impacting aquatic non-vascular plants.

As previously mentioned, the aerial non-cropland and non-residential granular uses of simazine will be cancelled later in 2010. In addition, simazine use on olives, nuts, grapes, corn, apples, cherries, pears, citrus, nectarines, peaches, and turf are not expected to indirectly impact DS larvae (via a reduction in non-vascular plants as food) because all RQs for these uses are below

LOCs. According to the 2002-2005 CA PUR data described in **Section 3.2.4.c** and summarized in **Table 3.1**, the highest simazine usage in California is reported for oranges and lemons (citrus), grapes, almonds and walnuts (nuts), avocados, olives, and peaches, which are not expected to cause effects to non-vascular plants as food for DS larvae.

Aquatic Invertebrates

As previously discussed in **Section 5.1.1.b**, acute RQs (**Table 5.2**) calculated using modeled peak aquatic EECs and the 48-hour TL_{50} for the water flea, *Daphnia magna*, did not exceed the non-endangered species LOC.   Raw data was not provided as part of the acute toxicity study for *Daphnia*; therefore, the probability of an individual effect to freshwater invertebrates was calculated based on a default assumption of 4.5 (with lower and upper bounds of 2 and 9) (Urban and Cook, 1986). The corresponding estimated chance of an individual acute mortality/ immobilization to a freshwater invertebrate at an RQ level of 0.13 is 1 in 29,900 (with respective upper and lower bounds of 1 in 26 and 1 in 1.31E+15).

The lowest chronic toxicity value from a submitted study was a *Daphnia* NOAEC value of 2,000 µg/L for the 80% formulated product of simazine. As previously discussed in **Section 4.2.2.b**, chronic toxicity data for freshwater invertebrates using the TGAI were not available, although acute data for freshwater fish show that the formulated products of simazine are less toxic than the TGAI. Therefore, use of the formulated product chronic toxicity for freshwater invertebrates may underestimate potential effects, given the available data for freshwater fish. In addition, there is uncertainty associated with the NOAEC value of 2,000 µg/L because no adverse effects to parental mortality or production of offspring were observed at this highest test concentration, despite an acute TL_{50} value (1,000 µg/L) for the same genus of freshwater invertebrate (*Daphnia*) that is two times lower than the chronic NOAEC. Due to the uncertainty of this chronic endpoint, a more conservative approach was taken. Using an acute to chronic ratio (ACR) from atrazine, a closely related chlorotriazine herbicide, with the *D. magna* acute endpoint (48-hour LC_{50} = 1,000 µg a.i./L) a chronic endpoint was calculated (NOAEC = 40 µg a.i./L).   Applying this new chronic endpoint to the 21-day EECs the chronic LOC was exceeded for simazine uses related to liquid applications simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), berries, tree plantations, tree nurseries, and avocados (4 lb ai/A), and granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).

DS juveniles and adults feed on zooplankton, primarily consuming planktonic copepods, cladocerans, amphipods, and insect larvae. The daphnid data described above is likely a good representative toxicity estimate for freshwater food items since most of the mentioned taxa are crustacea. For saltwater food items, however, the only available invertebrate data is from mollusca, which is probably not a good representative for DS saltwater food items. Although, mollusc larvae can also be planktonic (at least, for brief periods), they are not listed among DS chief food items. No exceedences of acute LOCs occurred using the acute endpoint from oyster data. Since no ACR was found for oysters, collembolans or corals among data from other triazine herbicides, chronic toxicity to saltwater invertebrates remains an unknown and cannot be precluded.

One study from the open literature showed effects at much lower concentrations (10 ug/L) than the oyster data (>296 to >3700 ug ai/L) but the exposure was not directly applicable. This data is from an open literature study on sublethal effects to corals (Owen *et al*., 2002). In this paper, authors exposed zooxanthellae (symbiotic indwelling algae) from three coral spp. (*Madracis mirabilis*, *Diplora strigos* and *Favia fragum*) to each of six herbicides for 6 h durations and estimated algal cell density every 2 h. After 6 h of exposure to simazine, the LOAEC based on cell density was 100 ug/L and the NOAEC was 10 ug/L. This applied to zooxanthallae from all three coral species. These data are supplemental since purity was not given, concentrations not measured and the method of exposure was not consistent with EPA guidance. This study raises interesting questions about sublethal effects to invertebrates based on indirect and interconnected mechanisms of toxicity. The taxon actually tested was the zooxanthallae, but the authors attempted to tie the herbicidal effects to sublethal effects to an animal life-form dependent on this symbiotic relationship. Since, as previously stated, crustacea and insects are the chief food items of the DS, this type of study is not directly applicable to effects to DS food, but certainly underscores the potential for effects from decreased primary productivity.

5.2.2.b. Potential Modification of Habitat

Aquatic Plants (Vascular and Non-vascular)

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. Emergent plants help reduce sediment loading and provide stability to nearshore areas and lower streambanks. In addition, vascular aquatic plants are important as attachment sites for egg masses of aquatic species.

Potential indirect effects to the DS based on impacts to habitat and/or primary production are assessed using RQs from freshwater aquatic vascular and non-vascular plant data. Based on RQs for non-vascular plants (previously described in **Section 5.1.1.c** and summarized in (**Table 5.3**), LOCs are exceeded for RQs for liquid applications of simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), berries, tree plantations, tree nurseries, and avocados (4 lb ai/A), and granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A). RQs for vascular plants are less than the LOC of 1 because the maximum peak EEC of 130 μg/L is less than the most sensitive duckweed EC_{50} value of 140 μg/L. Therefore, indirect effects to the DS via direct effects to vascular plants as habitat are not expected.

With respect to indirect effects to DS via direct habitat-related impacts to non-vascular plants, concentrations of simazine in aquatic systems near use sites could be high enough to affect sensitive algal species. As previously discussed in **Section 5.2.2.a**, the range of toxic endpoints for non-vascular plants falls with the range of peak modeled simazine concentrations and available monitoring data. Simazine concentrations in water would need to be < 36 μg/L to be below the LOC for non-vascular aquatic plants. In addition, recovery from the effects of simazine and the development of resistance to the effects of simazine in some vascular and non-vascular aquatic plants have been reported and may add uncertainty to these findings.

In summary, the weight of evidence shows:

- The LOC is exceeded for non-vascular aquatic plants for some simazine uses, which could lead to:
  - reduced primary productivity;
  - reduced food specifically needed for juvenile DS;
  - dissolved oxygen crash from decomposing plant matter and affect the DS; and
  - changes in flow and reduction in streambank stability and substrate for egg attachment.
- Field study and incident data involving fish mortality (also see **Section 5.2.1**) provide supporting evidence that a toxicity pathway exists in which aquatic plant mortality and decomposition, result in toxicity to the DS due to low dissolved oxygen.

Liquid applications of simazine to Christmas trees (5.94 lb ai/A), non-cropland (5 lb ai/A), berries, tree plantations, tree nurseries, and avocados (4 lb ai/A), and granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) **may** indirectly affect the DS via impacts to habitat and/or primary production through effects to non-vascular plants. The aerial non-cropland and non-residential granular uses of simazine are scheduled to be cancelled later in 2010.

<u>Terrestrial Plants</u>

Terrestrial plants serve several important habitat-related functions for the DS. 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.

Herbicides can adversely impact habitat in a number of ways. In the most extreme case, herbicides in spray drift and runoff from the site of application have the potential to kill (or reduce growth and/or biomass in) all or a substantial amount of the vegetation, thus removing or impacting structures which define the habitat, and reducing the functions (*e.g.*, cover, food supply for prey base) provided by the vegetation.

Simazine is a systemic herbicide that is absorbed by the plant through both the leaves and the roots. It acts by inhibiting photosynthesis within the targeted plant. Based on the available toxicity data for terrestrial plants, it appears that emerged dicot seedlings are more sensitive to simazine in the seedling emergence test than dicot plants in the vegetative vigor test. This is demonstrated by the difference in dicot response to the two guideline studies. The dicot EC_{25} values for the seedling emergence and vegetative vigor tests are 0.009 lb ai/A and 0.033 lb ai/A, respectively, representing almost a four-fold difference in sensitivity. Monocots show similar levels of sensitivity in the seedling emergence and vegetative vigor toxicity tests, and dicots and monocots show similar sensitivity in the vegetative vigor tests.

Riparian vegetation typically consists of three tiers of vegetation, which include a groundcover of grasses and forbs, an understory of shrubs and young trees, and an overstory of mature trees. While no guideline data are available on the toxicity of woody plants, the available toxicity information indicates that simazine is not likely to cause adverse effects to non-target woody plants (Wall, 2007). In addition, simazine is labeled for use around numerous woody species including citrus, tree nuts, and grapes, as well as uses associated with forestry, tree plantations/nurseries, woody shrubs, and shelterbelts. Therefore, simazine is generally not toxic to woody plants. Woody trees and shrubs in both upland and riparian habitats are expected to intercept some of the simazine that might otherwise be deposited on the more sensitive herbaceous species. Though upland herbaceous vegetation may be affected by simazine use, herbaceous plants are not as likely as woody plants to affect flow via runoff, and therefore, not considered as part of DS habitat effects in this assessment. Additionally, in natural systems, older plants, fallen leaves, and other debris often provide a litter layer, which may serve to protect newly emerging herbaceous plants.

As shown in **Table 5.4** and **Table 5.5,** RQs exceed LOCs for monocots and dicots inhabiting dry and semi-aquatic areas exposed to simazine via runoff and drift. In general, it appears that dicots are more sensitive than monocots to simazine in semi-aquatic areas. Dicots in semi-aquatic and dry areas are approximately 2 times more sensitive than monocots in similar areas; however, dicots and monocots show similar sensitivity to simazine in spray drift. Further examination of the terrestrial plant species sensitivity to simazine shows that for the tested species of monocots and dicots, 9 out of 10 species (all tested species with the exception of corn) are sensitive to simazine at maximum granular and non-granular application rates.

In summary, based on exceedance of the terrestrial plant LOCs for all simazine use patterns following runoff and spray drift to semi-aquatic and dry areas, the following general conclusions can be made with respect to potential harm to riparian habitat:

- Simazine may enter riparian areas via runoff and/or spray drift where it may be taken up by the plant by the leaves and roots of sensitive plants.

- Comparison of seedling emergence EC_{25} values to EECs estimated using Terrplant suggests that existing vegetation may be affected or inhibition of new growth may occur. Inhibition of new growth could result in degradation of high quality riparian habitat over time because as older growth dies from natural or anthropogenic causes, plant biomass may be prevented from being replenished in the riparian area. Inhibition of new growth may also slow the recovery of degraded riparian areas that function poorly due to sparse vegetation because simazine deposition onto bare soil would be expected to inhibit the growth of new vegetation. As stated previously, simazine is persistent and mobile; therefore, it is likely to be transported from soil surfaces during runoff events.

- Because LOCs were exceeded for 9 out of 10 species tested in the seedling emergence and vegetative vigor studies, it is likely that many species of herbaceous plants may be potentially affected by exposure to simazine via runoff and spray drift.

Based on a review of the simazine incidents for terrestrial plants, only three have been reported. In the first incident, a section of lawn grass was damaged following application of simazine to a swimming pool. In the remaining two incidents, both of which occurred on May 9, 2000, 130 acres of corn was damaged following aerial application of simazine and atrazine to corn, although both incidents were reported as “unlikely”. Although the reported number of simazine incidents for terrestrial plants is low, and due to uses either not relevant for this assessment (*i.e.* application to swimming pools) or cancelled (aerial application to corn), an absence of reports does not necessarily provide evidence of an absence of incidents. The only plant incidents that are reported are those that are alleged to occur on more than 45 percent of the acreage exposed to the pesticide. Therefore, an incident could impact 40% of an exposed crop and not be included in the EIIS database (unless it is reported by a non-registrant, such as a state agency, where data are not systemically collected.

In summary, terrestrial plant RQs are above LOCs; therefore, riparian vegetation **may** be affected. However, woody plants are generally not sensitive to environmentally-relevant simazine concentrations; therefore, effects on shading, bank stabilization, structural diversity (height classes) of vegetation, and woodlands are not expected. Given that riparian areas are comprised of a mixture of both non-sensitive woody (trees and shrubs) and sensitive grassy herbaceous vegetation, the DS may be indirectly affected by adverse effects to herbaceous vegetation.

5.2.3. Modification of Designated Critical Habitat

Based on the weight-of-evidence, there is a potential for the modification of designated critical habitat, the following pieces of evidence were weighed:

- The level of concern, LOC, is exceeded for both terrestrial monocots and dicots in both semi-dry and dry areas subject to runoff of simazine from all uses;
- The LOC is exceeded for both terrestrial monocots and dicots from spray drift from all simazine uses, except rights-of-way, non-bearing fruit, berries, shelterbelts and turf; and
- The LOC is exceeded for freshwater invertebrates and aquatic non-vascular plants (both are DS food) from simazine uses on Christmas trees, berries, tree plantations, tree nurseries, non-cropland, non-bearing fruit and avocados.
- Incident reports confirm that pathways are complete for simazine effects to terrestrial plants.
- The LOC is not exceeded for saltwater invertebrates.
- Monitoring data does not show toxic aquatic concentrations of simazine.

From these lines of evidence, the following conclusions were drawn:

- simazine **is likely** to indirectly affect the DS through loss of food, via effects to non-vascular plants (algae, primary food source for DS larvae) and freshwater invertebrates (primary food source of older DS in their freshwater habitat); and
- simazine **is likely** to indirectly affect the DS through changes to sedimentation, water quality and runoff via effects to terrestrial monocots and dicots from all simazine uses.

In summary, the Agency concludes that effects to DS food and terrestrial plant components of DS critical habitat are **likely**. Therefore, based on the weight-of-evidence, a potential **exists** for effects to the Delta smelt in both freshwater and saltwater habitat.

5.2.4. Spatial Extent of Potential Effects

Since LOCs are exceeded, analysis of the spatial extent of potential LAA effects is needed to determine where effects may occur in relation to the treated site. If the potential area of usage and subsequent Potential Area of LAA Effects overlaps with DS habitat or areas of occurrence and/or critical habitat, a likely to adversely affect determination is made. If the Potential Area of LAA Effects and the DS habitat and areas of occurrence and/or critical habitat, do not overlap, a no effect determination is made.

To determine this area, the footprint of simazine's use pattern is identified, using corresponding land cover data, see **Section 2.7.** This footprint represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types that represent the labeled uses. 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 down stream or down wind from use sites where organisms relevant to the assessed species may be affected). The determination of the buffer distance and downstream dilution for spatial extent of the effects determination is described below.

5.2.5. Spray Drift

In order to determine terrestrial and aquatic habitats of concern due to simazine exposures through spray drift, it is necessary to estimate the distance that spray applications can drift from the treated area and still be present at concentrations that exceed levels of concern. Ground applications of simazine granular formulations are not expected to result in any spray drift. For the flowable uses, a quantitative analysis of spray drift distances was completed using AgDRIFT.

As previously described in **Section 2.4.1**, downwind spray drift buffers were developed to determine the distance required to dissipate spray drift to below the LOC, based on both NOAEC and EC_{25} levels for terrestrial plants. Dissipation to the no effect level was modeled in order to provide potential buffer distances that are protective of endangered terrestrial plant species; this distance beyond the site of application is normally considered as the action area. When no obligate relationship exists between a listed species and terrestrial plants, the portion of the action area that is relevant to the listed species, in this case the DS, is defined by the dissipation distance to the EC_{25} level (i.e., the potential buffer distance required to protect non-endangered terrestrial plant species). In this case the action area for simazine is the entire State of California; however, the spray distances are included for comparison between conditions before and after the new restrictions go into effect. The spray drift distances presented in **Table 5.8**Error! Reference source not found. were derived based on the most sensitive EC_{25} value for dicots in the seedling emergence test (0.009 lb ai/A) and of spray application specifics before and after the restrictions go into effect.

Of the proposed mitigation measures relevant to this assessment that are expected to become final in later in 2010, all aerial applications and non-residential granular uses will be cancelled in California and spray drift and buffer restriction language will be added to the labels. The proposed spray drift language includes specific application restrictions for wind speed (< 10 mph), droplet size (coarse or coarser ASAE standard 572 spray), and release height (nozzle height no more than 4 feet above ground or crop canopy). The proposed buffer restrictions prohibit application of simazine within 66 feet of streams and rivers and 200 feet of lakes and reservoirs.

Based on the maximum simazine aerial application rate of 5 lb ai/A (for non-cropland uses), a spray drift buffer of 3,891 feet from the site of application is required to dissipate to levels below the LOC. For ground applications, distances of 2765 ft (based on seedling emergence data) and 184 ft (based on vegetative vigor) are needed to protect dicots from effects to propagation and general health, respectively, implying that the proposed buffers of 66 ft for streams and rivers and 200 ft for lakes and reservoirs, may not be adequately protective for dicot propagation. Although the seedling emergence endpoint is more sensitive, the Agency anticipates adverse effects that could reasonably measured to terrestrial plants via drift exposures are better defined by the vegetative vigor endpoint. The vegetative vigor toxicity test is intended to assess the potential effects on plants following deposition of simazine on the leaves and above-ground portions of plants, which are more likely to receive exposure via spray drift. Therefore, spray drift distances are derived for the vegetative vigor endpoint, as well as the seedling emergence endpoint, for both monocots and dicots, in **Table 5.8**. The drift buffers for the more sensitive seedling emergence endpoint for dicots were derived using a higher tier of the AgDRIFT model because the 1,000 foot limit of Tier 1 AgDrift was exceeded. However, spray drift dissipation distances reported for the vegetative vigor endpoints and for the monocot seedling emergence endpoint were based on the Tier 1 AgDRIFT model because the limits of the model were not exceeded using the spray drift parameters provided in **Section 3.3**. As shown in **Table 5.8,** adverse effects to terrestrial plants might reasonably be expected to occur up to 850 feet from the use site for aerial applications and 184 feet from the use site for ground applications of simazine.

This distance is expected to decrease when the label changes canceling aerial applications and incorporating spray drift language are implemented later in 2010. The proposed spray drift language will result in smaller dissipation distances because restrictions on droplet size, to more coarse drops (ASAE standard 572 spray), will result in less drift. In some cases, topography (such as an intervening ridge) or weather conditions (such as prevailing winds towards or away from DS habitat) could affect the estimates presented in **Table 5.8**. However, analysis of these site-specific details is beyond the scope of this assessment, which analyzes risk based on the label language prior to these changes.

Table 5.8 Spray Drift Dissipation Distances

Use	Application Rate (lb ai/A)	Dissipation Distance (ft)[1]		
		Seedling Emergence		Vegetative Vigor (Monocots and Dicots)
		Monocot	Dicot	
Using Current Label				
Ground Applications				
Christmas trees	5.94	315	676	184
Grapes	4.8	253	554	144
Apples, Pears, Sour Cherries, Avocados, Berries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, and Tree Plantations and Nurseries	4	207	469	118
Almonds, Nectarines, Peaches, Corn, and Turf	2	95	230	56
Aerial Applications				
Non-cropland	5	2550	3891	850
Using Proposed New Label Restrictions				
Ground Applications				
Christmas trees	5.94	148	390	75
Grapes	4.8	112	305	56
Apples, Pears, Sour Cherries, Avocados, Berries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, and Tree Plantations and Nurseries	4	85	246	46
Almonds, Nectarines, Peaches, Corn, and Turf	2	36	98	20
Aerial Applications not included on proposed new label.				

[1] Based on endpoints for seedling emergence of 0.02 lb ai/A for monocots and 0.009 lb ai/A for dicots, and for vegetative vigor of 0.033 lb ai/A for both monocots and dicots.

Given that the greatest buffer distance is 3,891 feet for terrestrial plants, the area of effects from aerial applications may be quite large. Since this assessment assumes that the action area is the entire State of California, this distance is not used to define the action area, but is mentioned descriptively here and to compare potential benefit from mitigation measures. According to estimates presented in **Table 5.8** the proposed new label restrictions on droplet size result in buffer distances ranging from 20-75 ft based on vegetative vigor data and from 36-390 based on seedling emergence data. Therefore, the new label restrictions should decrease the buffer distance by approximately half.

5.2.5.a. Downstream Dilution Analysis

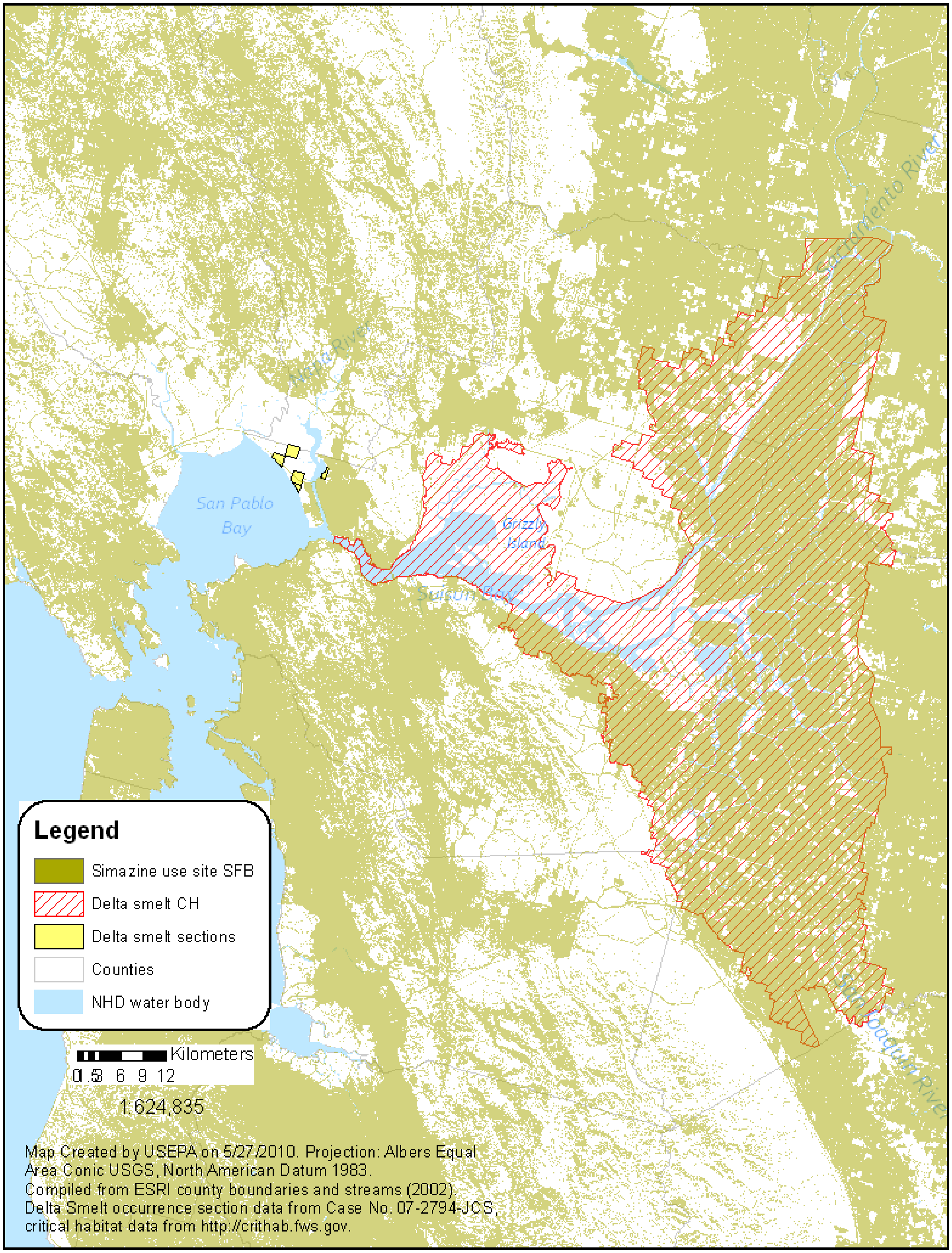
The downstream extent of exposure in streams and rivers where the EEC could potentially be above levels that would exceed the most sensitive LOC is calculated using the downstream dilution model. To complete this assessment, the greatest ratio of aquatic RQ to LOC was estimated. Using an assumption of 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 simazine present. The highest RQ/LOC ratio and the land cover class (Christmas trees) are used as inputs into the downstream dilution model.

Using a NOAEC for non-vascular aquatic plants (the most sensitive species) of 5.4 ug/L and a maximum peak EEC for applications to Christmas trees of 130 ug/L yields an RQ/LOC ratio of 24 (24/1). Using the downstream dilution approach (described in more detail in **Appendix E**) yields a target percent crop area (PCA) of 27.8%. This value has been input into the downstream dilution approach and results in a total of 18,704 kilometers of stream downstream from the initial area of concern (footprint of use). By way of comparison, there are 199,830 kilometers of streams within the initial area of concern, all of which are assumed to be at the modeled EEC. Similar to the spray drift buffer described above, the LAA/NLAA determination is based on the area defined by the point where concentrations exceed the EC_{50} value, in this case 36 ug/L (also for non-vascular aquatic plants). Applying the same approach to downstream extent yields a RQ/LOC ratio of 3.6 (3.6/1) which equates to a downstream dilution factor of 4.2% and adds a total of 10,885 kilometers to the initial area of concern.

5.2.5.b. Overlap of Potential Areas of LAA Effect and Habitat and Occurrence of the Delta Smelt

The spray drift and downstream dilution analyses help to identify areas of potential effect to the DS from registered uses of simazine. The Potential Area of LAA Effects on survival, growth, and reproduction for the DS from simazine spray drift extend from the site of application to 3891 feet from the site of application. For exposure to runoff and spray drift, the area of potential LAA effects extends up to a total of 10,885 km downstream from the site of application. When these distances are added to the footprint of the Initial Area of Concern (which represents potential simazine use sites) and compared to DS habitat, there are several areas of overlap (**Figure 5.1**). The overlap between the areas of LAA effect and DS habitat, including designated critical habitat, indicates that simazine use in California has the potential to affect the DS. More information on the spatial analysis is available in **Appendix E**.

Figure 5.1. Map Showing the Overlap of the Delta smelt habitat with cultivated, pasture, orchards and developed (all) land cover classes representing potential use sites.



5.3. Effects Determinations for the Delta Smelt

The Agency makes a **"may affect, and likely to adversely affect**" determination for the Delta smelt 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.

5.3.1. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in **Section 2.9.1**. Based on the conclusions of this assessment, only one of the hypotheses can be rejected, the hypothesis that labeled uses of simazine may directly affect the DS by causing mortality or by adversely affecting growth or fecundity. The other four stated hypotheses represent concerns in terms of direct and indirect effects of simazine on the DS and its designated critical habitat.

The labeled use of simazine may:

- indirectly affect DS and modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect DS and/or modify their designated critical habitat by reducing or changing the composition of the aquatic non-vascular plant community in the species' current range, thus affecting primary productivity and larval food supply;
- indirectly affect DS 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); and
- indirectly affect DS and/or modify their habitat by reducing or changing the composition of the terrestrial plant community in riparian zones and, thus, affecting sedimentation, water quality and runoff.

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

6.1.1. Aquatic Exposure Modeling of Simazine

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

The Agency acknowledges that there are some unique aquatic habitats that are not accurately captured by this modeling scenario and modeling results may, therefore, under- or over-estimate exposure, depending on a number of variables. The EXAMS pond is assumed to be representative of exposure to DS. In addition, the Services agree that the existing EXAMS pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004).

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 a farmer's field on a day-to-day basis. It considers factors such as rainfall and plant transpiration of water, as well as how and when the pesticide is applied. It has two major components: hydrology and chemical transport. Water movement is simulated by the use of generalized soil parameters, including field capacity, wilting point, and saturation water content. The chemical transport component can simulate pesticide application on the soil or on the plant foliage. Dissolved, adsorbed, and vapor-phase concentrations in the soil are estimated by simultaneously considering the processes of pesticide uptake by plants, surface runoff, erosion, decay, volatilization, foliar wash-off, advection, dispersion, and retardation.

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

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

6.1.2. Exposure in Estuarine/marine Environments

PRZM-EXAMS modeled EECs are intended to represent exposure of aquatic organisms in relatively small ponds and low-order streams. Therefore it is likely that EECs generated from the PRZM-EXAMS model will over-estimate potential concentrations in larger receiving water bodies such as estuaries, embayments, and coastal marine areas because chemicals in runoff water (or spray drift, etc.) should be diluted by a much larger volume of water than would be found in the 'typical' EXAMS pond. However, as chemical constituents in water draining from freshwater streams encounter brackish or other near-marine-associated conditions, there is potential for important chemical transformations to occur. Many chemical compounds can undergo changes in mobility, toxicity, or persistence when changes in pH, Eh (redox potential), salinity, dissolved oxygen (DO) content, or temperature are encountered. For example, desorption and re-mobilization of some chemicals from sediments can occur with changes in salinity (Jordan *et al.*, 2008; Means, 1995; Swarzenski *et al.*, 2003), changes in pH (*e.g.*, Wood and Baptista 1993; Parikh et al. 2004; Fernandez et al. 2005), Eh changes (Velde and Church, 1999; Wood and Baptista, 1993), and other factors. Thus, although chemicals in discharging rivers may be diluted by large volumes of water within receiving estuaries and embayments, the hydrochemistry of the marine-influenced water may negate some of the attenuating impact of the greater water volume; for example, the effect of dilution may be confounded by changes in chemical mobility (and/or bioavailability) in brackish water. In addition, freshwater contributions from discharging streams and rivers do not instantaneously mix with more saline water bodies. In these settings, water will commonly remain highly stratified, with fresh water lying atop denser, heavier saline water – meaning that exposure to concentrations found in discharging stream water may propagate some distance beyond the outflow point of the stream (especially near the water surface). Therefore, it is not assumed that discharging water will be rapidly diluted by the entire water volume within an estuary, embayment, or other coastal aquatic environment. PRZM-EXAMS model results should be considered consistent with concentrations that might be found near the head of an estuary unless there is specific information – such as monitoring data – to indicate otherwise. Conditions nearer to the mouth of a bay or estuary, however, may be closer to a marine-type system, and thus more subject to the notable buffering, mixing, and diluting capacities of an open marine environment. Conversely, tidal effects (pressure waves) can propagate much further upstream than the actual estuarine water, so discharging river water may become temporarily partially impounded near the mouth (discharge point) of a channel, and resistant to mixing until tidal forces are reversed.

The Agency does not currently have sufficient information regarding the hydrology and hydrochemistry of estuarine aquatic habitats to develop alternate scenarios for assessed listed species that inhabit these types of ecosystems. The Agency acknowledges that there are unique brackish and estuarine habitats that may not be accurately captured by PRZM-EXAMS modeling results, and may, therefore, under- or over-estimate exposure, depending on the aforementioned variables.

6.1.3. Modeled Versus Monitoring Concentrations

In order to account for uncertainties associated with modeling, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for simazine concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (*e.g.* application rates and timing, crops) associated with the agricultural areas are unknown, however, they are assumed to be representative of potential simazine use areas. Peak EECs resulting from different simazine uses ranged 5.6-130.2 µg/L. The maximum concentration of simazine reported by NAWQA (2000-2005) for California surface waters with agricultural watersheds (64.5 µg/L) was two times less than the maximum EEC, but within the range of EECs estimated for different uses. The maximum concentration of simazine reported by the California Department of Pesticide Regulation surface water database (2000-2006) (57.9µg/L) is roughly two times less than the highest peak EEC. Therefore, use of the PRZM/EXAMS EECs is assumed to represent a conservative measure of exposure.

6.2. Effects Assessment Uncertainties

6.2.1. Data Gaps and Uncertainties

Data gaps for this assessment were:

- saltwater fish chronic toxicity, and
- saltwater invertebrate chronic toxicity.

An endpoint was calculated, however, using a freshwater fish acute to chronic ratio (ACR) for simazine for saltwater fish, but no ACR was found for oysters, collembolans, or corals to use to calculate a saltwater invertebrate chronic endpoint, therefore, risk cannot be precluded for this taxon.

Uncertainties for this assessment were:

- exposure uncertainties, including combined effects with other pesticides;
- mean, measured concentrations not available for some aquatic studies;
- toxicity seen in aquatic toxicity tests near the saturation point for simazine, increasing uncertainty of actual test concentrations;
- some data from tests with formulated product;
- some aquatic endpoints that were suspect because listed concentrations were >100 mg/L, while simazine solubility in water at 20°C is 3.5 mg/L;
- crustacean data with the most sensitive *D. magna* endpoints having a lower acute than chronic effects concentration (**Table 4.1**)**,** and some reported endpoints being >100 mg/L (**Appendix G**);
- terrestrial plant toxicity tests conducted on herbaceous crop species only, and extrapolation to woody shrubs, trees and wild herbaceous species contributes to uncertainty;
- uncertainty inherent in extrapolating across taxa for direct chronic effects to saltwater fish;

- uncertainty inherent in extrapolating across pesticides for indirect effects from effects to freshwater invertebrate food;
- development of resistance to the effects of simazine in some vascular and non-vascular aquatic plants have been reported and may add uncertainty to these findings;
- uncertain toxicity mechanisms of simazine and its degradates;
- effects extrapolations from surrogate species to the Delta smelt; and
- age class sensitivity uncertainties for the Delta smelt.

6.2.2. Age Class and Sensitivity of Effects Thresholds

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

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

6.2.3. Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on simazine are not available for copepods, the chief food of the DS; therefore, other invertebrates are used as surrogate species for copepods. Endpoints based on daphnid and shrimp ecotoxicity data are assumed to be protective of potential indirect effects to the DS. 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.

6.2.4. 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.

Open literature is useful in identifying sublethal effects associated with exposure to simazine. These effects in freshwater fish include, but are not limited to, decreased response from olfactory epithelium and effects on endocrine-mediated processes. However, no data are available to link the sublethal measurement endpoints to direct mortality or diminished reproduction, growth and survival that are used by OPP as assessment endpoints. While the study by Moore and Lower (2001) attempted to relate the results of olfactory perfusion assays to decreased predator avoidance and homing response in salmon, there a number of uncertainties associated with the study that limit its utility. OPP acknowledges that sublethal effects have been associated with simazine exposure in aquatic systems; however, at this point there are insufficient data to definitively link the measurement endpoints to assessment endpoints. To the extent to which sublethal effects are not considered in this assessment, the potential direct and indirect effects of simazine on DS may be underestimated.

7. Risk Conclusions

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

Based on the best available information, the Agency makes a Likely to Adversely Affect determination for the Delta smelt. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the DS from the use of simazine. Given the LAA determination for the DS and potential modification of designated critical habitat for DS, a description of the baseline status and cumulative effects is provided in Attachment 3.

A summary of the risk conclusions and effects determinations for the Delta smelt and their critical habitat, given the uncertainties discussed in **Section 6** and **Attachment 1**, is presented in **Table 7.1** and **Table 7.2**. Use specific effects determinations are provided in **Table 7.3**.

Table 7.1. Effects Determination Summary for Effects of Simazine on the Delta Smelt

Species	Effects Determination	Basis for Determination
Delta smelt (*Hypomesus transpacificus*)	LAA[1]	**Potential for Direct Effects**
		Freshwater Life Stages (Eggs, Larvae, and Breeding Adults): No acute or chronic LOCs are exceeded for fish..
		Saltwater Life Stage (Juveniles and Adults): No acute or chronic LOCs were exceeded for fish
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity The acute and chronic LOCs for aquatic invertebrates are exceeded for uses on Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. There is overlap of the delta smelt habitat with these uses. The LOC for aquatic nonvascular plants is exceeded for uses on Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular uses on berries and non-bearing fruit. There is overlap of the delta smelt habitat with these uses. The LOC for aquatic vascular plants is not exceeded for any uses. Field study and incident data support a scenario of indirect effects to the DS through aquatic plant kills resulting in low dissolved oxygen from plant decomposition, and possibly through lowered food supply.
		Riparian habitat Riparian vegetation may be affected because terrestrial plant RQs are above the terrestrial plant LOC for all uses. There is overlap of delta smelt habitat with these uses. Risk to plants is limited to grassy, herbaceous, riparian vegetation (woody plants are not sensitive to simazine); therefore, impacts to flow (runoff) and sedimentation are the most likely effects.

[1]LAA=likely to adversely affect.

Table 7.2. Effects Determination Summary for the Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination	Basis for Determination
Modification of aquatic PCEs	**HM**[1]	As summarized in **Table 1.1**, simazine may affect sensitive freshwater invertebrates that are food to the DS; and as such, part of their critical habitat. This applies to liquid simazine uses on: Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. Simazine may affect sensitive saltwater invertebrates that are food to the DS, and as such, part of their critical habitat. Invertebrates that inhabit isohaline (2 ppt) estuarine habitat are especially important and both freshwater and saltwater invertebrate data are used to estimate risk.. The aquatic plant LOC is exceeded for non-vascular plants. Non-vascular plants are the chief food source for DS larvae and so this is especially important for areas used by the DS as spawning grounds and rearing habitat. This applies to liquid simazine uses on: Christmas trees, berries, tree plantations, tree nurseries, non-cropland and avocados; and granular simazine uses on berries and non-bearing fruit. Water quality can also be compromised due to low dissolved oxygen resulting from plant mortality and decomposition. The LOC for terrestrial plants is exceeded for all simazine uses. Riparian plants are a component of all four PCEs for the DS. Alterations in riparian vegetation can affect runoff/flow, water quality and sedimentation. Risk to plants is limited to grassy, herbaceous, riparian vegetation. Woody plants are not sensitive to simazine; therefore, temperature and shading impacts are unlikely

[1]Habitat Modification

Table 7.3. Simazine Use-specific Risk Summary for Delta smelt

Uses	Potential for Effects to Identified Taxa Found in the Aquatic Environment							
	AquaticVertebrates (Direct Effect to DS)		Aquatic Invertebrates (Indirect Effect to DS/Food)		Aquatic Plants (Indirect Effect to DS/ Food and Habitat)		Terrestrial Plants (Indirect Effect to DS/ Habitat)	
	Acute	Chronic	Acute	Chronic	Vascular	Non-vascular	Monocots	Dicots
Christmas trees	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Berries	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Tree plantations	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Tree nurseries	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Non-cropland	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Non-bearing fruit	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Avocados	No	No	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
Olives	No	No	No	No	No	No	**Yes**	**Yes**
Nuts (high rate)	No	No	No	No	No	No	**Yes**	**Yes**
Grapes	No	No	No	No	No	No	**Yes**	**Yes**
Nuts (low rate)	No	No	No	No	No	No	**Yes**	**Yes**
Corn	No	No	No	No	No	No	**Yes**	**Yes**
Shelterbelts	No	No	No	No	No	No	**Yes**	**Yes**
Fruit (low and high rates)	No	No	No	No	No	No	**Yes**	**Yes**
Citrus	No	No	No	No	No	No	**Yes**	**Yes**
Turf (residential, recreational, and sod farm)	No	No	No	No	No	No	**Yes**	**Yes**

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.

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 DS 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, identified by the letter E followed by a number, is located in Appendix H.

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9. MRID List

00024377	40614414	42634603
00025438	40614415	42634604
00027829	40614416	42662401
00027856	40614417	43004501
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00158638	42503702	47046103
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40614411	42503704	
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