Risks of Simazine Use to Federally Threatened California Red-legged Frog
(*Rana aurora draytonii*)

Pesticide Effects Determination

Environmental Fate and Effects Division
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1. Executive Summary

The purpose of this assessment is to evaluate potential direct and indirect effects on the California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of simazine as an herbicide on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of the species' designated critical habitat. 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 and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

The CRLF was listed as a threatened species by USFWS in 1996. The species is endemic to California and Baja California (Mexico) and inhabits both coastal and interior mountain ranges. A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS, 1996) in California.

Simazine is a triazine herbicide with currently, labeled uses including several fruit and nut crops, corn, and a number of non-agricultural uses including homeowner and recreational turf, Christmas trees, tree plantations and nurseries, shelterbelts, and nonselective weed control in industrial sites, highway medians, railroad rights-of-way, lumberyards, petroleum sites, and non crop areas on farms. The following uses are considered as part of the federal action evaluated in this assessment: almonds, nectarines, apples, pears, sour cherries, avocados, berries (blueberries, boysenberries, cranberries, loganberries, and raspberries), citrus (grapefruit, lemons, and oranges), nuts (almonds, filberts, hazelnuts, almonds, walnuts, macadamia nuts), grapes, olives, peaches, non-bearing fruit trees (apples, cherries, peaches, and pears), Christmas tree plantations for lumber, non-crop areas (includes commercial/industrial/institutional premises/equipment/highway uses), tree plantations, tree nurseries, shelterbelts, and residential, recreational, and sod farm turf. Simazine can be applied as a liquid via ground sprayer, banded application, or aerial broadcast, or as granular formulation.

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 and terrestrial habitats of the CRLF. 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 CRLF, 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 CRLF 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.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey and its habitats to simazine are assessed separately for the two habitats. 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. 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 than the highest peak model-estimated environmental concentration.

To estimate simazine exposures to the terrestrial-phase CRLF, and its potential prey resulting from uses involving simazine applications, the T-REX model is used for both foliar and granular uses. Terrestrial exposure from granular applications are based on LD_{50}/ft^2 values and an earthworm fugacity model. AgDRIFT and AgDISP are also used to estimate deposition of simazine on terrestrial habitats from spray drift. The TerrPlant model is used to estimate simazine exposures to terrestrial-phase habitat, including plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar and granular simazine applications

The assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF itself, as well as indirect effects, such as reduction of the prey base or modification of its habitat. Direct effects to the CRLF in the aquatic habitat are based on toxicity information for freshwater fish, which are generally used as a surrogate for aquatic-phase amphibians. In the terrestrial habitat, direct effects are based on toxicity information for birds, which are used as a surrogate for terrestrial-phase amphibians. Given that the CRLF's prey items and designated critical habitat requirements in the aquatic habitat are dependant on the availability of freshwater aquatic invertebrates and aquatic plants, toxicity information for these taxonomic groups is also discussed. In the terrestrial habitat, indirect effects due to depletion of prey are assessed by considering effects to terrestrial insects, small terrestrial mammals, and frogs. Indirect effects due to modification of the terrestrial habitat are characterized by available data for terrestrial monocots and dicots.

With respect to simazine degradates, deisopropylatrazine (DIA) and diaminochloroatrazine (DACT), it is assumed that each degradate is less toxic than the parent compound for aquatic receptors. Comparison of available toxicity information for

DIA and DACT indicates lesser aquatic toxicity than the parent for freshwater fish, invertebrates, and aquatic plants. However, the acute toxicity data for mammals indicates that DIA is more toxic than parent simazine, with a corresponding LD_{50} value of 1,240 mg/kg, as compared to > 5,000 mg/kg for simazine. Although the degradate toxicity data indicate that DIA is more toxic to mammals than parent simazine, indirect effects to terrestrial-phase CRLFs via direct acute effects to mammals are assessed using toxicity data for simazine because the available fate data show that DIA does not form and persist in the environment at any substantial level. Degradate toxicity data are 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 the simazine degradates are expected to lose efficacy as an herbicide.

Risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. Acute and chronic RQs are compared to the Agency's levels of concern (LOCs) to identify instances where simazine use within the action area has the potential to adversely affect the CRLF and its designated critical habitat via direct toxicity or indirectly based on direct effects to its food supply (*i.e.*, freshwater invertebrates, algae, fish, frogs, terrestrial invertebrates, and mammals) or habitat (*i.e.*, aquatic plants and terrestrial upland and riparian vegetation). When RQs for a particular type of effect are below LOCs, the pesticide is determined to have "no effect" on the subject species. Where RQs exceed LOCs, a potential to cause adverse effects is identified, leading to a conclusion of "may affect." If a determination is made that use of simazine use within the action area "may affect" the CRLF and its designated critical habitat, additional information is considered to refine the potential for exposure and effects, and the best available information is used to distinguish those actions that "may affect, but are not likely to adversely affect" (NLAA) from those actions that are "likely to adversely affect" (LAA) the CRLF and its critical habitat.

The best available data suggest that simazine is not likely to adversely affect the aquatic-phase CRLF by direct toxic effects or by indirect effects resulting from effects to aquatic invertebrates, fish, and other aquatic-phase frogs as food items. In addition, direct acute effects and indirect effects via reduction of terrestrial invertebrates as prey are not expected for terrestrial-phase CRLFs. However, an "LAA" determination was concluded for the aquatic-phase CRLF, based on indirect effects related to a reduction in algae as food items for the tadpole, and on aquatic non-vascular plants and sensitive herbaceous terrestrial plants that comprise its habitat. For the terrestrial-phase CRLF, an "LAA" determination was concluded for chronic direct effects and indirect effects related to a reduction in mammals and terrestrial-phase frogs as food items, and herbaceous terrestrial plants as habitat. Given these direct and indirect effects to the CRLF, modification of critical habitat is also expected for both aquatic and terrestrial primary constituent elements (PCEs). A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat is presented in Tables 1.1 and 1.2. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2.

Table 1.1 Effects Determination Summary for Direct and Indirect Effects of Simazine on the CRLF		
Assessment Endpoint	**Effects Determination[1]**	**Basis for Determination**
Aquatic-Phase CRLF (Eggs, Larvae, and Adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	No effect	Using freshwater fish as a surrogate, no acute and chronic LOCs are exceeded.
Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants, fish, and frogs)	<u>Freshwater invertebrates</u>: NLAA	Simazine may affect sensitive aquatic invertebrates, such as the water flea; however, the low probability (<4 %) of an individual effect to the water flea is not likely to indirectly affect the CRLF, given the wide range of other types of freshwater invertebrates that the species consumes. Based on the non-selective nature of feeding behavior in the CRLF, the low magnitude of anticipated acute individual effects to preferred aquatic invertebrate prey species (<0.1%), simazine is not likely to indirectly affect the CRLF via reduction in freshwater invertebrate food items. This finding is based on insignificant effects. The effects are insignificant because the probability of an individual effect level to freshwater invertebrates (< 4 % at predicted levels of exposure) is low and the most sensitive species of freshwater invertebrate species is likely to overestimate the sensitivity of the majority of freshwater invertebrate food items in the CRLF's diet.
	<u>Non-vascular aquatic plants</u>: LAA	Simazine uses related to liquid applications on 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) exceed LOCs; therefore, indirect effects to tadpoles that feed on algae are possible.
	<u>Fish and frogs</u>: No effect	Using freshwater fish as a surrogate, no acute and chronic LOCs are exceeded.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.,* aquatic plant community)	<u>Non-vascular aquatic plants</u>: LAA	LOCs are exceeded for non-vascular aquatic 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); LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).
	<u>Vascular aquatic plants:</u> No effect	RQs for vascular plants are less than LOCs for all simazine use patterns
Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the	<u>Direct effects to forested riparian vegetation:</u> NLAA <u>Direct effects to</u>	Riparian vegetation may be affected because terrestrial plant RQs are above LOCs. However, woody plants are generally not sensitive to environmentally-relevant concentrations of simazine; therefore, effects on shading, bank stabilization, and structural diversity of riparian

species' current range.	grassy/herbaceous riparian vegetation: LAA < 184 ft (ground) NLAA ≥ 184 ft (ground) LAA < 850 ft (aerial); NLAA ≥ 850 ft (aerial)	areas in the action area are not expected. Aquatic-phase CRLFs may be indirectly affected by adverse effects to sensitive herbaceous vegetation (based on all simazine non-granular and granular uses), which provides habitat and cover for the CRLF and attachment sites for its egg masses.
Terrestrial-Phase CRLF (Juveniles and adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Acute: No effect	The acute avian effects data (used as a surrogate for the terrestrial-phase CRLF) show no mortality at the highest treatment levels of simazine in both the acute oral and subacute dietary studies. In addition, the predicted granular EECs in mg ai/ft^2 are well below the adjusted LD_{50} values for two weight classes that are intended to be representative of juvenile and adult terrestrial-phase CRLFs.
	Chronic: LAA (for non-granular simazine uses) NLAA (for granular simazine uses)	Chronic reproductive effects are possible, based on non-granular uses of simazine. However, chronic direct effects to the CRLF exposed to granules are unlikely. This finding is based on discountable effects (*i.e.*, chronic effects to simazine granules are not likely to occur and/or result in a "take" of a single listed terrestrial-phase CRLF).
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	Terrestrial invertebrates: NLAA	Simazine is non-toxic to terrestrial invertebrates at environmentally relevant concentrations. This finding is based on discountable effects (*i.e.*, acute effects to simazine at the expected levels of exposure are not likely to occur and/or result in a "take" of a single listed CRLF via a reduction in terrestrial invertebrates as food items).
	Mammals: LAA	Chronic RQs for non-granular formulations exceed LOCs. Chronic effects to insectivorous mammals that consume invertebrates exposed to simazine granules are also possible.
	Frogs: LAA	Chronic risks for terrestrial-phase frogs exposed to non-granular uses of simazine may occur, although acute mortality is not likely.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	Direct effects to forested riparian vegetation: NLAA Direct effects to grassy/herbaceous riparian vegetation: LAA < 184 ft (ground) NLAA ≥ 184 ft (ground) LAA < 850 ft (aerial); NLAA ≥ 850 ft (aerial)	Riparian vegetation may be affected because terrestrial plant RQs are above LOCs. However, woody plants are generally not sensitive to environmentally-relevant concentrations of simazine; therefore, effects to woodlands within the action area are not expected. Terrestrial-phase CRLFs may be indirectly affected by adverse effects to sensitive herbaceous vegetation (based on all simazine non-granular and granular uses), which provides habitat and cover for the CRLF and its prey.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis		
Assessment Endpoint	**Effects Determination**	**Basis for Determination**
Aquatic-Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Habitat modification	Sensitive herbaceous riparian vegetation may be affected based on all granular and non-granular uses of simazine; therefore, critical habitat may be modified by an increase in sediment deposition and reduction in herbaceous riparian vegetation that provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult aquatic-phase CRLFs.
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[1]	Habitat modification	Sensitive herbaceous riparian vegetation and non-vascular aquatic plants may be affected; therefore, critical habitat may be modified via turbidity and reduction in oxygen content necessary for normal growth and viability of juvenile and adult aquatic-phase CRLFs.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	No effect to growth and viability Habitat modification based on alteration of food source	Direct effects to the aquatic-phase CRLF, via mortality, growth, and/or fecundity, are not expected. However, critical habitat of the CRLF may be modified via simazine-related impacts to non-vascular aquatic plants as food items for tadpoles. LOCs are exceeded for non-vascular aquatic 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); LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	Habitat modification	Based on the results of the effects determinations for aquatic plants, critical habitat of the CRLF may be modified via simazine-related impacts to non-vascular aquatic plants as food items for tadpoles. LOCs are exceeded for non-vascular aquatic 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); LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).
Terrestrial-Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that	Habitat modification	Modification to critical habitat may occur via simazine-related impacts to sensitive herbaceous vegetation, which provide habitat and cover for the terrestrial-phase CRLF and its prey, based on all assessed uses of simazine. Modification to critical habitat is not expected to occur in woodland areas

[1] Physico-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.

provides the CRLF shelter, forage, and predator avoidance		because woody plants are not sensitive to environmentally relevant concentrations of simazine.
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	Habitat modification	
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Habitat modification	Based on the characterization of indirect effects to terrestrial-phase CRLFs via reduction in the prey base, critical habitat may be modified via a reduction in mammals and terrestrial-phase amphibians as food items.
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Habitat modification	Direct acute effects, via mortality, are not expected for the terrestrial-phase CRLF; however, chronic reproductive effects are possible for all non-granular uses of simazine. Therefore, simazine may adversely critical habitat by altering chemical characteristics necessary for normal growth and viability of terrestrial-phase CRLFs and their mammalian and amphibian food sources.

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

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

- Enhanced information on the density and distribution of CRLF life stages within specific recovery units and/or designated critical habitat within the action area. 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 species.

- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, 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 frogs 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* (U.S. EPA 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS 1998) and is consistent with procedures and methodology outlined in the Overview Document (U.S. EPA 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS, 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 California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of simazine on agricultural crops (*i.e.*, almonds, apples, cherries, pears, nectarines, peaches, berries, avocado, citrus, grapes, olives, and corn) and non-agricultural commodities (*i.e.*, non-bearing apples; Christmas trees; tree plantations and nurseries; homeowner, recreational and sod farm turf; and non-cropland). In addition, this assessment evaluates whether these uses are expected to result in modification of the species' critical habitat. This ecological risk assessment has been prepared consistent with a settlement agreement in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-

JSW(JL)) settlement entered in Federal District Court for the Northern District of California on October 20, 2006.

In this assessment, direct and indirect effects to the CRLF and potential modification to its critical habitat are evaluated in accordance with the methods described in the Agency's Overview Document (U.S. EPA 2004). Screening level methods include use of standard models such as PRZM-EXAMS, T-REX, TerrPlant, AgDRIFT, and AgDISP, all of which are described at length in the Overview Document. Additional refinements include an analysis of the usage data, a spatial analysis, and use of an earthworm fugacity model to predict concentrations of simazine granules in terrestrial invertebrates food items for terrestrial-phase CRLFs and mammals. Use of such information is consistent with the methodology described in the Overview Document (U.S. EPA 2004), which specifies that "the assessment process may, on a case-by-case basis, incorporate additional methods, models, and lines of evidence that EPA finds technically appropriate for risk management objectives" (Section V, page 31 of U.S. EPA 2004).

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 CRLF 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 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".

Critical habitat identifies specific areas that have the physical and biological features, (known as primary constituent elements or PCEs) essential to the conservation of the listed species. The PCEs for CRLFs are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat.

If the results of initial screening-level assessment methods show no direct or indirect effects (no LOC exceedances) upon individual CRLFs or upon the PCEs of the species' designated critical habitat, a "no effect" determination is made for use of simazine as it relates to this species and its designated critical habitat. If, however, direct or indirect effects to individual CRLFs are anticipated or effects may impact the PCEs of the

CRLF's designated critical habitat, a preliminary "may affect" determination is made for the FIFRA regulatory action regarding simazine.

If a determination is made that use of simazine within the action area(s) associated with the CRLF "may affect" this species or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to the CRLF and other taxonomic groups upon which these species depend (*e.g.,* aquatic and terrestrial vertebrates and invertebrates, aquatic plants, riparian vegetation, *etc.*). Additional information, including spatial analysis (to determine the geographical proximity of CRLF habitat and simazine use sites) and further evaluation of the potential impact of simazine on the PCEs is also used to determine whether modification of designated critical habitat may occur. Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the CRLF or the PCEs of its designated critical habitat. This information is presented as part of the Risk Characterization in Section 5 of this document.

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 (defined in Section 2.7), 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 (*i.e.*, the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of simazine that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the CRLF's designated critical habitat have been identified by the Services and are discussed further in Section 2.6.

2.2 Scope

Simazine is 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.

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.

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

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 aquatic-phase CRLFs. Although the degradate toxicity data indicates that DIA is more toxic to mammals than parent simazine, indirect effects to terrestrial-phase CRLFs via direct acute effects to mammals are assessed using toxicity data for simazine because 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 provided in Section 4 and Appendix A.

The Agency does not routinely include, in its risk assessments, an evaluation of mixtures of active ingredients, either those mixtures of multiple active ingredients in product formulations or those in the applicator's tank. 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, the data may be used qualitatively or quantitatively in accordance with the Agency's Overview Document and the Services' Evaluation Memorandum (U.S., EPA 2004; USFWS/NMFS, 2004).

Simazine has registered products that contain multiple active ingredients. Analysis of the available open literature and acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in Appendix B. The results of this analysis show that an assessment based on the toxicity of the single active ingredient of simazine is appropriate.

The results of available toxicity data for mixtures of simazine with other pesticides are presented in Section A.6 of Appendix A. Based on a review of the available data, 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 CRLF is addressed as part of the uncertainty analysis for this effects determination.

2.3 Previous Assessments

A Reregistration Eligibility Decision (RED) was completed for simazine on April 6, 2006 (U.S. EPA, 2006)[2]. The results of the Agency's ecological risk assessment for simazine, which was completed as part of the RED, 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

[2] Available via the internet at: http://www.epa.gov/oppsrrd1/reregistration/REDs/simazine_red.pdf

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. Simazine is not likely to be acutely toxic to estuarine/marine fish and invertebrates, and it is unlikely to cause acute mortality to birds and mammals, although acute sublethal effects to birds are possible.

The Agency has also completed effects determinations for the Barton Springs salamander for simazine (U.S. EPA, 2007a) 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 show 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.

2.4 Stressor Source and Distribution

2.4.1 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 ≈ 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 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 (6.1×10^{-9} mm Hg at 20°C) and Henry's Law Constant (3.2×10^{-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.

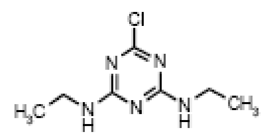
Table 2.1 Summary of Simazine Environmental Fate Properties

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
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)	00158638 43004501	Supplemental Supplemental

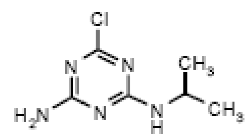
Table 2.1 Summary of Simazine Environmental Fate Properties				
Study	**Half-lives, Days**	**Major Degradates** ***Minor Degradates***	**MRID #**	**Study Status**
		GS-17792 and GS-28279		
Anaerobic Soil Metabolism	56 days (sandy loam)	none *G-28279, G-30414, G-28273, and GS-17792*	00027857	Supplemental
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
Terrestrial Field Dissipation	186 days (bareground, MN) max 0.13 ppm in 12-18" at day 270	*G-28279 and G-30414 (6-12")*	40614417	Unacceptable
	149 days (bareground, CA) 0.56 ppm in 6-12" at day 564	G-28279 (max 0.16 ppm 6-12" day 269) and G-30414 (max 0.57ppm 18-24" day 564)	40614418	Unacceptable
	33 days (citrus crop, FL) 0-8"	G-28279 (max 0.28 ppm 0-8" day 19) and G-30414 (max 0.01ppm 0-8" day 91)	40634201	Unacceptable
	44 days (bareground, FL) 0-8"	G-28279 (max 0.39 ppm 0-8" day 18) and G-30414 (max 0.52ppm 0-8" day 30)		
	26 days (citrus crop, FL) 0-8"	G-28279 (max 0.24ppm 0-8" day 15) and G-30414 (max 1.4ppm 0-8" day 15)	40634202	Unacceptable
	15 days (bareground, FL) 0-8"	G-28279 (max 0.31ppm 0-8" day 15) and G-30414 (max 0.83ppm 0-8" day 31)		Supplemental
	119 days (raspberries, OR) 0-8" 125 days (bareground, OR) 0-8"	G-28279 (max 1.1ppm 0-8") and G-30414 (max <0.09ppm 0-8")	40614413 40614414	Unacceptable
	110 days (corn plot, MO) 0-8" 101 days (bareground, MO) 0-8"	G-28279 (max <0.2ppm 0-8") and G-30414 (max <0.24ppm 0-8")	40614415 40614416	Unacceptable
	480 days (Nebraska) 12-24"	Not analyzed	00027863	Supplemental

Table 2.1 Summary of Simazine Environmental Fate Properties				
Study	**Half-lives, Days**	**Major Degradates** ***Minor Degradates***	**MRID #**	**Study Status**
Aquatic Field Dissipation	60 to 700 days in lakes	G-28279	00027829	Supplemental
	12 days in GA swimming pool water	G-28279 and G-30414	40614420	Supplemental
	53 days in IA man-made pond water	G-28279 and G-30414	40614422	Supplemental

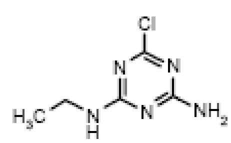
G-28279 = DIA/CEAT; G-28273 = DACT; G-30414 = Hydroxysimazine



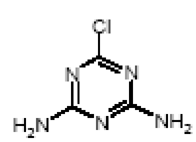
Simazine



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, Sparling et al., 2001, LeNoir et al., 1999, and McConnell et al., 1998). 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). Several sections of critical habitat for the CLRF 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 CRLF.

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) are 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 2007 growing season in California. Environmental exposures are estimated for assessed uses of simazine according to the label for the 2007 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 CRLF[1]		
Use[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
Filberts or Hazlenut	4 or 2 + 2[3]	1 2
Grapes	4.8	1
Macadamia Nuts	4	1
Olives	4	1
Peaches	2	1

Table 2.2 Simazine Uses Assessed for the CRLF[1]		
Use[2]	**Max. Single Appl. Rate (lb ai/A)**	**Max. Number of Application per Year**
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.

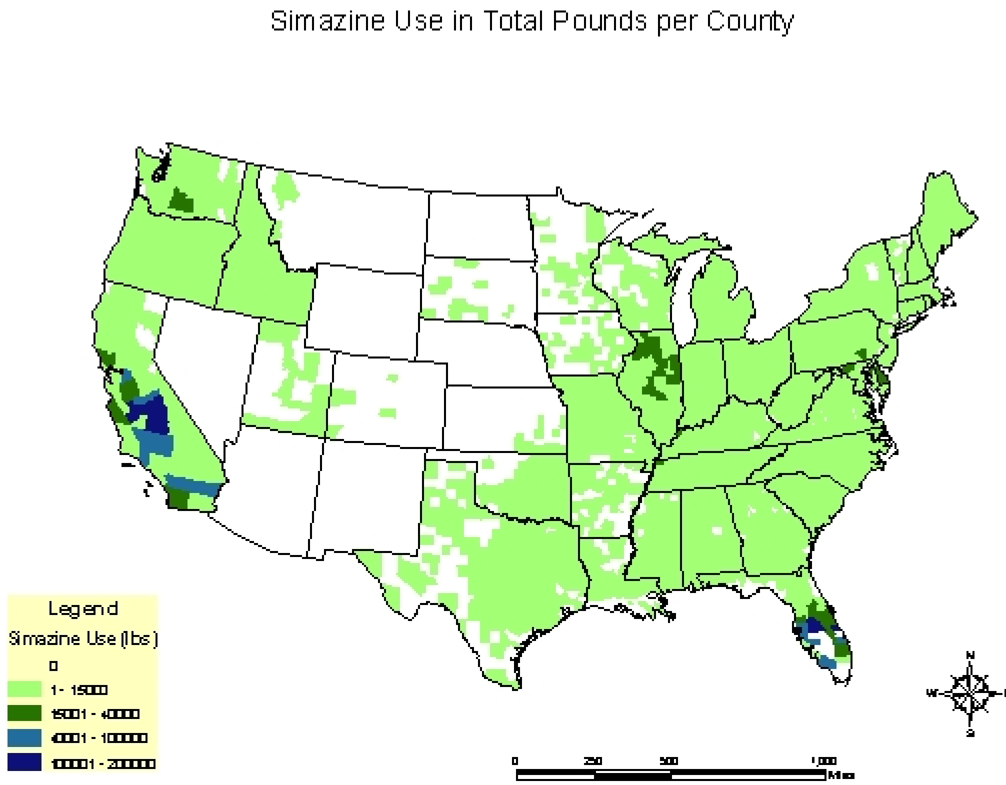


Figure 2.2 Simazine Use in Total Pounds per County

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[3], 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[4] . 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. Four years (2002-2005) of usage data were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved

[3] 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.
[4] 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.

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

Between 2002 and 2005, simazine was reportedly used in 53 counties in California. The principal use was on orchard vineyard crops including oranges, grapes, almonds, and walnuts. In addition, a non-agricultural use site (rights-of-way) had significant amount of use with the 6^{th} overall amount of pounds applied. The greatest average usage (average of pounds applied per commodity across all four years) was to oranges in Tulare county at roughly 112,000 lbs. By far, the greatest usage of simazine in California is to oranges at an average of approximately 200,000 lbs annually, followed by wine grapes at approximately 118,000 lbs annually, table grapes at an approximate average of 112,000 lbs annually, almonds at 60,000 lbs annually, walnuts at approximately 48,000 lbs annually, rights-of-way at 39,000 lbs annually, avocados at 16,000 lbs annually, lemons at 15,000 lbs annually, olives at 14,000 lbs annually, and peaches at 11,000 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.

Table 2.3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 2002 to 2005 for Currently Registered Simazine Uses

Site Name	Average Pounds All Uses	Avg App Rate All Uses	Avg 95th% App Rate	Avg 99th% App Rate	Avg Max App Rate
ORANGE	197336.1	2.1	3.3	4.2	7.9
GRAPE, WINE	117984.7	1.3	2.5	3.1	6.4
GRAPE	112477.7	1.4	2.4	2.7	5.6
ALMOND	59756.0	0.9	2.0	2.4	4.0
WALNUT	47506.6	1.5	4.0	5.6	8.3
RIGHTS OF WAY	38686.0	3.3	9.0	9.0	9.0
AVOCADO	16188.5	2.3	3.4	5.8	12.0
LEMON	14916.0	2.1	3.2	4.7	8.7
OLIVE	13975.0	1.4	2.3	2.8	4.7
PEACH	10727.2	1.4	2.0	2.2	3.1
LANDSCAPE MAINTENANCE	9690.3	0.5	0.5	0.5	0.5
NECTARINE	8123.1	2.7	3.2	3.6	4.6
GRAPEFRUIT	5021.9	2.0	3.3	3.7	4.5
PEAR	2530.7	1.7	2.5	4.3	4.3
APPLE	2107.5	1.4	2.0	2.1	2.1

Table 2.3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 2002 to 2005 for Currently Registered Simazine Uses					
Site Name	Average Pounds All Uses	Avg App Rate All Uses	Avg 95th% App Rate	Avg 99th% App Rate	Avg Max App Rate
UNCULTIVATED NON-AG	1184.2	2.2	3.6	3.8	3.8
N-OUTDR PLANTS IN CONTAINERS	851.7	2.2	4.8	6.5	7.0
PLUM	526.1	1.1	1.7	2.4	2.4
CITRUS	495.8	1.6	2.3	2.5	2.5
FOREST, TIMBERLAND	287.2	4.9	6.9	6.9	6.9
N-GRNHS FLOWER	267.0	3.1	3.7	3.8	3.8
TANGERINE	222.7	3.8	4.3	4.3	4.3
CHERRY	194.1	1.1	1.6	1.6	1.6
N-OUTDR FLOWER	183.3	2.3	4.0	4.4	4.4
UNCULTIVATED AG	159.1	2.0	2.6	2.6	2.6
BLUEBERRY	157.2	1.8	2.2	2.2	2.2
PECAN	118.8	0.9	1.4	1.4	1.4
LETTUCE	108.3	17.3	33.8	33.8	33.8
APRICOT	62.4	0.9	1.4	1.4	1.4
CORN	59.0	1.3	1.4	1.5	1.5
N-GRNHS PLANTS IN CONTAINERS	52.1	2.6	4.6	4.6	4.6
CHRISTMAS TREE	47.4	1.7	2.4	2.4	2.4
BOYSENBERRY	26.6	1.0	1.1	1.1	1.1
RANGELAND	20.5	1.4	1.4	1.4	1.4
PRUNE	17.7	1.4	2.2	2.2	2.2
STRAWBERRY	16.8	1.9	1.9	1.9	1.9
ALFALFA	16.1	1.4	1.7	1.7	1.7
N-OUTDR TRANSPLANTS	7.9	1.7	1.7	1.7	1.7
MINT	7.9	1.8	1.8	1.8	1.8
PERSIMMON	5.6	1.4	1.6	1.6	1.6
CAULIFLOWER	4.0	1.6	1.6	1.6	1.6
NUTS	1.4	3.6	3.6	3.6	3.6
PASTURELAND	1.3	0.4	0.4	0.4	0.4
RASPBERRY	0.8	0.4	0.5	0.5	0.5
TANGELO	0.7	1.0	1.0	1.0	1.0
COTTON	0.5	1.8	1.8	1.8	1.8
OAT	0.4	0.0	0.0	0.0	0.0
KIWI	0.3	0.4	0.4	0.4	0.4
BLACKBERRY	0.2	0.9	0.9	0.9	0.9

2.5 Assessed Species

The CRLF was federally listed as a threatened species by USFWS effective June 24, 1996 (USFWS, 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (USFWS, 2002). A brief summary of information regarding CRLF distribution, reproduction, diet, and habitat requirements is provided in Sections 2.5.1 through 2.5.4, respectively. Further information on the status, distribution, and life history of and specific threats to the CRLF is provided in Attachment 1.

Final critical habitat for the CRLF was designated by USFWS on April 13, 2006 (USFWS, 2006; 71 FR 19244-19346). Further information on designated critical habitat for the CRLF is provided in Section 2.6.

2.5.1 Distribution

The CRLF is endemic to California and Baja California (Mexico) and historically inhabited 46 counties in California including the Central Valley and both coastal and interior mountain ranges (USFWS, 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (USFWS, 1996). The species has an elevational range of near sea level to 1,500 meters (5,200 feet) (Jennings and Hayes, 1994); however, nearly all of the known CRLF populations have been documented below 1,050 meters (3,500 feet) (USFWS, 2002).

Populations currently exist along the northern California coast, northern Transverse Ranges (USFWS 2002), foothills of the Sierra Nevada (5-6 populations), and in southern California south of Santa Barbara (two populations) (Fellers, 2005a). Relatively larger numbers of CRLFs are located between Marin and Santa Barbara Counties (Jennings and Hayes 1994). A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS, 1996). Occupied drainages or watersheds include all bodies of water that support CRLFs (*i.e.*, streams, creeks, tributaries, associated natural and artificial ponds, and adjacent drainages), and habitats through which CRLFs can move (*i.e.*, riparian vegetation, uplands) (USFWS, 2002).

The distribution of CRLFs within California is addressed in this assessment using four categories of location including recovery units, core areas, designated critical habitat, and known occurrences of the CRLF reported in the California Natural Diversity Database (CNDDB) that are not included within core areas and/or designated critical habitat (see Figure 2.2). Recovery units, core areas, and other known occurrences of the CRLF from the CNDDB are described in further detail in this section, and designated critical habitat is addressed in Section 2.6. Recovery units are large areas defined at the watershed level that have similar conservation needs and management strategies. The recovery unit is primarily an administrative designation, and land area within the recovery unit boundary is not exclusively CRLF habitat. Core areas are smaller areas within the recovery units that comprise portions of the species' historic and current range and have been determined by USFWS to be important in the preservation of the species. Designated critical habitat is generally contained within the core areas, although a number of critical habitat units are outside the boundaries of core areas, but within the boundaries of the recovery units. Additional information on CRLF occurrences from the CNDDB is used to cover the current range of the species not included in core areas and/or designated critical habitat, but within the recovery units.

Recovery Units

Eight recovery units have been established by USFWS for the CRLF. These areas are considered essential to the recovery of the species, and the status of the CRLF "may be considered within the smaller scale of the recovery units, as opposed to the statewide range" (USFWS, 2002). Recovery units reflect areas with similar conservation needs and population statuses, and therefore, similar recovery goals. The eight units described for the CRLF are delineated by watershed boundaries defined by US Geological Survey hydrologic units and are limited to the elevational maximum for the species of 1,500 m above sea level. The eight recovery units for the CRLF are listed in Table 2.4 and shown in Figure 2.3.

Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see Figure 2.3). Table 2.4 summarizes the geographical relationship among recovery units, core areas, and designated critical habitat. The core areas, which are distributed throughout portions of the historic and current range of the species, represent areas that allow for long-term viability of existing populations and reestablishment of populations within historic range. These areas were selected because they: 1) contain existing viable populations; or 2) they contribute to the connectivity of other habitat areas (USFWS 2002). Core area protection and enhancement are vital for maintenance and expansion of the CRLF's distribution and population throughout its range.

For purposes of this assessment, designated critical habitat, currently occupied (post-1985) core areas, and additional known occurrences of the CRLF from the CNDDB are considered. Each type of locational information is evaluated within the broader context of recovery units. For example, if no labeled uses of *CHEM X* occur (or if labeled uses occur at predicted exposures less than the Agency's LOCs) within an entire recovery unit, a "no effect" determination would be made for all designated critical habitat, currently occupied core areas, and other known CNDDB occurrences within that recovery unit. Historically occupied sections of the core areas are not evaluated as part of this assessment because the USFWS Recovery Plan (USFWS 2002) indicates that CRLFs are extirpated from these areas. A summary of currently and historically occupied core areas is provided in Table 2.4 (currently occupied core areas are bolded). While core areas are considered essential for recovery of the CRLF, core areas are not federally-designated critical habitat, although designated critical habitat is generally contained within these core recovery areas. It should be noted, however, that several critical habitat units are located outside of the core areas, but within the recovery units. The focus of this assessment is currently occupied core areas, designated critical habitat, and other known CNDDB CRLF occurrences within the recovery units. Federally-designated critical habitat for the CRLF is further explained in Section 2.6.

Table 2.4 California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat

Recovery Unit [1] (Figure 2.a)	Core Areas [2,7] (Figure 2.a)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
Sierra Nevada Foothills and Central Valley (1) (eastern boundary is the 1,500m elevation line)	**Cottonwood Creek (partial) (8)**	--	✓	
	Feather River (1)	BUT-1A-B	✓	
	Yuba River-S. Fork Feather River (2)	YUB-1	✓	
	--	NEV-1[6]		
	Traverse Creek/Middle Fork American River/Rubicon (3)	--	✓	
	Consumnes River (4)	ELD-1	✓	
	S. Fork Calaveras River (5)	--		✓
	Tuolumne River (6)	--		✓
	Piney Creek (7)	--		✓
	East San Francisco Bay (partial)(16)	--	✓	
North Coast Range Foothills and Western Sacramento River Valley (2)	**Cottonwood Creek (8)**	--	✓	
	Putah Creek-Cache Creek (9)	--		✓
	Jameson Canyon – Lower Napa Valley (partial) (15)	--	✓	
	Belvedere Lagoon (partial) (14)	--	✓	
	Pt. Reyes Peninsula (partial) (13)	--	✓	
North Coast and North San Francisco Bay (3)	Putah Creek-Cache Creek (partial) (9)	--		✓
	Lake Berryessa Tributaries (10)	NAP-1	✓	
	Upper Sonoma Creek (11)	--	✓	
	Petaluma Creek-Sonoma Creek (12)	--	✓	
	Pt. Reyes Peninsula (13)	MRN-1, MRN-2	✓	
	Belvedere Lagoon (14)	--	✓	
	Jameson Canyon-Lower Napa River (15)	SOL-1	✓	
South and East San Francisco Bay (4)	--	CCS-1A[6]		
	East San Francisco Bay (partial) (16)	ALA-1A, ALA-1B, STC-1B	✓	
	--	STC-1A[6]		
	South San Francisco Bay	SNM-1A	✓	

	(partial) (18)			
Central Coast (5)	**South San Francisco Bay (partial) (18)**	SNM-1A, SNM-2C, SCZ-1	✓	
	Watsonville Slough- Elkhorn Slough (partial) (19)	SCZ-2 [5]	✓	
	Carmel River-Santa Lucia (20)	MNT-2	✓	
	Estero Bay (22)	--	✓	
	--	SLO-8[6]		
	Arroyo Grande Creek (23)	--	✓	
	Santa Maria River-Santa Ynez River (24)	--	✓	
Diablo Range and Salinas Valley (6)	**East San Francisco Bay (partial) (16)**	MER-1A-B, STC-1B	✓	
	--	SNB-1[6], SNB-2[6]		
	Santa Clara Valley (17)	--	✓	
	Watsonville Slough- Elkhorn Slough (partial)(19)	MNT-1	✓	
	Carmel River-Santa Lucia (partial)(20)	--	✓	
	Gablan Range (21)	SNB-3	✓	
	Estrella River (28)	SLO-1A-B	✓	
Northern Transverse Ranges and Tehachapi Mountains (7)	--	SLO-8[6]		
	Santa Maria River-Santa Ynez River (24)	STB-4, STB-5, STB-7	✓	
	Sisquoc River (25)	STB-1, STB-3	✓	
	Ventura River-Santa Clara River (26)	VEN-1, VEN-2, VEN-3	✓	
	--	LOS-1[6]		
Southern Transverse and Peninsular Ranges (8)	**Santa Monica Bay-Ventura Coastal Streams (27)**	--	✓	
	San Gabriel Mountain (29)	--		✓
	Forks of the Mojave (30)	--		✓
	Santa Ana Mountain (31)	--		✓
	Santa Rosa Plateau (32)	--	✓	
	San Luis Rey (33)	--		✓
	Sweetwater (34)	--		✓
	Laguna Mountain (35)	--		✓

[1] Recovery units designated by the USFWS (USFWS, 2000, pg 49).
[2] Core areas designated by the USFWS (USFWS, 2000, pg 51).
[3] Critical habitat units designated by the USFWS on April 13, 2006 (USFWS, 2006, 71 FR 19244-19346).
[4] Currently occupied (post-1985) and historically occupied core areas as designated by the USFWS (USFWS, 2002, pg 54).
[5] Critical habitat unit where identified threats specifically included pesticides or agricultural runoff (USFWS, 2002).
[6] Critical habitat units that are outside of core areas, but within recovery units.
[7] Currently occupied core areas that are included in this effects determination are bolded.

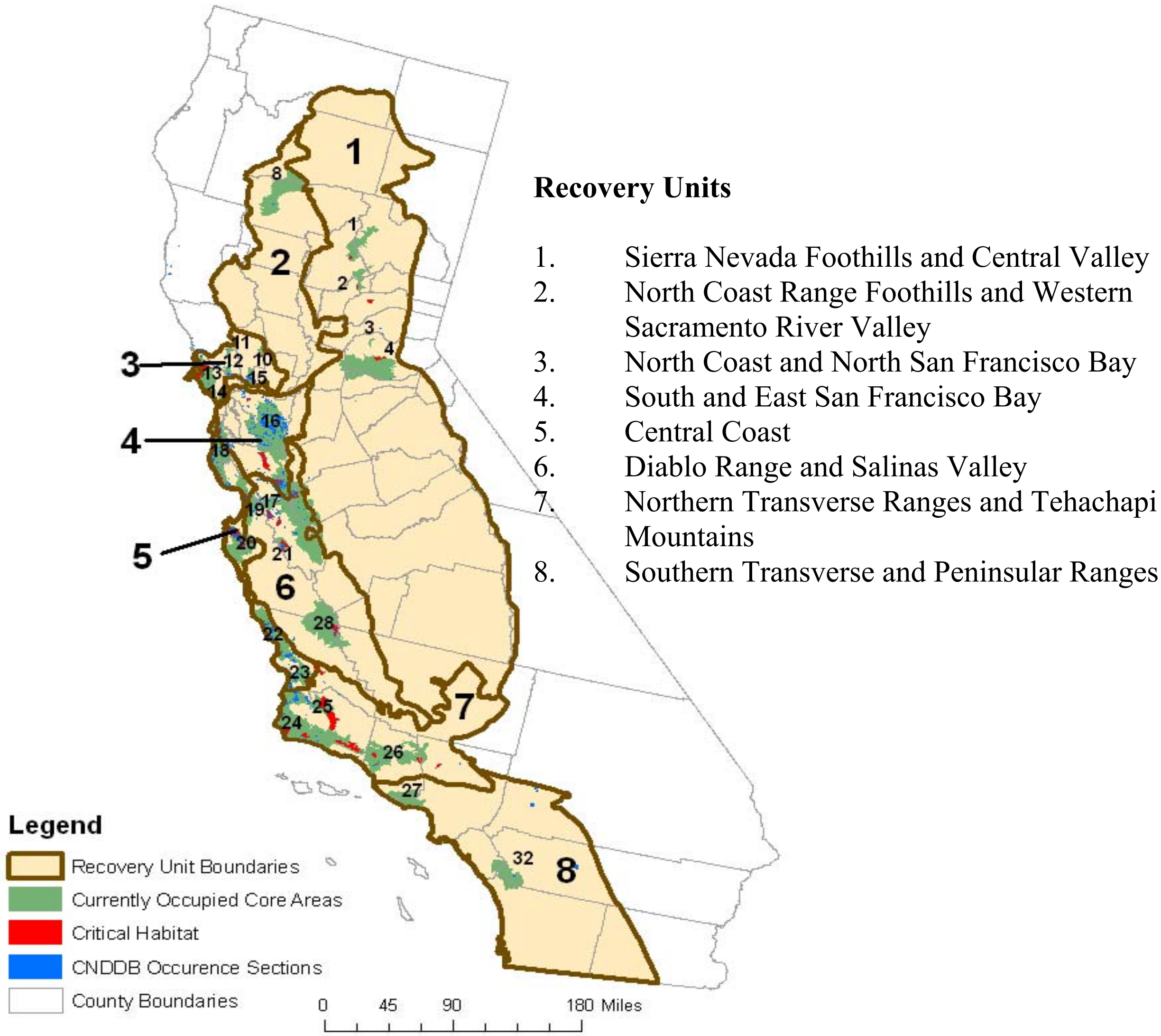


Figure 2.3 Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

Core Areas

1. Feather River
2. Yuba River- S. Fork Feather River
3. Traverse Creek/ Middle Fork/ American R. Rubicon
4. Cosumnes River
5. South Fork Calaveras River*
6. Tuolumne River*
7. Piney Creek*
8. Cottonwood Creek
9. Putah Creek – Cache Creek*
10. Lake Berryessa Tributaries
11. Upper Sonoma Creek
12. Petaluma Creek – Sonoma Creek
13. Pt. Reyes Peninsula
14. Belvedere Lagoon
15. Jameson Canyon – Lower Napa River
16. East San Francisco Bay
17. Santa Clara Valley
18. South San Francisco Bay
19. Watsonville Slough-Elkhorn Slough
20. Carmel River – Santa Lucia
21. Gablan Range
22. Estero Bay
23. Arroyo Grange River
24. Santa Maria River – Santa Ynez River
25. Sisquoc River
26. Ventura River – Santa Clara River
27. Santa Monica Bay – Venura Coastal Streams
28. Estrella River
29. San Gabriel Mountain*
30. Forks of the Mojave*
31. Santa Ana Mountain*
32. Santa Rosa Plateau
33. San Luis Ray*
34. Sweetwater*
35. Laguna Mountain*

* Core areas that were historically occupied by the California red-legged frog are not included in the map

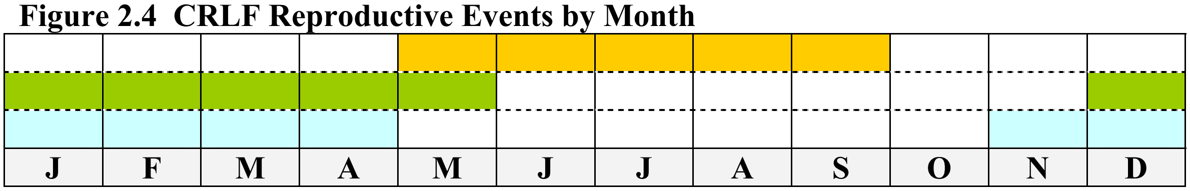
Other Known Occurrences from the CNDDB

The CNDDB provides location and natural history information on species found in California. The CNDDB serves as a repository for historical and current species location sightings. Information regarding known occurrences of CRLFs outside of the currently occupied core areas and designated critical habitat is considered in defining the current range of the CRLF. See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.

2.5.2 Reproduction

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers, 2005a). According to the Recovery Plan (USFWS, 2002), CRLFs breed from November through late April. Peaks in spawning activity vary geographically; Fellers (2005b) reports peak spawning as early as January in parts of coastal central California. Eggs are fertilized as they are being laid. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto, 1984). Egg masses contain approximately 2000 to 6000 eggs ranging in size between 2 and 2.8 mm (Jennings and Hayes, 1994). Embryos hatch 10 to 14 days after fertilization (Fellers, 2005a) depending on water temperature. Egg predation is reported to be infrequent and most mortality is associated with the larval stage (particularly through predation by fish); however, predation on eggs by newts has also been reported (Rathburn, 1998). Tadpoles require 11 to 28 weeks to metamorphose into juveniles (terrestrial-phase), typically between May and September (Jennings and Hayes, 1994; USFWS, 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers, 2005b; USFWS, 2002). Males reach sexual maturity at 2 years, and females reach sexual maturity at 3 years of age; adults have been reported to live 8 to 10 years (USFWS, 2002). Figure 2.4 depicts CRLF annual reproductive timing.

Figure 2.4 CRLF Reproductive Events by Month



Light Blue = **Breeding/Egg Masses**
Green = **Tadpoles (except those that over-winter)**
Orange = **Young Juveniles**
Adults and juveniles can be present all year

2.5.3 Diet

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus

(USFWS, 2002). Tadpoles filter and entrap suspended algae (Seale and Beckvar, 1980) via mouthparts designed for effective grazing of periphyton (Wassersug, 1984; Kupferberg *et al.*; 1994; Kupferberg, 1997; Altig and McDiarmid, 1999).

Juvenile and adult CRLFs forage in aquatic and terrestrial habitats, and their diet differs greatly from that of larvae. The main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic and terrestrial invertebrates found along the shoreline and on the water surface. Hayes and Tennant (1985) report, based on a study examining the gut content of 35 juvenile and adult CRLFs, that the species feeds on as many as 42 different invertebrate taxa, including Arachnida, Amphipoda, Isopoda, Insecta, and Mollusca. The most commonly observed prey species were larval alderflies (*Sialis* cf. *californica*), pillbugs (*Armadilliadrium vulgare*), and water striders (*Gerris* sp). The preferred prey species, however, was the sowbug (Hayes and Tennant, 1985). This study suggests that CRLFs forage primarily above water, although the authors note other data reporting that adults also feed under water, are cannibalistic, and consume fish. For larger CRLFs, over 50% of the prey mass may consists of vertebrates such as mice, frogs, and fish, although aquatic and terrestrial invertebrates were the most numerous food items (Hayes and Tennant, 1985). For adults, feeding activity takes place primarily at night; for juveniles feeding occurs during the day and at night (Hayes and Tennant, 1985).

2.5.4 Habitat

CRLFs require aquatic habitat for breeding, but also use other habitat types including riparian and upland areas throughout their life cycle. CRLF use of their environment varies; they may complete their entire life cycle in a particular habitat or they may utilize multiple habitat types. Overall, populations are most likely to exist where multiple breeding areas are embedded within varying habitats used for dispersal (USFWS, 2002). Generally, CRLFs utilize habitat with perennial or near-perennial water (Jennings et al., 1997). Dense vegetation close to water, shading, and water of moderate depth are habitat features that appear especially important for CRLF (Hayes and Jennings, 1988). Breeding sites include streams, deep pools, backwaters within streams and creeks, ponds, marshes, sag ponds (land depressions between fault zones that have filled with water), dune ponds, and lagoons. Breeding adults have been found near deep (0.7 m) still or slow moving water surrounded by dense vegetation (USFWS, 2002); however, the largest number of tadpoles have been found in shallower pools (0.26 – 0.5 m) (Reis, 1999). Data indicate that CRLFs do not frequently inhabit vernal pools, as conditions in these habitats generally are not suitable (Hayes and Jennings, 1988).

CRLFs also frequently breed in artificial impoundments such as stock ponds, although additional research is needed to identify habitat requirements within artificial ponds (USFWS, 2002). Adult CRLFs use dense, shrubby, or emergent vegetation closely associated with deep-water pools bordered with cattails and dense stands of overhanging vegetation (http://www.fws.gov/endangered/features/rl_frog/rlfrog.html#where).

In general, dispersal and habitat use depends on climatic conditions, habitat suitability, and life stage. Adults rely on riparian vegetation for resting, feeding, and dispersal. The foraging quality of the riparian habitat depends on moisture, composition of the plant community, and presence of pools and backwater aquatic areas for breeding. CRLFs can be found living within streams at distances up to 3 km (2 miles) from their breeding site and have been found up to 30 m (100 feet) from water in dense riparian vegetation for up to 77 days (USFWS, 2002).

During dry periods, the CRLF is rarely found far from water, although it will sometimes disperse from its breeding habitat to forage and seek other suitable habitat under downed trees or logs, industrial debris, and agricultural features (UWFWS, 2002). According to Jennings and Hayes (1994), CRLFs also use small mammal burrows and moist leaf litter as habitat. In addition, CRLFs may also use large cracks in the bottom of dried ponds as refugia; these cracks may provide moisture for individuals avoiding predation and solar exposure (Alvarez, 2000).

2.6 Designated Critical Habitat

In a final rule published on April 13, 2006, 34 separate units of critical habitat were designated for the CRLF by USFWS (USFWS, 2006; FR 51 19244-19346). A summary of the 34 critical habitat units relative to USFWS-designated recovery units and core areas (previously discussed in Section 2.5.1) is provided in Table 2.4.

'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.' All designated critical habitat for the CRLF was occupied at the time of listing. Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be '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)). PCEs include, but are not limited to, 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. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

- Breeding aquatic habitat;
- Non-breeding aquatic habitat;
- Upland habitat; and
- Dispersal habitat.

Further description of these habitat types is provided in Attachment 1.

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, USFWS does not include areas where existing management is sufficient to conserve the species. Critical habitat is designated outside the geographic area presently occupied by the species only when a designation limited to its present range would be inadequate to ensure the conservation of the species. For the CRLF, all designated critical habitat units contain all four of the PCEs, and were occupied by the CRLF at the time of FR listing notice in April 2006. The FR notice designating critical habitat for the CRLF includes a special rule exempting routine ranching activities associated with livestock ranching from incidental take prohibitions. The purpose of this exemption is to promote the conservation of rangelands, which could be beneficial to the CRLF, and to reduce the rate of conversion to other land uses that are incompatible with CRLF conservation. Please see Attachment 1 for a full explanation on this special rule.

USFWS has established adverse modification standards for designated critical habitat (USFWS, 2006). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of simazine that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to USFWS (2006), activities that may modify critical habitat and therefore result in adverse effects to the CRLF include, but are not limited to the following:

(1) Significant alteration of water chemistry or temperature to levels beyond the tolerances of the CRLF that result in direct or cumulative adverse effects to individuals and their life-cycles.
(2) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat that could result in elimination or reduction of habitat necessary for the growth and reproduction of the CRLF by increasing the sediment deposition to levels that would adversely affect their ability to complete their life cycles.
(3) Significant alteration of channel/pond morphology or geometry that may lead to changes to the hydrologic functioning of the stream or pond and alter the timing, duration, water flows, and levels that would degrade or eliminate the CRLF and/or its habitat. Such an effect could also lead to increased sedimentation and degradation in water quality to levels that are beyond the CRLF's tolerances.
(4) Elimination of upland foraging and/or aestivating habitat or dispersal habitat.
(5) Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.

(6) Alteration or elimination of the CRLF's food sources or prey base (also evaluated as indirect effects to the CRLF).

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

For listed species assessment purposes, the action area is considered to be the area affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). 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 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 CRLF and its designated critical habitat within the state of California. Deriving the geographical extent of this portion of the action area is based on consideration of the types of effects that simazine may be expected to have on the environment, the exposure levels to simazine that are associated with those effects, and the best available information concerning the use of simazine and its fate and transport within the state of California.

The definition of action area requires a stepwise approach that begins with an understanding of 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 CRLF, 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 2.5.

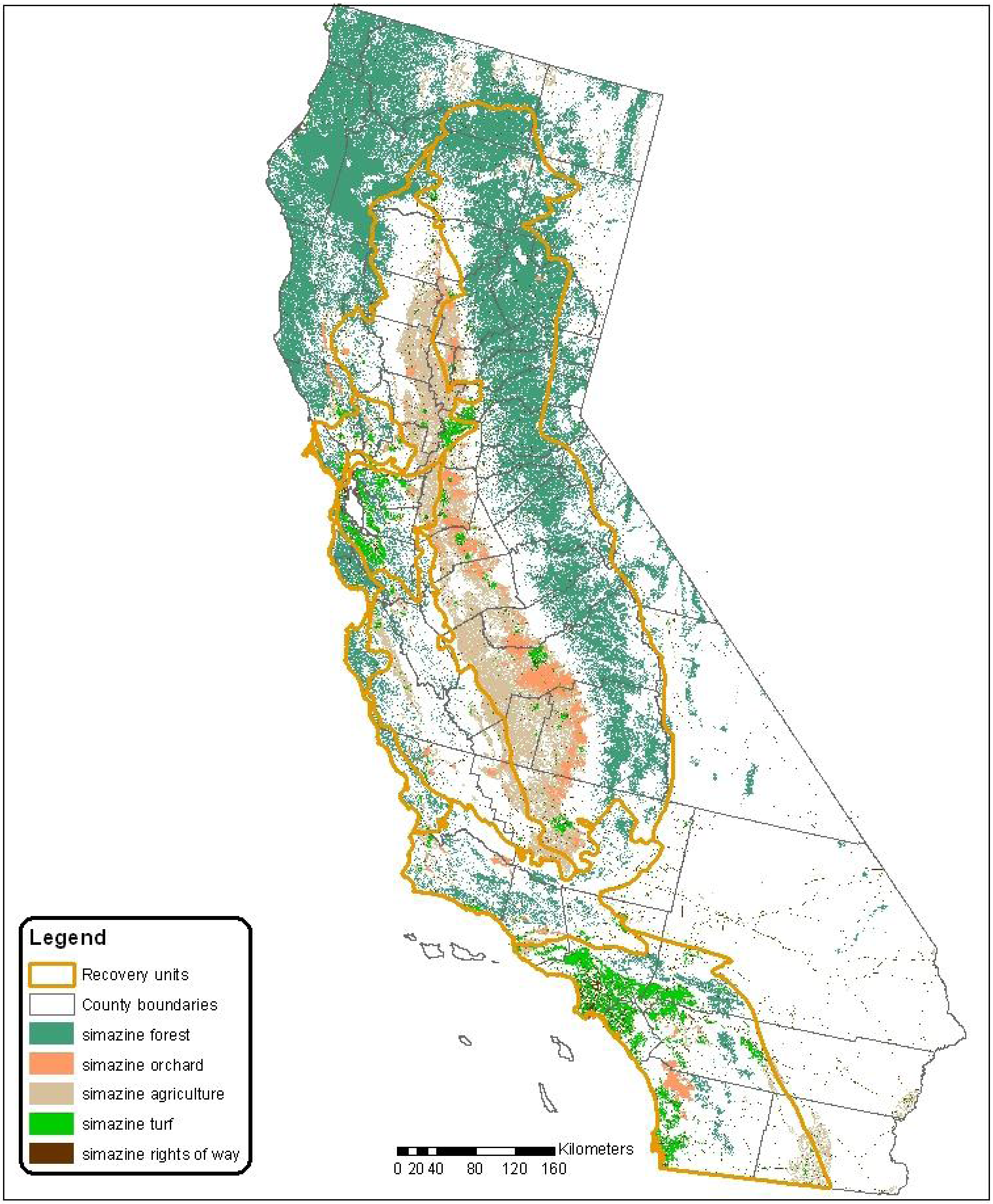


Figure 2.5 Initial area of concern, or "footprint" of potential use, for simazine

Once the initial area of concern is defined, the next step is to compare the extent of that area with the results of the screening-level risk assessment. The screening-level risk assessment identifies which taxa, if any, are predicted to be exposed at concentrations above the Agency's Levels of Concern (LOC). The screening-level assessment includes an evaluation of the environmental fate properties of simazine to determine which routes of transport are likely to have an impact on the CRLF.

For simazine, the principal routes of transport away from the application site are expected to be runoff and spray drift due to its mobility and moderate persistence. However, simazine has also been documented to occur in air monitoring samples, albeit at low concentrations, and thus, long-range transport away from the area of application cannot be precluded. Typically, air monitoring studies do not distinguish the route of transport associated with the detections. The location of the available air monitoring for simazine (Majewski, 2002) suggest that these detections are related to nearby sources and are more likely due to spray drift than long-range transport. Furthermore, the vapor pressure of simazine suggests that volatilization leading to long-range transport is unlikely.

LOC exceedances are used to describe how far effects may be seen from the initial area of concern. Factors considered include: spray drift, downstream run-off, atmospheric transport, *etc.* Typically, this information is incorporated into GIS and a map of the action area is created.

The AgDRIFT model (Version 2.01) is used to define how far from the initial area of concern an effect to a given terrestrial species may be expected. The spray drift analysis for simazine using the most sensitive terrestrial toxicity endpoint (*i.e.*, terrestrial plants) suggests that the distance for potential effects from the treated area of concern is beyond the range of the AgDRIFT model (*i.e.*, 1000 feet). Subsequently, the AgDISP model (Version 8.15) with the Gaussian extension (used for longer range transport because the limits of the regular AgDISP model were exceeded) was used to define this distance. The AgDISP model was run in ground mode using default settings (except for wind speed at 10 mph and release height at 4 feet). Using the Gaussian extension, a maximum spray drift distance of 8,740 feet was derived. Further detail on the spray drift analysis is provided in Section 3.2.5.

In addition to the buffered area from the spray drift analysis, the final action area also considers the downstream extent of simazine that exceeds the LOC (discussed in Section 3.2.6). It should be noted that the action area for simazine is based on the endangered species LOCs for aquatic and terrestrial plants. However, the portion of the action area that is relevant to the CRLF is based on the non-listed species LOCs for aquatic and terrestrial plants because the CRLF does not have an obligate relationship w/plants
The action area for simazine, including the full extent (based on the listed species LOC for terrestrial plants), is depicted in Figure 2.6. The portion of the action area that is relevant for the CRLF (based on the non-listed LOC for terrestrial plants) is presented in Figure 2.7.

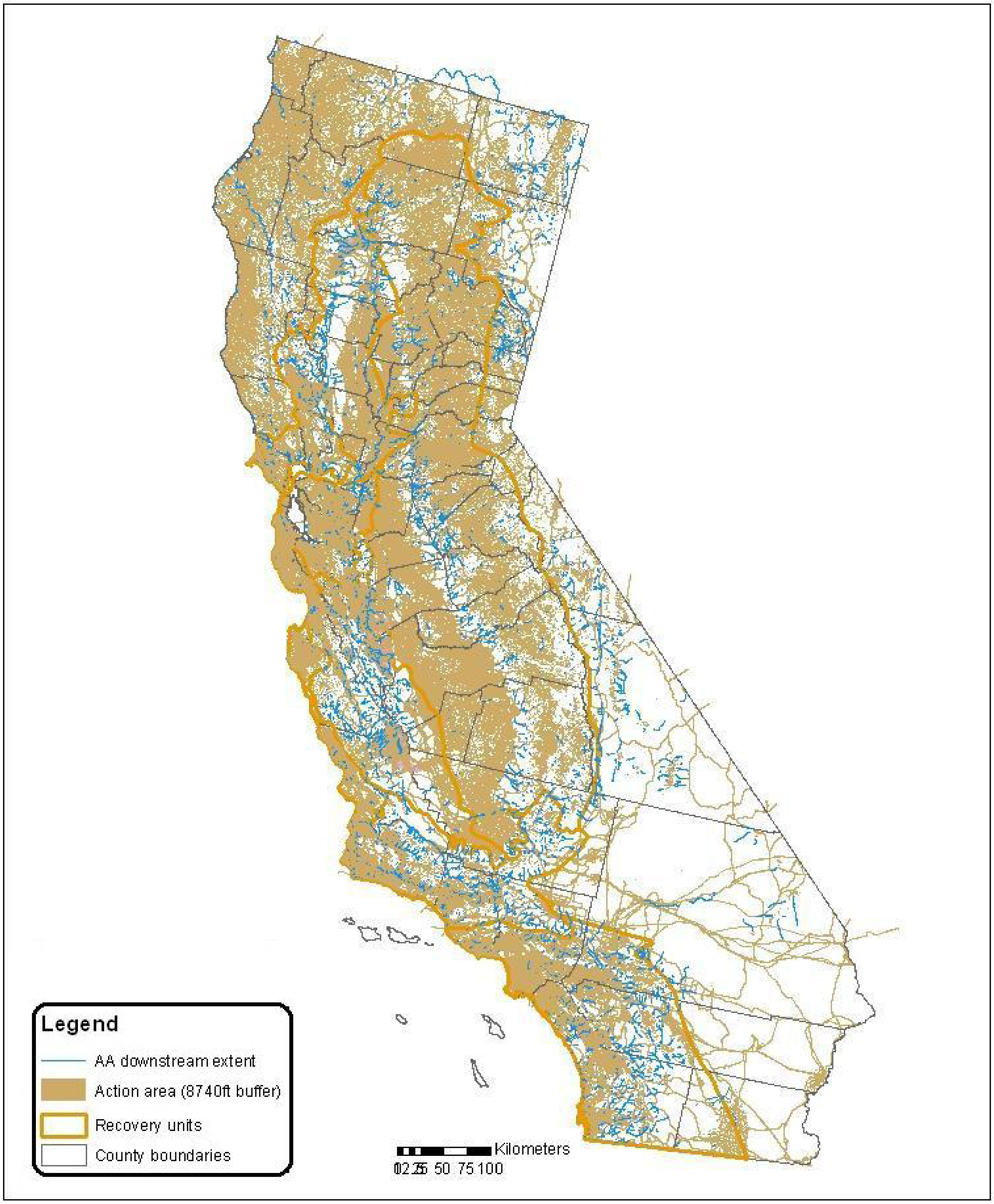


Figure 2.6 Simazine Action Area for the California Red Legged Frog

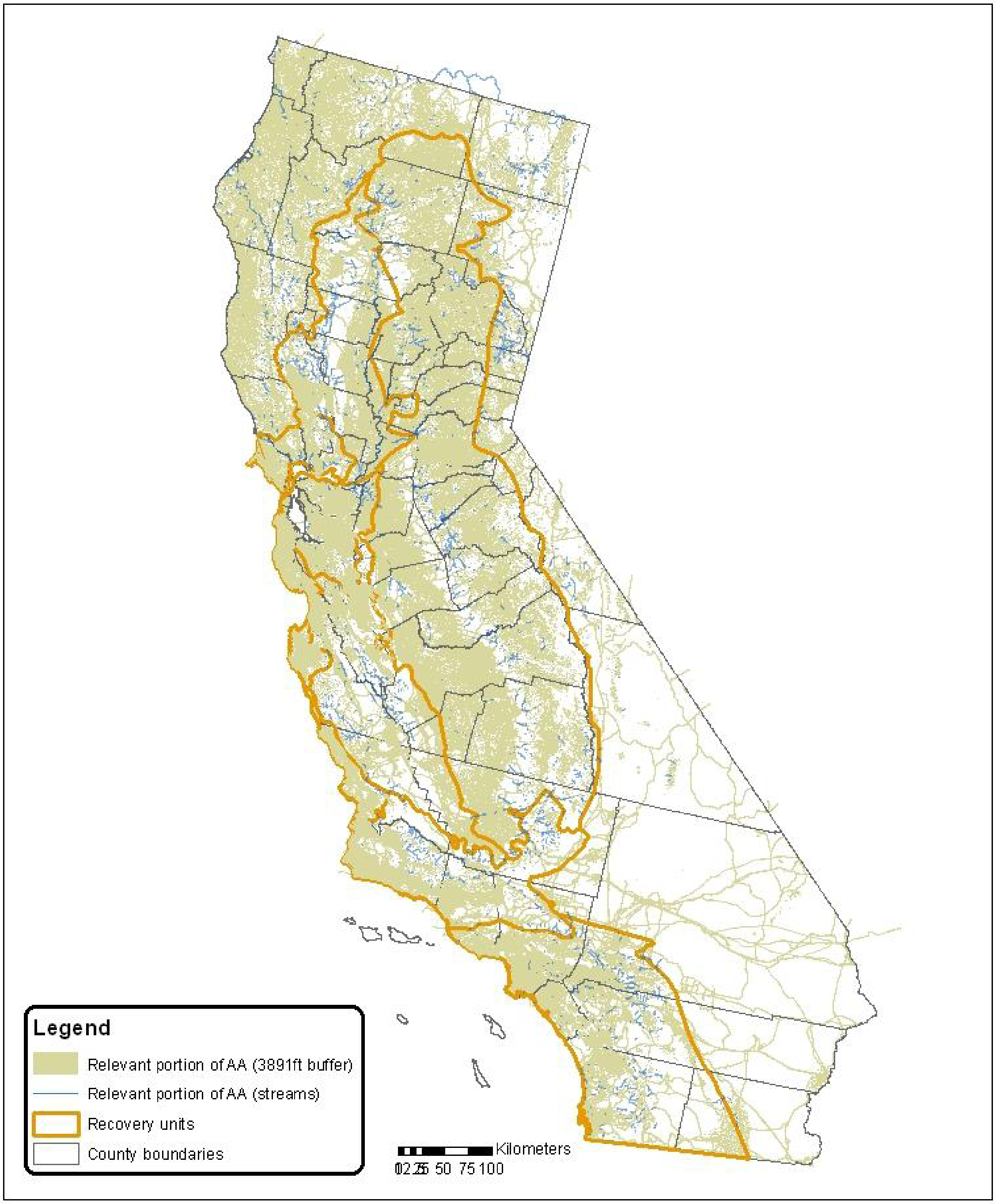


Figure 2.7 Portion of the Action Area that is Relevant for the California Red Legged Frog

Subsequent to defining the action area, an evaluation of usage information was conducted to determine the area where use of simazine may impact the CRLF. 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

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected."[5] Selection of the assessment endpoints is based on valued entities (*e.g.,* CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (*e.g.,* waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of simazine (*e.g.,* runoff, spray drift, *etc.*), and the routes by which ecological receptors are exposed to simazine *(e.g.,* direct contact, *etc.).*

2.8.1 Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. In addition, potential modification of critical habitat is assessed by evaluating potential effects to PCEs, which are components of the habitat areas that provide essential life cycle needs of the CRLF. Each assessment endpoint requires one or more "measures of ecological effect," defined as changes in the attributes of an assessment endpoint or changes in a surrogate entity or attribute in response to exposure to a pesticide. Specific measures of ecological effect are generally evaluated based on acute and chronic toxicity information from registrant-submitted guideline tests that are performed on a limited number of organisms. Additional ecological effects data from the open literature are also considered.

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. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to simazine is provided in Table 2.5.

[5] From U.S. EPA (1992). *Framework for Ecological Risk Assessment.* EPA/630/R-92/001.

Table 2.5 Assessment Endpoints and Measures of Ecological Effects	
Assessment Endpoint	**Measures of Ecological Effects**[6]
Aquatic-Phase CRLF (Eggs, larvae, juveniles, and adults)[a]	
Direct Effects	
1. Survival, growth, and reproduction of CRLF	1a. Fathead minnow LC_{50} 1b. Fathead minnow chronic NOAEC
Indirect Effects and Critical Habitat Effects	
2. Survival, growth, and reproduction of CRLF individuals via indirect effects on aquatic prey food supply (*i.e.,* fish, freshwater invertebrates, non-vascular plants)	2a. Fathead minnow LC_{50} 2b. Fathead minnow chronic NOAEC 2c. Water flea acute TL_{50} 2d. Water flea chronic NOAEC. 2e. Non-vascular plant (freshwater algae) acute EC_{50}
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.,* aquatic plant community)	3a. Vascular plant acute EC_{50} (duckweed) 3b. Non-vascular plant acute EC_{50} (freshwater algae)
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation	4a. Monocot and dicot seedling emergence EC_{25} 4b. Monocot and dicot vegetative vigor EC_{25}
Terrestrial-Phase CRLF (Juveniles and adults)	
Direct Effects	
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Mallard duck acute LD_{50}[b] 5b. Bobwhite quail chronic NOAEC[b]
Indirect Effects and Critical Habitat Effects	
6. Survival, growth, and reproduction of CRLF individuals via effects on terrestrial prey (*i.e.,*terrestrial invertebrates, small mammals , and frogs)	6a. Honey bee oral LD_{50} 6b. Rat acute LD_{50} 6b. Rat chronic NOAEC 6b. Mallard duck acute LD_{50}[b] 6b. Bobwhite quail chronic NOAEC [b]
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.,* riparian and upland vegetation)	7a. Monocot EC_{25} (seedling emergence) 7b. Dicot EC_{25} (seedling emergence)

[a] Adult frogs are no longer in the "aquatic phase" of the amphibian life cycle; however, submerged adult frogs are considered "aquatic" for the purposes of this assessment because exposure pathways in the water are considerably different that exposure pathways on land.
[b] Birds are used as surrogates for terrestrial phase amphibians.

[6] All registrant-submitted and open literature toxicity data reviewed for this assessment are included in Appendix A.

2.8.2 Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of simazine that may alter the PCEs of the CRLF's critical habitat. PCEs for the CRLF 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 CRLF. 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.

Adverse modification to the critical habitat of the CRLF includes, but is not limited to, the following, as specified by USFWS (2006):

1. Alteration of water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs.
2. Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.
3. Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat.
4. Significant alteration of channel/pond morphology or geometry.
5. Elimination of upland foraging and/or aestivating habitat, as well as dispersal habitat.
6. Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
7. Alteration or elimination of the CRLF's food sources or prey base.

Measures of such possible effects by labeled use of simazine on critical habitat of the CRLF are described in Table 2.6. 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. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 2.6 Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat[a]	
Assessment Endpoint	**Measures of Ecological Effect**
Aquatic-Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	a. Non-vascular plant acute EC_{50} (freshwater algae) b. Distribution of EC_{25} values for terrestrial monocots c. Distribution of EC_{25} values for terrestrial dicots
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	a. Non-vascular plant acute EC_{50} (freshwater algae) b. Distribution of EC_{25} values for terrestrial monocots c. Distribution of EC_{25} values for terrestrial dicots
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	a. Fathead minnow LC_{50} b. Fathead minnow chronic NOAEC c. Water flea acute TL_{50} d. Water flea chronic NOAEC. e. Non-vascular plant (freshwater algae) acute EC_{50}
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	a. Non-vascular plant acute EC_{50} (freshwater algae)
Terrestrial-Phase PCEs (Upland Habitat and Dispersal Habitat)	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	a. Distribution of EC_{25} values for monocots b. Distribution of EC_{25} values for dicots c. Honey bee oral LD_{50} d. Rat acute LD_{50} e. Rat chronic NOAEC f. Mallard duck acute LD_{50} g. Bobwhite quail chronic NOAEC
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	

[a] Physico-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.

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 (U.S. EPA, 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 for this endangered species assessment:

- Labeled uses of simazine within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- Labeled uses of simazine within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;
- Labeled uses of simazine within the action area may indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the current range of the species and designated critical habitat, thus affecting primary productivity and/or cover;
- Labeled uses of simazine within the action area may indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (*i.e.,* riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- Labeled uses of simazine within the action area may modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- Labeled uses of simazine within the action area may modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- Labeled uses of simazine within the action area may modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- Labeled uses of simazine within the action area may modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.
- Labeled uses of simazine within the action area may modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor simazine release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial phases of the CRLF are shown in Figures 2.8 and 2.9, respectively, and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in Figures 2.10 and 2.11, respectively. Exposure routes shown in dashed lines (long-range atmospheric transport and groundwater) are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the CRLF and modification to designated critical habitat is expected to be negligible.

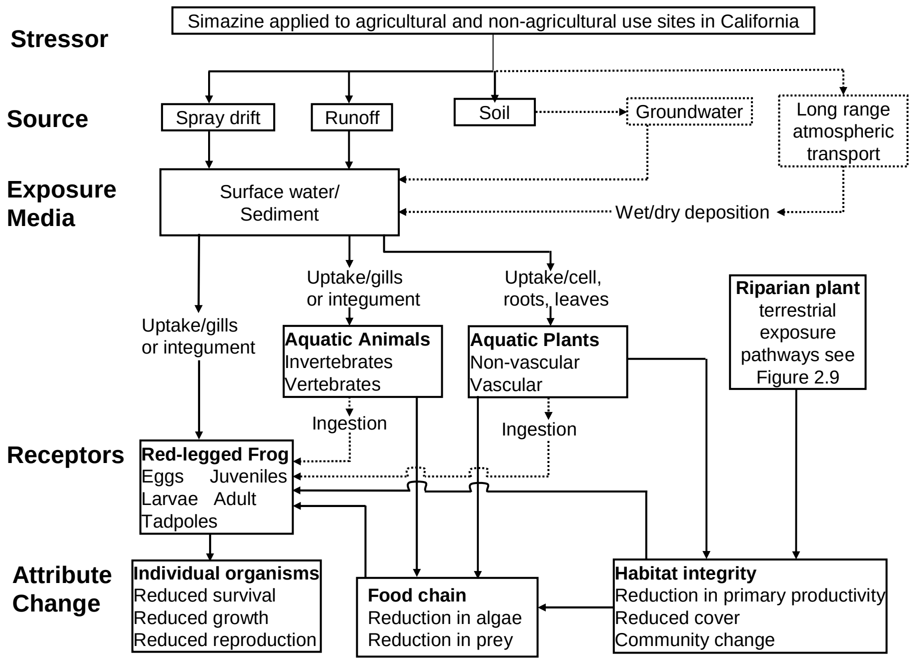


Figure 2.8 Conceptual Model for Aquatic-Phase of the CRLF

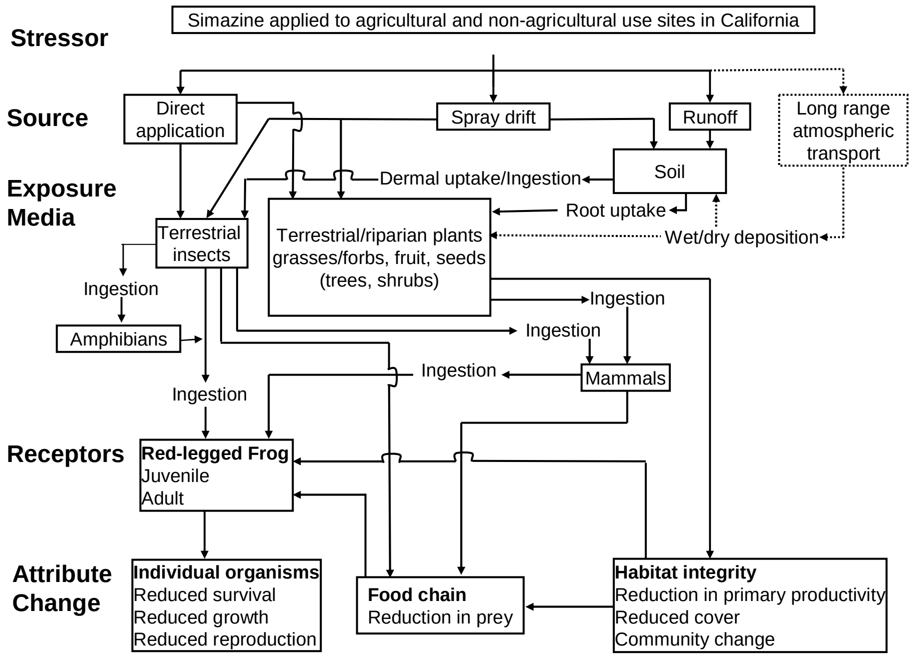


Figure 2.9 Conceptual Model for Terrestrial-Phase of the CRLF

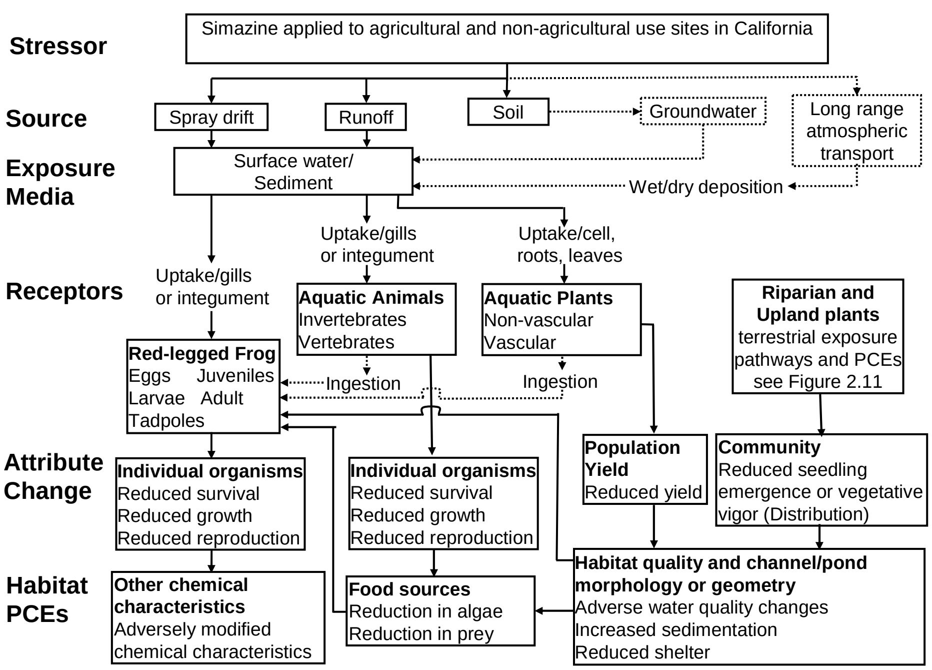


Figure 2.10 Conceptual Model for Pesticide Effects on Aquatic Component of CRLF Critical Habitat

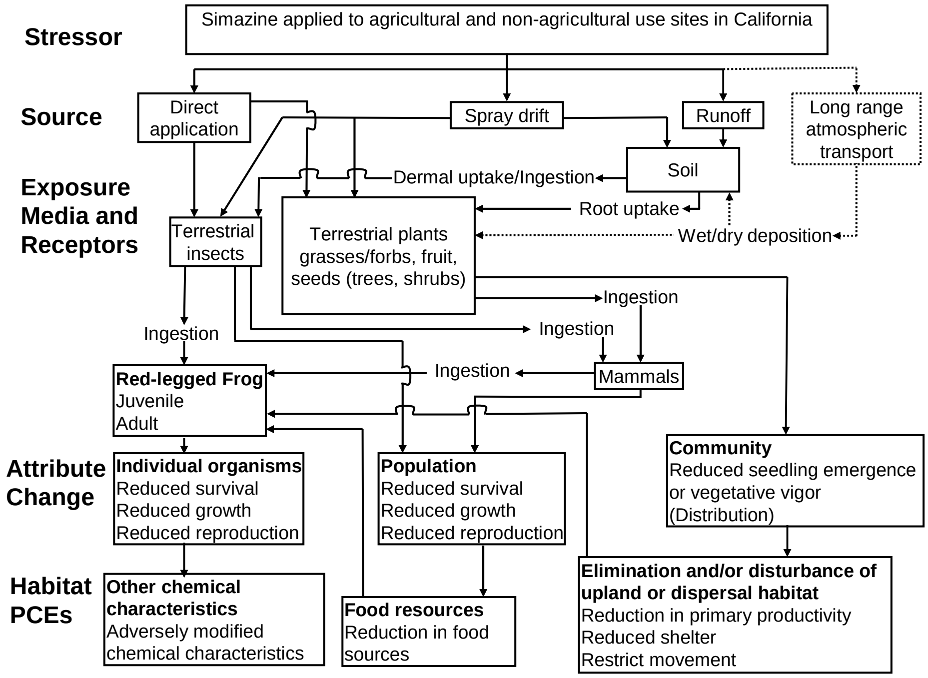


Figure 2.11 Conceptual Model for Pesticide Effects on Terrestrial Component of CRLF Critical Habitat

2.10 Analysis Plan

In order to address the risk hypothesis, the potential for adverse direct and indirect effects to the CRLF, its prey, and its habitat is estimated. 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 (U.S. EPA, 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.

2.10.1 Measures to Evaluate the Risk Hypothesis and Conceptual Model

2.10.1.1 Measures of Exposure

The environmental fate properties of simazine along with available monitoring data indicate that runoff and spray drift are the principle potential transport mechanisms of simazine to the aquatic and terrestrial habitats of the CRLF. In this assessment, transport of simazine through runoff and spray drift is considered in deriving quantitative estimates of simazine exposure to CRLF, its prey and its habitats. 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. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to predict terrestrial EECs on food items is T-REX. 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.

PRZM (v3.12beta, May 24, 2001) and EXAMS (v2.98.04, Aug. 18, 2002) are screening simulation models coupled with the input shell pe4v01.pl (Aug.8, 2003) to generate daily exposures and 1-in-10 year EECs of simazine that may occur in surface water bodies adjacent to application sites receiving simazine through runoff and spray drift. PRZM simulates pesticide application, movement and transformation on an agricultural field and the resultant pesticide loadings to a receiving water body via runoff, erosion and spray drift. EXAMS simulates the fate of the pesticide and resulting concentrations in the water body. The standard scenario used for ecological pesticide assessments assumes application to a 10-hectare agricultural field that drains into an adjacent 1-hectare water body that is 2 meters deep (20,000 m^3 volume) with no outlet. PRZM/EXAMS is used to estimate screening-level exposure of aquatic organisms to simazine. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10 year peak is used for estimating acute exposures of direct effects to the CRLF, as well as indirect effects to the CRLF through effects to potential prey items, including: algae, aquatic invertebrates, fish, and frogs. The 1-in-10-year 60-day mean is used for assessing chronic exposure to the CRLF and fish and frogs serving as prey items. The 1-in-10-year 21-day mean is used for assessing aquatic invertebrate chronic exposure, which are also potential prey items.

Exposure estimates for the terrestrial-phase CRLF and terrestrial invertebrates and mammals (serving as potential prey) assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.3.1, 12/07/2006). This model incorporates the Kenega nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenega, 1972). The Fletcher *et al.* (1994) modifications to the Kenega nomograph are based on measured field residues from 249 published research papers, including information on 118 species of plants, 121 pesticides, and 17 chemical classes. These modifications represent the 95th percentile of the expanded data set. For modeling purposes, direct exposures of the CRLF to simazine through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey (small mammals) are assessed using the small mammal (15 g) which consumes short grass. The small bird (20g) consuming small insects and the small mammal (15g) consuming short grass are used because these categories represent the largest RQs of the size and dietary categories in T-REX that are appropriate surrogates for the CRLF and one of its prey items. Estimated exposures of terrestrial insects to simazine are bound by using the dietary based EECs for small insects and large insects. In addition, terrestrial exposures from granular applications (mg ai/square foot) for the CRLF are also estimated using T-REX and an earthworm fugacity model.

EECs for terrestrial plants inhabiting dry and wetland areas are derived using TerrPlant (version 1.2.2, 12/26/2006). This model uses estimates of pesticides in runoff and in spray drift to calculate EECs. EECs are based upon solubility, application rate and minimum incorporation depth.

Two spray drift models, AgDISP and AgDRIFT are used to assess exposures of terrestrial phase CRLF and its prey to simazine deposited on terrestrial habitats by spray drift. AgDISP (version 8.13; dated 12/14/2004) (Teske and Curbishley, 2003) is used to simulate aerial and ground applications using the Gaussian farfield extension.

2.10.1.2 Measures of Effect

Data identified in Section 2.8 are used as measures of effect for direct and indirect effects to the CRLF. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. The ECOTOXicology database (ECOTOX) was searched in order to provide more ecological effects data and in an attempt to bridge existing data gaps. ECOTOX is a source for locating single chemical toxicity data for aquatic life, terrestrial plants, and wildlife. ECOTOX was created and is maintained by the Agency's Office of Research and Development, and the National Health and Environmental Effects Research Laboratory's Mid-Continent Ecology Division.

The assessment of risk for direct effects to the terrestrial-phase CRLF makes the assumption that toxicity of simazine to birds is similar to the terrestrial-phase CRLF. The same assumption is made for fish and aquatic-phase CRLF. Algae, aquatic invertebrates, fish, and amphibians represent potential prey of the CRLF in the aquatic habitat. Terrestrial invertebrates, small mammals, and terrestrial-phase amphibians represent potential prey of the CRLF in the terrestrial habitat. Aquatic, semi-aquatic, and terrestrial plants represent habitat of CRLF.

The acute measures of effect used for animals in this screening level assessment are the LD_{50}, LC_{50} and EC_{50}. LD stands for "Lethal Dose", and LD_{50} is the amount of a material, given all at once, that is estimated to cause the death of 50% of the test organisms. LC stands for "Lethal Concentration" and LC_{50} is the concentration of a chemical that is estimated to kill 50% of the test organisms. EC stands for "Effective Concentration" and the EC_{50} is the concentration of a chemical that is estimated to produce a specific effect in 50% of the test organisms. Endpoints for chronic measures of exposure for listed and non-listed animals are the NOAEL/NOAEC and NOEC. NOAEL stands for "No Observed-Adverse-Effect-Level" and refers to the highest tested dose of a substance that has been reported to have no harmful (adverse) effects on test organisms. The NOAEC (*i.e.*, "No-Observed-Adverse-Effect-Concentration") is the highest test concentration at which none of the observed effects were statistically different from the control. The NOEC is the No-Observed-Effects-Concentration. For non-listed plants, only acute exposures are assessed (*i.e.*, EC_{25} for terrestrial plants and EC_{50} for aquatic plants).

2.10.1.3 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 CRLF 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. For the assessment of simazine risks, the risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see Appendix C).

For this endangered species assessment, listed species LOCs are used for comparing RQ values for acute and chronic exposures of simazine directly to the CRLF. If estimated exposures directly to the CRLF of simazine resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is "may affect". When considering indirect effects to the CRLF due to effects to animal prey (aquatic and terrestrial invertebrates, fish, frogs, and mice), the listed species LOCs are also used. If estimated exposures to CRLF prey of simazine resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is a "may affect." If the acute RQ being considered also exceeds the non-listed species acute risk LOC, then the effects determination is a LAA. If the RQ is between the listed species LOC and the non-listed species LOC, then further lines of evidence (*i.e*. probability of individual effects, species sensitivity distributions) are considered in distinguishing between a determination of NLAA and a LAA. When considering indirect effects to the CRLF due to effects to algae as dietary items or plants as habitat, the non-listed species LOC for plants is used because the CRLF does not have an obligate relationship with any particular aquatic and/or terrestrial plant. If the RQ being considered for a particular use exceeds the non-listed species LOC for plants, the effects determination is LAA.

3. Exposure Assessment

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 (U.S. EPA, 2006), 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 in 2010. Of the proposed mitigation measures relevant to this assessment that are expected to become final 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.

Currently registered non-agricultural uses of simazine within the CRLF 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 CRLF 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.

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.

Table 3.1 Simazine Uses, Scenarios, and Application Information for the CRLF risk assessment[1]				
Scenario	Uses 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.
[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 AgDISP, 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.

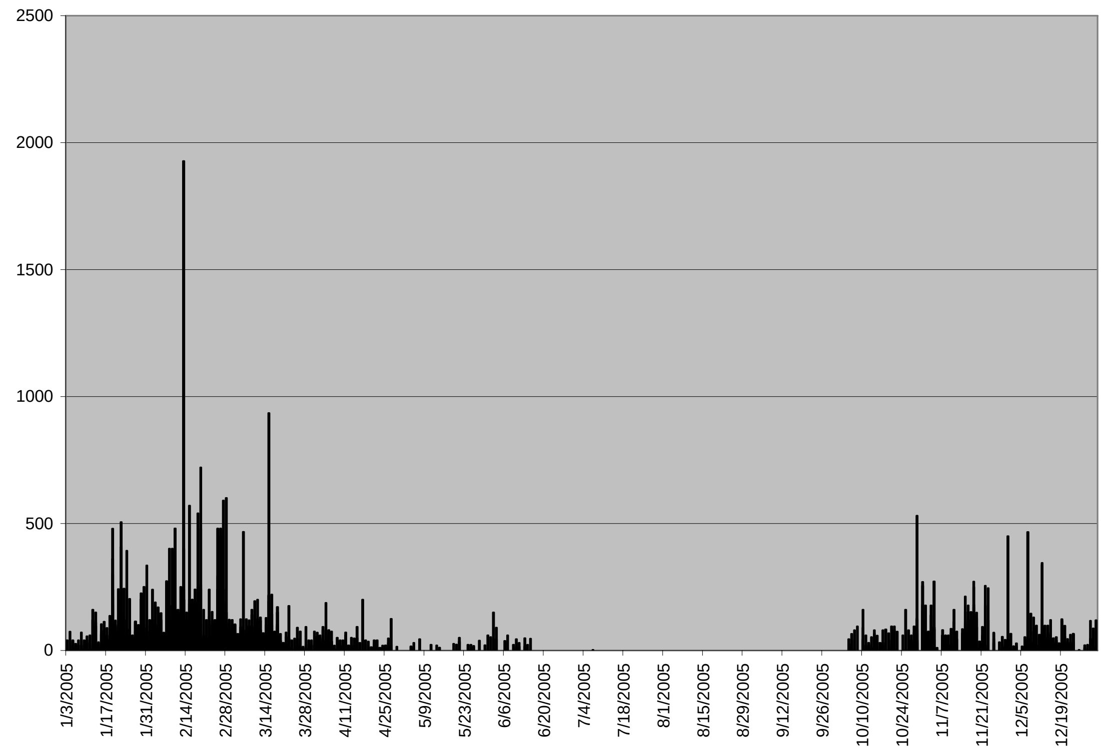


Figure 3.1 Summary of Applications of Simazine to Grapes in 2005 from CDPR PUR data.

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

http://pestdata.ncsu.edu/cropprofiles/cropprofiles.cfm

3.2.2 Model Inputs

Simazine is a triazine herbicide used on a wide variety of food and non-food crops. Simazine environmental fate data used for generating model parameters is listed in Table 2.2. The input parameters for PRZM and EXAMS are in Table 3.2.

Table 3.2 Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Simazine Endangered Species Assessment for the CRLF		
Fate Property	**Value**	**MRID (or source)**
Molecular Weight	202 g/mole	Product Chemistry

Table 3.2 Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Simazine Endangered Species Assessment for the CRLF		
Fate Property	**Value**	**MRID (or source)**
Henry's constant	3.2x 10^{-10} Pa 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 Soil Metabolism (benthic)	$t_{1/2}$ = 168 days (input value is three times the single laboratory anaerobic aquatic metabolism half-life of 56 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

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.

Table 3.3 Aquatic EECs (µg/L) for Simazine Agricultural and Non-agricultural 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

Table 3.3 Aquatic EECs (µg/L) for Simazine Agricultural and Non-agricultural 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 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 CRLF 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.

3.2.4.1 USGS NAWQA Surface Water Data

Surface water monitoring data from the United States Geological Survey (USGS) NAWQA program was accessed on June 28, 2007 and all data for the state of California were downloaded. A total of 2,004 water samples were analyzed for simazine. Of these samples, simazine was detected in 1,756 samples (196 were estimated either above or below the range of quantitation) with a frequency of detection of 88%. The maximum concentration detected was 64.5 μg/L in Mustang Creek near Monpelier 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 sites (all but one sample collected since 2000) were above 10 μg/L, and 117 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 0.67 μg/L while the average concentration of all detections was 0.76 μg/L.

3.2.4.2 USGS NAWQA Groundwater Data

Groundwater monitoring data from the United States Geological Survey (USGS) NAWQA program were accessed on June 28, 2007 and all data for the state of California was downloaded. A total of 674 water samples were analyzed for simazine. Of these samples, simazine was detected in 288 samples (39 were estimated either above or below the range of quantitation) with a frequency of detection of 43%. 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 0.024 μg/L while the average concentration of all detections was 0.049 μg/L.

3.2.4.3 California Department of Pesticide Regulation (CPR) Data

Surface water monitoring data was accessed from the California Department of Pesticide regulation (CDPR) on June 28, 2007 and all data with analysis for simazine were extracted. A total of 4,053 samples were available. Of these samples, simazine was detected in 1,988 samples for a frequency of detection of 49%. The maximum concentration was 36.1 μg/L in 2002 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 68 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.

3.2.4.4 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; Capel et al., 1994, McConnell, et al, 2004, Kuang, et al, 2003, Foreman, et al, 1999, Dubus, et al, 2000), simazine has been detected in rainwater 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 been below 1 μg/L (Makjewski, et al 2002, Kuang, et al, 2003, Dubus, et al, 2000). 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.

3.2.5 Spray Drift Buffer Analysis

In order to determine terrestrial and aquatic habitats of concern due to simazine exposures through spray drift, it necessary to estimate the distance that spray applications can drift from the treated field and still be present at concentrations that exceed levels of concern. An analysis of spray drift distances was completed using all available tools, including AgDRIFT, AgDISP, and the Gaussian extension to AgDISP. For simazine use relative to the terrestrial-phase CRLF, the results of the screening-level risk assessment indicate that spray drift using the most sensitive endpoints for terrestrial plants exceeds the 1,000 foot range of the AgDrift model for the Tier I ground mode (no higher tier modeling for ground applications is available in AgDrift). Subsequently, the AgDISP model with the Gaussian extension (for longer range transport because the extent of the regular AgDISP model was exceeded) was used to evaluate potential distances beyond which exposures would be expected to be below LOC.

The AgDISP model was run in ground mode and aerial mode (for non-cropland use only) with the following settings beyond the standard default settings.

- 20 gal/acre spray volume rate (label specific)
- 4 ft release height (label specific)
- 15 ft release height for aerial applications (label specific)
- 10 mph limitation (label specific)
- Very fine to fine spectrum (default value)
- No canopy
- Nonvolatile fraction of 0.075 (for 5.94 lb ai/A), 0.0625 (for 5 lb ai/A), 0.06 (for 4.8 lb ai/A), 0.05 (for 4 lb ai/A), and 0.025 (for 2 lb ai/A)

- Volatile fraction of 0.0314 (for 5.94 lb ai/A), 0.0262 (for 5 lb ai/A), 0.0251 (for 4.8 lb ai/A), 0.021 (for 4 lb ai/A), and 0.0105 (for 2 lb ai/A)

For the terrestrial phase, an analysis was conducted using the most sensitive terrestrial endpoint, the terrestrial plant NOAEC of 0.0018 lbs ai/acre. This distance identifies those locations where terrestrial landscapes can be impacted by spray drift deposition alone (no runoff considered) at concentrations above the listed species LOC for terrestrial plants. The LOC was compared to the highest RQ for aerial applications to non-cropland at 5.0 lbs ai/acre. In this analysis, the most sensitive endpoint was the NOAEC of 0.0018 lbs ai/A (0.002016 kg/hectare), which yielded a terrestrial spray drift distance of 8,740 feet. Similar analysis was conducted for application rates of 4.8 lbs ai/acre (grapes), 4 lbs ai/acre (fruit, berries, avocado, citrus, olives, and forestry), and 2 lbs ai/acre (almonds, fruit, corn, and turf). Each lower application rate yields a lower buffer distance. These distances represent the maximum extent where effects are possible using the most sensitive data and the endangered species LOC for plants (1.0).

In order to characterize the portion of the action area that is relevant to the CRLF and specific to the area where the effects determination (*i.e.* NLAA versus LAA) will be made, a similar analysis was conducted using the most sensitive non-endangered plant EC_{25} of 0.009 lbs ai/acre. Typically the NOAEC is used when there is an obligate relationship between the species being assessed and endangered plants (or other taxa). However, there is no obligate relationship between the CRLF and any endangered plant; therefore the LAA/NLAA determination is based on the area defined by the non-listed species LOC (*i.e.*, EEC/EC_{50}). Using the same approach described above, the maximum distance for the aerial use of simazine on non-cropland at 5.0 lbs ai/acre is 3,891 feet with reductions in distance for lower application rates. A summary of the modeled distances by application rate is presented in Table 3.4.

Table 3.4 Summary of AgDISP Predicted Terrestrial Spray Drift Distances

Application Rate (method)	Uses Represented	NOAEC Distance (ft)	EC_{25} Distance (ft)
5.0 (aerial)	Non-cropland	8740	3891
5.94 (ground)	Christmas trees	5770	2765
4.8 (ground)	Grapes	4540	2628
4 (ground)	Apples, Pears, Sour Cherries, Avocados, Berries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries	4032	2523
2 (ground)	Almonds, Nectarines, Peaches, Corn, and Turf	3110	2198

Given that the greatest buffer distance is 8,740 feet for terrestrial plants, this value was used to define the action area (*i.e.*, this buffer distance is added to the initial area of concern depicted in Figure 2.5). The action area (based on the buffer distance of 8,740 feet) and the portion of the action area that is relevant to the CRLF (based on impacts to terrestrial plants at the non-listed LOC and a corresponding buffer distance of 3,891 feet) is shown in Figure 2.6.

Similar to the analysis described above (except that only AgDRIFT was needed), the buffer distance needed to get below the most sensitive aquatic LOC was determined. This distance identifies those locations where water bodies can be impacted by spray drift deposition alone (no runoff considered) resulting in concentrations above the LOC. The most sensitive aquatic endpoint is for aquatic non-vascular plants (blue green algae) with NOAEC and EC_{50} values of 5.4 and 36 µg/L, respectively. The analysis yields a much lower buffer distance than the terrestrial buffer with a distance of 135 feet (based on the non-listed LOC using the EC_{50} value). The results of the analysis are presented in Table 3.5.

Table 3.5 Summary of AgDRIFT Predicted Aquatic Spray Drift Distances

Application Rate (method)	Uses Represented	NOAEC Distance (ft)	EC_{50} Distance (ft)
5.0 (aerial)	Non-cropland	>1,000	135
5.94	Christmas trees	6.56	0
4.8	Grapes	3.28	0
4	Apples, Pears, Sour Cherries, Avocados, Berries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries	3.28	0
2	Almonds, Nectarines, Peaches, Corn, and Turf	0	0

3.2.6 Downstream Dilution Analysis

The final step in defining the action area is to determine the downstream extent of exposure in streams and rivers where the EEC could potentially be above levels that would exceed the most sensitive LOC. 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 use of the “RQ to LOC ratio” provides information on the concentration that must be reached in downstream water to be below the LOC. Therefore, the analysis defines the point were the percentage of treated area with the watershed would yield sufficient non-impacted water to dilute the EECs to concentrations below the LOC. Further details on this approach are provided in Appendix D.

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 D) 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.

3.3 Terrestrial Animal Exposure Assessment

T-REX (Version 1.3.1) is used to calculate dietary and dose-based EECs of simazine for the CRLF and its potential prey (*e.g.* small mammals and terrestrial insects) inhabiting terrestrial areas. EECs used to represent the CRLF are also used to represent exposure values for frogs serving as potential prey of CRLF adults. T-REX simulates a 1-year time period. For this assessment, spray and granular applications of simazine are considered, as discussed in Sections 3.3.1 and 3.3.2 below.

3.3.1 Spray Applications

Terrestrial EECs for non-granular formulations of simazine were derived for the uses summarized in Table 3.4. Given that no data on interception and subsequent dissipation from foliar surfaces is available for simazine, a default foliar dissipation half-life of 35 days is used based on the work of Willis and McDowell (1987). Use-specific input values, including number of applications, application rate and application interval are provided in Table 3.6. An example output from T-REX is available in Appendix E.

Table 3.6 Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Simazine with T-REX

Use (Application method)	Application rate (lbs ai/A)	Number of Applications
Christmas trees (ground)	5.94	1
Non-cropland (aerial)	5	1
Grapes (ground)	4.8	1
Apples, Pears, Sour Cherries, Avocados, Berries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, and Tree Plantations, Tree Nurseries (ground)	4	1
Almonds, Nectarines, Peaches, and Corn (ground)	2	1
Turf (ground)	1	2

T-REX is also used to calculate EECs for terrestrial insects exposed to simazine. Dietary-based EECs calculated by T-REX for small and large insects (units of a.i./g) are used to bound an estimate of exposure to bees. Available acute contact toxicity data for bees exposed to simazine (in units of µg a.i./bee), are converted to µg a.i./g (of bee) by multiplying by 1 bee/0.128 g. The EECs are later compared to the adjusted acute contact toxicity data for bees in order to derive RQs.

For modeling purposes, exposures of the CRLF to simazine through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey are assessed using the small mammal (15 g) which consumes short grass. Upper-bound Kenega nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential prey (Table 3.7). Dietary-based EECs for small and large insects reported by T-REX as well as the resulting adjusted EECs are available in Table 3.8. An example output from T-REX v. 1.3.1 is available in Appendix E.

Table 3.7 Upper-bound Kenega Nomogram EECs for Dietary- and Dose-based Exposures of the CRLF and its Prey to Simazine

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
Christmas trees	802	913	1,426	1,359
Non-cropland	675	769	1200	1144
Grapes	648	738	1,152	1,098
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, and Tree Plantations, and Tree Nurseries	540	615	960	915
Almonds, Nectarines, Peaches, and Corn	270	308	480	458
Turf	135	154	240	229

Table 3.8 EECs (ppm) for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items

Use	Small Insect	Large Insect
Christmas trees	802	89
Non-cropland	675	75
Grapes	648	72
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, and Tree Plantations, and Tree Nurseries	540	60
Almonds, Nectarines, Peaches, and Corn	270	30
Turf	135	15

3.3.2 Granular Applications

Terrestrial exposures from granular applications (mg ai/square foot) for the CRLF are also estimated using the T-REX Version 1.3.1. Broadcast treatment of simazine-treated granules assumes that 100% of the granules are unincorporated on the ground. Risk to terrestrial animals from ingesting granules is based on LD_{50}/ft^2 values. Although the habitat of the CRLF and its prey items are not limited to a square foot, there is presumably a direct correlation between the concentration of a pesticide in the environment (mg/ft^2) and the chance that an animal will be exposed to a concentration that could adversely affect its survival. Further description of the mg/ft^2 index is provided in U.S. EPA (1992 and 2004).

In order to derive an estimate of the granular exposure per square foot, the granular application rates for simazine were converted from lb ai/A to mg/ft^2 in Table 3.9 using the following equation: mg/ft^2 EEC = (application rate in lb ai/A x 453,590 mg/lb) / 4,560 ft^2/A). The LD_{50}/ft^2 values are calculated using the avian toxicity value (adjusted LD_{50} of the assessed animal and its weight classes) as a surrogate for the terrestrial-phase CRLF and the EEC (mg ai/ft^2).

Table 3.9 Terrestrial EECs for Granular Uses of Simazine

Use	Application Rate (lb ai/A)	Number of Applications	EEC (mg/ft^2)
Non-bearing Fruit	8	1	83.3
Berries	4	1	41.7
Shelterbelts	3	1	31.2
Turf	1	2	10.4

Uncertainties associated with use of the T-REX model to estimate risk to the terrestrial-phase of the CRLF based on ingestion of simazine granules are discussed in Section 6.2.4.

3.4 Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.1.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method (Table 3.10). 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 3.10. An example output from TerrPlant v.1.2.2 is available in Appendix F.

Table 3.10 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 CRLF or modify its designated critical habitat. As previously discussed in Section 2.7, assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of CRLF, as well as indirect effects, such as reduction of the prey base or modification of its habitat. In addition, potential modification of critical habitat are assessed by evaluating effects to the PCEs, which are components of the critical habitat areas that provide essential life cycle needs of the CRLF. Direct effects to the aquatic-phase of the CRLF are based on toxicity information for freshwater fish, while terrestrial-phase effects are based on avian toxicity data, given that birds are generally used as a surrogate for terrestrial-phase amphibians. Because the frog's prey items and habitat requirements are dependent on the availability of freshwater fish and invertebrates, small mammals, terrestrial invertebrates, and aquatic and terrestrial plants, toxicity information for these taxa are also discussed. Acute (short-term) and chronic (long-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on simazine.

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

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (U.S. EPA, 2004). Open literature data presented in this assessment were obtained from 2006 simazine RED as well as ECOTOX information obtained on September 30, 2006. 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.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, maintenance of CRLF 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 and/or not appropriate for use in this assessment) are included in Appendix G. Appendix G also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment.

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 the Ecological Incident Information System (EIIS), are conducted to further refine the characterization of potential ecological effects associated with exposure to simazine. A summary of the available aquatic and terrestrial ecotoxicity information, use of the probit dose response relationship, and the incident information for simazine are provided in Sections 4.1 through 4.4, respectively.

With respect to simazine degradates, deisopropylatrazine (DIA) and diaminochloroatrazine (DACT), it is assumed that each of the degradates are 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 the parent for freshwater fish, invertebrates, and aquatic plants. However, the acute toxicity data for mammals indicates that DIA is more toxic than parent simazine, with a corresponding LD_{50} value of 1,240 mg/kg, as compared to > 5,000 mg/kg for simazine. Although the degradate toxicity data indicates that DIA is more toxic to mammals than parent simazine, indirect effects to terrestrial-phase CRLFs via direct acute effects to mammals are assessed using toxicity data for simazine because the available fate data show that DIA does not form and persist in the environment at any substantial level. Therefore, indirect effects to terrestrial-phase CRLFs via direct acute effects to mammals as prey items are evaluated using the acute toxicity data for simazine. 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 Plant EC_{50} (µg/L)	Mammalian LD_{50} (mg/kg)
Simazine	6,400	1000	36	>5,000
DACT	>100,000	>100,000	No data	No data
DIA	17,000	126,000	2,500	1,240

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 aquatic- and terrestrial-phase CRLFs. 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 A.

The results of available toxicity data for mixtures of simazine with other pesticides are presented in Section A.6 of 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 CRLF is addressed as part of the uncertainty analysis for this effects determination.

4.1 Toxicity of Simazine to Aquatic Organisms

Table 4.2 summarizes the most sensitive aquatic toxicity endpoints for the CRLF, 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 CRLF is presented below. Additional information is provided in Appendix A.

Table 4.2 Freshwater Aquatic Toxicity Profile for Simazine

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Citation MRID # (Author & Date)	Comment
Acute Direct Toxicity to Aquatic-Phase CRLF	Fathead Minnow[1]	96-hour LC_{50} = 6,400 µg/L (TGAI) Probit slope unavailable	000333-09 (Sleight, 1971)	Supplemental: Nominal concentrations; no raw data provided
Chronic Direct Toxicity to Aquatic-Phase CRLF	Fathead Minnow[1]	NOAEC = 960 µg/L[2] LOAEC = 2000 µg/L[2] (80% formulated product)	000436-76 (Mayer & Sanders, 1976)	Acceptable: 12% reduction in fry growth at 2,000 µg/L[2]
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Freshwater Invertebrates (*i.e.* prey items)	*Daphnia magna*	48-hour TL_{50} = 1,000 µg/L (TGAI) Probit slope unavailable	450882-21 (Sanders, 1970)	Supplemental: Nominal concentrations; no raw data provided
Indirect Toxicity to Aquatic-Phase CRLF via Chronic Toxicity to Freshwater Invertebrates (*i.e.* prey items)	*Daphnia magna*	NOAEC = 2,000 µg/L[2] LOAEC = >2,000 µg/L[2] (80% formulated product)	000436-76 (Mayer & Sanders, 1976)	Acceptable: No adverse effects at the highest test concentration
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Non-vascular Aquatic Plants	Blue-green algae	5-day EC_{50} = 36 µg/L (TGAI) NOAEC = 5.4 µg/L	426624-01 (Thompson and Swigert, 1992a)	Supplemental: A NOAEC could not be determined based on cell density. Existing cell density data was used to calculate an EC_{05} for use as a

				NOAEC
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Vascular Aquatic Plants	Duckweed	14-day EC_{50} = 140 μg/L NOAEC = 54 μg/L	425037-04 (Thompson and Swigert, 1992b)	Acceptable: LOAEC of 110 μg/L based on reduction in frond number

[1] Used as a surrogate for the aquatic-phase CRLF.
[2] Data for the TGAI are not available. Concentrations are adjusted for % a.i.

It should be noted that a considerable number of freshwater acute toxicity data 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 aquatic fish and invertebrates is categorized using the system shown in Table 4.3 (U.S. EPA, 2004). Toxicity categories for aquatic plants have not been defined.

Table 4.3 Categories of Acute Toxicity for Aquatic Organisms

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

4.1.1 Toxicity to Freshwater Fish

Ecotoxicity data for freshwater fish are generally used as surrogates for aquatic-phase amphibians when amphibian toxicity data are not available (U.S. EPA, 2004). A comprehensive search of the open literature provided no toxicity information on lethal or sublethal effects of simazine to amphibians. However, atrazine, a triazine herbicide in the same chemical class as simazine, has been associated with endocrine-related effects (*i.e.*, gonadal abnormalities and laryngeal alterations) in frogs. The Agency review of the current database of published studies and registrant submitted studies on atrazine lead to the conclusion that there was sufficient evidence to formulate a hypothesis that atrazine exposure may impact gonadal development in amphibians, but there was insufficient data to confirm or refute the hypothesis (transmission of meeting minutes of the Scientific Advisory Panel (SAP) held June 17-20, 2003; (http://www.epa.gov/oscpmont/sap/2003/June/junemeetingreport.pdf). Because atrazine and simazine share a similar mechanism of herbicidal action and similar degradates, including DIA and DACT, the current hypothesis regarding potential sublethal effects of atrazine to amphibians may be applicable to simazine depending on the outcome of future studies on atrazine. The results of these studies, as well as other recent open literature data, which focus on the potential effects of atrazine on amphibian gonadal development, are being reviewed. This information will be presented and discussed as part of a second SAP to be held in October 2007.

Given that no simazine toxicity data are available for aquatic-phase amphibians, freshwater fish data were used as a surrogate to estimate direct acute and chronic risks to the CRLF. Freshwater fish toxicity data were also used to assess potential indirect effects of simazine to the CRLF. Direct effects to freshwater fish resulting from exposure to simazine may indirectly affect the CRLF via reduction in available food. As discussed in Section 2.5.3, over 50% of the prey mass of the CRLF may consist of vertebrates such as mice, frogs, and fish (Hayes and Tennant, 1985).

A summary of acute and chronic freshwater fish data, including data from the open literature, is provided below in Sections 4.1.1.1 through 4.1.1.3.

4.1.1.1 Freshwater Fish: Acute Exposure (Mortality) Studies

As shown in Table A-10, submitted acute toxicity values for technical grade simazine exceed its expected water solubility (~3.5 mg/L), with values ranging from 6.4 to >32 mg ai/L. The solubility of simazine is dependant on the water temperature, with a trend toward decreasing solubility at lower temperatures (Schwarzenbach *et al.*, 1993). The following mathematical function describes the relationship between water solubility and temperature: Log (mg/L) = 0.021(T, K) - 5.5358 (R^2 = 0.9862, n = 5), where T = temperature and K = kelvin. Further examination of the test temperatures for the acute freshwater studies reveals that all submitted tests were conducted at temperatures < 18°C. Based on the mathematical relationship between solubility and temperature, the expected solubility of simazine in water at a temperature of 18°C would be approximately 3.8 mg/L. With respect to technical grade simazine, the reported acute LC_{50} values for fathead minnow (MRID 000333-09) and bluegill sunfish (MRID 000254-38) are 6,400 and 16,000 µg/L, respectively. While both of these LC_{50} values exceed the predicted limit of simazine's solubility in water (3,800 µg/L), 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. Therefore, the fathead minnow LC_{50} value of 6,400 µg/L was selected as the surrogate acute freshwater fish toxicity endpoint and used to assess direct acute effects of simazine to the CRLF. 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/L was established in the 96-hour fathead minnow study. This no effect level is consistent with the results of a 28-day subacute rainbow trout study (MRID 000436-68). Following 28-days of exposure, no mortality or other toxic symptoms were observed at the 2,500 µg/L treatment level. The subacute study was classified as supplemental because the fish were too large (25-40g) and only one treatment level (2,500 µg/L) was tested. In the acute bluegill sunfish study, which is classified as core, no mortality was observed in treatment groups ≤ 5,600 µg/L, and 40% mortality was observed in the 10,000 µg/L treatment group.

There is additional uncertainty 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.

Based on the available data, simazine is categorized as moderately toxic to freshwater fish on an acute basis. No additional data on the acute toxicity of simazine or its degradates to freshwater fish were located in the open literature.

4.1.1.2 Freshwater Fish: Chronic Exposure (Growth/Reproduction) Studies

Chronic freshwater fish acute toxicity studies were used to assess potential direct effects via growth and reproduction to the aquatic-phase of the CRLF. 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 000436-76). 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 Table A-12 of Appendix A.

4.1.1.3 Freshwater Fish: Sublethal Effects and Additional Open Literature Information

In addition to submitted studies, data were located in the open literature that report sublethal effect levels to freshwater fish that are less than the selected measures of effect summarized in Table 4.2. Although these studies report potentially sensitive endpoints, effects on survival, growth, or reproduction were not observed in the available full life-cycle studies at concentrations that induced the reported sublethal effects described below and in Appendix A.

No additional information is available that indicates greater acute freshwater fish sensitivity to simazine than the submitted data. In addition, no laboratory freshwater fish early life-stage or life-cycle tests using simazine and/or its formulated products were located in the open literature. However, one laboratory study on sublethal effects of simazine to male Atlantic salmon (*Salmo salar* L.) is available. In a study conducted by Moore and Lower (2001; ECOTOX# 67727), simazine inhibited *in vitro* olfactory function in male Atlantic salmon parr. The results of the this study are summarized in Table A-13 of 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 smolts 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.

Although these studies raise questions about the potential effects of simazine on endocrine-mediated functions in anadromous fish, it is not possible to quantitatively link these sublethal effects to the selected assessment endpoints for the CRLF (*i.e.*, survival, growth, and reproduction of individuals and modification to designated critical habitat). Therefore, potential sublethal effects on fish are evaluated qualitatively in Section 5.2 and not used as part of the quantitative risk characterization. Further detail on sublethal effects to fish is provided in Sections A.4.3 and Table A-13 of Appendix A.

4.1.2 Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data were used to assess potential indirect effects of simazine to the CRLF. Direct effects to freshwater invertebrates resulting from exposure to simazine may indirectly affect the CRLF via reduction in available food items. As discussed in Section 2.5.3, the main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic invertebrates found along the shoreline and on the water surface, including aquatic sowbugs, larval alderflies and water striders.

A summary of acute and chronic freshwater invertebrate data, including data published in the open literature, is provided below in Sections 4.1.2.1 through 4.1.2.3.

4.1.2.1 Freshwater Invertebrates: Acute Exposure Studies

Acute toxicity data for simazine are available for the preferred test species, *Daphnia magna*, as well as seven other freshwater invertebrates including the seed shrimp (*Cypridopsis vidua*), scud (*Gammarus lacustris* and *G. fasciatus*), stonefly (*Pteronarcys californica*), sowbug (*Asellus brevicaudus*), glass shrimp (*Palaemonetes kadiakensis*), and crayfish (*Orconectes nais*). Results of acute toxicity tests with freshwater invertebrates are tabulated in Table A-14 of Appendix A.

In a comparative analysis of herbicides on six species of freshwater invertebrates, 48-hr exposure to simazine at concentrations of 1,000 and 3,700 µg/L resulted in 50 percent mortality in daphnia and seed shrimp, respectively (MRID 450882-21). In the same analysis, simazine did not appear to have any effect on the scud (*G. fasciatus*), sowbug, glass shrimp, or crayfish, with 48-hr TL_{50} values exceeding 100,000 µg/L. However, as previously mentioned, toxicity values > 100,000 µg/L exceed the water solubility of simazine by a wide margin; therefore, the validity of the data is uncertain. TL_{50} values reported in the study are median tolerance limits, representative of the concentration in water in which 50 percent of the animals exhibit a specific response (*i.e.*, mortality, immobilization) at a given time. It should be noted that no test concentrations or raw data were provided as part of this study; therefore, it was classified as supplemental. In addition, the slope of the dose-response relationship for daphnia could not be determined due to a lack of raw data and test concentrations.

Two additional supplemental 96-hr acute toxicity studies on freshwater invertebrates are available for the technical grade of simazine. In a chemical database of acute toxicity to freshwater animals maintained by the Columbia National Fisheries Research Laboratory of the U.S. Fish and Wildlife Service, 96-hr exposure of the stonefly (*P. californica*) to simazine resulted in an EC_{50} of 1,900 µg/L (MRID 400980-01). A 96-hr EC_{50} value of 13,000 µg/L was reported for the scud (*G. lacustris*) (MRID 050092-42) in a study classified as supplemental because no mortality data were provided and test concentrations were not specified.

Based on the available data, simazine is categorized as highly to slightly toxic to freshwater invertebrates on an acute basis. No additional data on the acute toxicity of simazine or its degradates to freshwater invertebrates were located in the open literature.

4.1.2.2 Freshwater 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 000436-76) using the preferred species *D. magna*. The results of this test are summarized in Table A-16 of Appendix A. No treatment-related adverse effects to parental mortality and production of offspring occurred during the 21-day study at the highest test concentration of 2,000 μg/L. The only treatment-related effect was a significant increase in production of offspring produced at the 80 μg/L test concentration. Therefore, the NOAEC value is 2,000 μg/L.

4.1.2.3 Freshwater Invertebrates: Open Literature Data

Only one chronic toxicity study on freshwater invertebrates is available from the open literature. It appears that *D. pulex* fed a diet of green alga are less sensitive to the effects of simazine, as compared with those that are fed mixed bacterial cultures. Similar to the results reported in the registrant submitted studies, simazine concentrations at the highest treatment level (5,000 μg/L) were shown to enhance reproduction and growth in *D. pulex* that were fed green alga following 14 days of exposure. Conversely, reproduction was significantly reduced at simazine concentrations of 5,000 and 1,000 μg/L when mixed bacterial cultures were used as the food source. However, no significant differences in the number of offspring per adult were observed at treatment levels of 100, 200, or 2,000 μg/L; therefore, the results are erratic and not dose-dependant. Given the variability in reproductive responses in *D. pulex* fed mixed bacterial cultures and issues of comparability between chronic freshwater invertebrate guidelines (where invertebrates are not fed mixed bacterial cultures), the data from this study are addressed qualitatively. The results of this study are described in further detail in Section A.4.7 and Table A.17 of Appendix A.

4.1.3 Toxicity to Aquatic Plants

Aquatic plant toxicity studies were used as one of the measures of effect to evaluate whether simazine may affect primary production and the availability of aquatic plants as food for CRLF tadpoles. Primary productivity is essential for indirectly supporting the growth and abundance of the CRLF.

Two types of studies were used to evaluate the potential of simazine to affect aquatic plants. Laboratory and field studies were used to determine whether simazine may cause direct effects to aquatic plants. A summary of the laboratory data and freshwater field studies for aquatic plants is provided in Sections 4.1.3.1 and 4.1.4.

4.1.3.1 Aquatic Plants: Laboratory Data

A summary of acute toxicity of simazine to aquatic plants is provided in Table A-21 of Appendix A. 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 425037-04). 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 426624-01). 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.

4.1.4 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 Section A.4.8 and summarized in Table A-18 of Appendix A.

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. Tables A-23 and A-18 of Appendix A provide 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 flos-aquae* 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 Section A.5.3.

4.2 Toxicity of Simazine to Terrestrial Organisms

Table 4.4 summarizes the most sensitive terrestrial toxicity endpoints for the CRLF, 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 for the CRLF is presented below.

Table 4.4 Terrestrial Toxicity Profile for Simazine				
Endpoint	**Species**	**Toxicity Value Used in Risk Assessment**	**Citation MRID# (Author & Date)**	**Comment**
Acute Direct Toxicity to Terrestrial-Phase CRLF (LD_{50})	Mallard duck[1]	LD_{50} = >4,640 mg ai/kg-bw	000727-98 (Fink, 1976)	**Supplemental**: No mortality at the highest test concentration; however, reduced reaction to external stimuli, wing droop, and depression were observed at concentrations as low as 1,000 mg ai/kg-bw one hour after dosing. Birds were 14 days old rather than required age of 14-16 weeks; therefore, there is uncertainty associated with the reported sublethal effects.
Acute Direct Toxicity to Terrestrial-Phase CRLF (LC_{50})	Mallard duck and Bobwhite quail[1]	LC_{50} = >5,000 mg ai/kg-diet	000229-23 (Hill et al., 1975)	**Acceptable:** No mortality at the highest test concentration
Chronic Direct Toxicity to Terrestrial-Phase CRLF	Bobwhite quail[1]	NOAEC = 100 mg ai/kg LOAEC = 500 mg ai/kg	001631-34 (Beavers, 1986)	**Acceptable**: Reduction in number of eggs laid, viable embryos, live embryos, hatchlings, and 14-day old chick survivors at 500 mg ai/kg
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to mammalian prey items)	Rat	Simazine LD_{50} = >5,000 mg ai/kg-bw	001488-97 (Rosenfeld, 1985)	**Acceptable:** At 5,000 mg ai/kg-bw, 3/10 animals died
Indirect Toxicity to Terrestrial-Phase CRLF (via chronic toxicity to mammalian prey items)	Rat	NOAEC = 10 mg ai/kg LOAEC = 100 mg ai/kg	418036-01 (Epstein et al., 1991)	**Acceptable**: Reduction in body weight gain
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to terrestrial invertebrate prey items)	Honey bee	LD_{50} = >96.7 μg ai/bee	000369-35 (Atkins et al., 1975)	**Acceptable**: 6.5% mortality in the 96.7 μg ai/bee treatment group
Indirect Toxicity to Terrestrial- and Aquatic-Phase CRLF (via toxicity to terrestrial plants)	Seedling Emergence Monocots (Onions)	EC_{25} = 0.02 lb ai/A	426346-03 (Chetram, 1993a)	**Acceptable**: Onion shoot height
	Seedling Emergence Dicots	EC_{25} = 0.009 lb ai/A	426346-03 (Chetram, 1993a)	**Acceptable**: Lettuce dry weight

	(Lettuce)			
	Vegetative Vigor Monocots (Oats)	EC_{25} = 0.033 lb ai/A	426346-04 (Chetram, 1993b)	**Acceptable**: Oats dry weight
	Vegetative Vigor Dicots (Lettuce)	EC_{25} = 0.033 lb ai/A	426346-04 (Chetram, 1993b)	**Acceptable**: Lettuce dry weight

[1] Used as a surrogate for the terrestrial-phase CRLF.

Acute toxicity to terrestrial animals is categorized using the classification system shown in Table 4.5 (U.S. EPA, 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4.5 Categories of Acute Toxicity for Avian and Mammalian Studies

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

4.2.1 Toxicity to Birds

As specified in the Overview Document, the Agency uses birds as a surrogate for terrestrial-phase amphibians when amphibian toxicity data are not available (U.S. EPA, 2004). No terrestrial-phase amphibian data are available for simazine; therefore, acute and chronic avian toxicity data are used to assess the potential direct effects of simazine to terrestrial-phase CRLFs.

4.2.1.1 Birds: Acute Exposure (Mortality) Studies

Acute oral toxicity data are available for a number of avian species; this data is summarized in Table A-1 of Appendix A. Simazine is classified as practically non-toxic to birds on an acute exposure basis. The acute oral toxicity of simazine is based on a 14-day study to 14-day old mallard ducks (*Anas platyrhynchos*) (MRID 000727-98); the LD_{50} exceeded the highest dose tested (>4640 mg ai/kg bw). There was no mortality during the study. However, reduced reaction to external stimuli (sound and movement), wing droop, and depression were observed at the 1,000, 2,150, and 4,640 mg/kg doses one hour after dosing, as compared to the control group. As a result, the mallard NOAEC is 464 mg/kg. It should be noted that this study is classified as supplemental because it deviates from the guideline protocol in that the birds were 14 days old rather than 14 to 16 weeks.

The results of the subacute dietary studies for the preferred test species, bobwhite quail (*Colinus virginianus*) and mallard duck (*A. platyrhynchos*), are summarized in Table A-3 of Appendix A**.** Subacute avian dietary toxicity values for the technical grade and a 80% formulation indicate that simazine is practically non-toxic. Hill *et al.* reported no mortality in four species of birds at the highest concentrations of technical simazine tested (MRID 000229-23). Corresponding LC_{50} values for the mallard duck, bobwhite quail, and ring-necked pheasant (*Phasianus colchicus*) are > 5,000 mg/kg; the LC_{50} value for the Japanese quail (*Coturnix coturnix japonica*) is >3,720 mg/kg. Mortalities were observed in bobwhite quail and mallard duck acute dietary tests with the formulated product of simazine (Simazine 80 WP). In the bobwhite test (MRID 000233-18), mortality was 40% at 8800 mg/kg ai, beginning on Day 4 through Day 9. The bobwhite NOAEL of <4000 mg/kg ai is based on a 90% reduction in body weight gain and a 37% reduction in food consumption over the exposure period (Day 1 through Day 7). In the mallard test (MRID 000233-19), 30% mortality occurred at 25,600 mg/kg ai, with all deaths occurring between Days 5 and 8. The mallard NOAEL of <800 mg/kg ai is based on a 48 to 59% reduction in body weight gain and a 24% reduction in food consumption during the exposure period.

Based on a review of the open literature, no additional information on the acute and subacute toxicity of simazine to birds is available that indicates greater avian sensitivity than the registrant-submitted studies.

4.2.1.2 Birds: Chronic Exposure (Growth, Reproduction) Studies

Two avian reproduction studies for simazine are available, which are summarized in Table A-4 and Section A.1.3 of Appendix A. The primary reproductive effect of simazine on avian reproduction appears to be reduction in the number of eggs laid.

The most sensitive reproductive endpoint is based on the bobwhite quail study (MRID 001631-34), where the NOAEC was determined to be 100 mg/kg, based on reduction in the number of eggs laid, viable embryos, live embryos, hatchlings, and 14-day old chick survivors. The primary reproductive effect of simazine on avian reproduction appears to be reduction in the number of eggs laid. The number of eggs laid was reduced by 20% at the highest treatment level of 500 mg/kg. Adverse reproductive effects increased by approximately 13% at the embryo viability stage and remained constant throughout the study, also affecting the number hatched and survival of 14-day chicks. The LOAEC was the highest concentration tested of 500 mg/kg.

In the mallard duck reproduction study (MRID 435769-01), simazine technical had a significant adverse effect on egg production and female weight gain at the 450 mg/kg ai test concentration. The reduced number of hatchlings and 14-day old survivors at that level, as compared to the control group, can be attributed to the reduced number of eggs laid. The number of eggs laid was reduced by approximately 50% at the highest treatment level of 450 mg/kg. The NOAEC was determined to be 150 mg/kg, based on reduction in the number of eggs laid and female body weight; the LOAEC was 450 mg/kg.

Based on a review of the open literature, no additional information on the chronic toxicity of simazine to birds is available that suggests greater sensitivity than the registrant-submitted data.

4.2.2 Toxicity to Mammals

Mammalian toxicity data are used to assess potential indirect effects of simazine to the terrestrial-phase CRLF. Direct effects to small mammals resulting from exposure to simazine may also indirectly affect the CRLF via reduction in available food. As discussed in Section 2.5.3, over 50% of the prey mass of the CRLF may consist of vertebrates such as mice, frogs, and fish (Hayes and Tennant, 1985).

4.2.2.1 Mammals: Acute Exposure (Mortality) Studies

The acute mammalian toxicity data for simazine is summarized in Table A-5 and Section A.2.1 of Appendix A. Rats exposed to technical grade simazine showed no mortality at the highest doses tested. The corresponding LD_{50} value for the TGAI is >5,000 mg/kg-bw, classifying technical grade simazine as practically non-toxic (MRID 001488-97) to mammals on an acute basis. In this study, one out of five males and two out of five females died. Therefore, the LD_{50} value of >5,000 mg/kg for simazine is based on a 30% mortality rate at the highest test concentration of 5,000 mg/kg.

Acute mammalian oral toxicity data are also available for one of the degradates of simazine, DIA, and are summarized in Table A-6 and Section A.2.1 of Appendix A. Both the female and male LD_{50} values are more toxic to laboratory rats than technical grade values for the parent simazine with respective values of 810 and 2,290 mg/kg (MRID 430123-01). The combined LD_{50} value for males and females is 1,240 mg/kg.

Based on a review of the open literature, no additional information on the acute toxicity of simazine or its degradates to mammals is available that indicates greater sensitivity than the studies discussed above.

4.2.2.2 Mammals: Chronic Exposure (Growth, Reproduction) Studies

Reproductive and developmental mammalian toxicity values for simazine are reported in Table A-7 and Section A.2.2. These studies provide adequate toxicity data on chronic developmental and reproductive effects of simazine. Chronic studies using laboratory rats show consistent reductions in adult body weight gain and adult body weight at simazine concentrations of 100 mg/kg-diet. The corresponding NOAEC value for these studies is 10 mg/kg-diet (MRIDs 418036-01 and 406144-05). In addition, reproductive effects including increased abortions, reduced fetal weight, and increased skeletal variations have been observed in New Zealand white rabbits at a concentration of 200 mg/kg/day, with a corresponding NOAEL value of 75 mg/kg/day (MRID 001614-07).

In March 2002, the Agency's Health Effects Division (HED) evaluated the available scientific evidence for determining whether a common mechanism of toxicity exists among certain triazine-containing pesticides, including simazine, atrazine, propazine, tribenuron-methyl (Express) and the 2-hydroxyatrazine, DEA, DIA, and DACT (EPA, 2002). Treatment of laboratory animals with these chemicals results in toxic neuroendocrine effects such as mammary gland tumors in only female rats, attenuation of the lutenizing hormone (LH) surge, alteration of the estrous cycle, altered pregnancy maintenance, and delayed pubertal development. The development of mammary gland tumors in female rates is postulated to be associated with disruption of the hypothalamic-pituitary-gonadal (HPG) axis. Altered secretory activity of the HPG axis begins with a decrease in the release of gonadotropin releasing hormone (GnRH) by the hypothalamus followed by a consequent attenuation of the LH surge during the estrous cycle. As a result, ovulation does not occur and the estrous cycle is prolonged, thereby increasing exposure to estrogen. Increased exposure to estrogen is conducive to the development of mammary gland tumors. Based on the available weight-of-evidence, HED determined that atrazine, simazine, propazine, and the degradates DEA, DIA, and DACT can be grouped by a common mechanism of toxicity for disruption of the HPG axis. Therefore, equivalent mammalian toxicity is assumed for the parent compound and degradates of simazine. Submitted studies provide evidence that administration of these compounds to female SD rats leads to increased incidence and/or early onset of benign and mammary gland tumors. Simazine at dose levels of 100 ppm (5.3 mg/kg/day) and 1000 ppm (45.8 mg/kg/day) resulted in a statistically-significant dose-related trend in mammary gland carcinomas (MRID 406144-05). The corresponding NOAEC value for this study was 10 ppm or 0.47 mg/kgBW/day.

Based on a review of the open literature, no additional information on the chronic toxicity of simazine or its degradates to mammals is available that suggests greater sensitivity than the submitted data.

4.2.3 Toxicity to Terrestrial Invertebrates

Terrestrial invertebrate toxicity data are used to assess potential indirect effects of simazine to the terrestrial-phase CRLF. Direct effects to terrestrial invertebrates resulting from exposure to simazine may also indirectly affect the CRLF via reduction in available food.

4.2.3.1 Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

The use of simazine on corn and other crops that require pollination may result in exposure to non-target beneficial insects, such as the honey bee. The results of acute contact toxicity testing of simazine on the honey bee (*Apis mellifera*) are summarized in Table A-8 and Section A.3.1. By 48 hours in the contact test, 6.5% mortality was observed in the 96.7 µg/bee treatment group (MRID 000369-35); therefore, the LD_{50} value for the contact test is >96.7 µg/bee. As a result, simazine is categorized as practically non-toxic to honeybees on an acute contact basis. The acute contact honey bee LD_{50} = >96.7 µg/bee (converted to 754 ppm based on Mayer and Johansen, 1990) is used to assess potential indirect effects to the terrestrial-phase CRLF.

4.2.3.2 Terrestrial Invertebrates: Open Literature Studies

Three open literature studies on simazine effects to non-target insects including earthworms and beetles were located and are summarized in Table A-9 and Section A.3.2 of Appendix A. All studies are classified as qualitative because no effects were observed at the highest test concentrations.

The results of two earthworm studies (Martin, 1982: ECOTOX #58170; Lydy and Linck, 2003; ECOTOX #71459) showed no adverse effects to mortality and growth, following 96-hours of exposure at 10 ug/cm^2 and 7 days of exposure at 100 ppm, the highest simazine concentrations tested. Samsoe-Peterson (1987; ECOTOX # 70278) evaluated the effects of simazine (50% a.i.) on the rove beetle, *Aleochara bileneata*. Following 5 days of exposure, no mortality or reduction in egg production were observed in the simazine-treated adult female beetles at an application rate of 600 L/ha (assuming that the density of water is 8.35 lbs/gallon, an application rate of 600 L/ha is roughly equivalent to 534 lb/A). Although this application rate was intended to be the "maximum recommended practical use", it is well above the current maximum registered labeled use for simazine of 5.94 lb ai/A. According to the standard used by the International Organization of Biological Control (IOBC) working group "Pesticides and Beneficial Organisms", simazine was classified as "harmless" to the rove beetle.

4.2.4 Toxicity to Terrestrial Plants

Terrestrial plant toxicity data are used to evaluate the potential for simazine to affect riparian zone and upland vegetation within the action area for the CRLF. Impacts to riparian and upland (*i.e.*, grassland, woodland) vegetation may result in indirect effects to both aquatic- and terrestrial-phase CRLFs, as well as modification to designated critical habitat PCEs via increased sedimentation, alteration in water quality, and reduction in of upland and riparian habitat that provides shelter, foraging, predator avoidance and dispersal for juvenile and adult CRLFs.

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. Sub-lethal 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. A drawback to these tests is that they 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.

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 4.6 and also in Appendix A (Tables A-19 and A-20).

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 4.6 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		0.049	0.063	Dry Weight	2.19

	Radish				
	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. In addition, 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 Table A-20b of Appendix A.

4.3 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 (U.S. EPA, 2004). As part of the risk characterization, an interpretation of acute RQ for listed species is discussed. This interpretation is presented in terms of the chance of an individual event (*i.e.*, mortality or immobilization) should exposure at the EEC actually occur for a species with sensitivity to 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.

4.4 Incident Database Review

A review of the EIIS database for ecological incidents involving simazine was completed on May 22, 2006. The results of this review for terrestrial, plant, and aquatic incidents are discussed below in Sections 4.4.1 through 4.4.3, respectively.

4.4.1 Terrestrial Incidents

Only two simazine incidents have been reported involving terrestrial organisms. The first incident entailed two quail found dead in an area in Yosemite National Park treated with granular simazine to control weeds. Chemical analysis of the crop and gizzard contents was conducted, and 0.5 ppm simazine was detected. The reported certainty index for the quail incident (# I005754-015) was categorized as "unlikely" because the detected concentrations of simazine were "not enough to cause a kill." In the second incident, which occurred on June 26, 1998, five Canada geese were found dead in a corn field in Rockingham County, Virginia, following spray application of Princep 4L (#I008168-001). Soil and vegetative samples were collected along the bank near the creek in which the dead geese were found. Substantial concentrations of simazine and atrazine were found in the samples. Simazine detections ranged from 0.16 to 2.3 ppm in soil and 8.5 to 20.5 ppm in foliage. The certainty index for the corn field incident is "probable."

4.4.2 Plant Incidents

Three simazine incidents have been reported for terrestrial plants. 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."

4.4.3 Aquatic Incidents

Nine freshwater aquatic incidents involving fish kills have been reported for simazine between the years of 1976 and 1995. 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 H. 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 H.

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations to determine the potential ecological risk from varying simazine use scenarios within the action area and likelihood of direct and indirect effects on the CRLF and its designated critical habitat. 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 CRLF or its designated critical habitat (*i.e.*, "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect").

5.1 Risk Estimation

Risk is estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (Appendix C). For acute exposures to the CRLF and its animal prey in aquatic habitats, as well as terrestrial invertebrates, the LOC is 0.05. For acute exposures to the CRLF and mammals, the LOC is 0.1. The LOC for chronic exposures to CRLF and its prey, as well as acute exposures to plants is 1.0.

Risk to the aquatic-phase CRLF is estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended simazine usage scenarios summarized in Table 3.3 and the appropriate aquatic toxicity endpoint from Table 4.2. Risks to the terrestrial-phase CRLF and its prey (*e.g.* terrestrial insects, small mammals and terrestrial-phase frogs) are estimated based on exposures resulting from foliar and granular applications of simazine (Tables 3.5 through 3.7) and the appropriate toxicity endpoint from Table 4.4. Exposures are also derived for terrestrial plants, as discussed in Section 3.3 and summarized in Table 3.8, based on the highest application rates of simazine use within the action area.

5.1.1 Exposures in the Aquatic Habitat

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.

5.1.1.1 Direct Effects to Aquatic-Phase CRLF

Direct effects to the aquatic-phase CRLF are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60-day EECs and the lowest chronic toxicity value for freshwater fish are used. As shown in Table 5.1, all acute and chronic RQs are well below their respective LOCs; therefore, direct effects associated with acute and chronic exposure to simazine are not expected to occur for the aquatic-phase CRLF. 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 5.2.1.1.

Table 5.1 Summary of Direct Effect RQs for the Aquatic-phase CRLF

Direct Effects to CRLF[a]	Surrogate Species	Toxicity Value (µg/L)	EEC (µg/L)[b]	RQ	Probability of Individual Effect	LOC Exceedance and Risk Interpretation
Acute Direct Toxicity	Fathead minnow	LC_{50} = 6,400	Peak: 130.2	0.02	1 in 9.6E+13 (1 in 2,950 to 1 in 2.3E+52)[c]	No[d]
Chronic Direct Toxicity		NOAEC = 960	60-day: 91.4	0.10	Not calculated for chronic endpoints	No[e]

[a] RQs associated with acute and chronic direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items.
[b] The highest EEC based on foliar use of simazine on Christmas trees at 5.94 lb ai/A (see Table 3.3).
[c] A probit slope value for the acute fathead minnow 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).
[d] RQ < acute endangered species LOC of 0.05.
[e] RQ < chronic LOC of 1.0.

5.1.1.2 Indirect Effects to Aquatic-Phase CRLF via Reduction in Prey (non-vascular aquatic plants, aquatic invertebrates, fish, and frogs)

Non-vascular Aquatic Plants

Indirect effects of simazine to the aquatic-phase CRLF (tadpoles) via reduction in non-vascular aquatic plants in its diet are based on peak EECs from the standard pond and the lowest acute toxicity value for aquatic non-vascular plants. As shown in Table 5.2, RQs exceed the acute risk LOC (RQ $\geq$1.0) for aquatic 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. The preliminary effects determination is "may effect", based on indirect effects to aquatic-phase CRLFs based on a reduction in non-vascular aquatic plants as food items.

Table 5.2 Summary of Acute RQs Used to Estimate Indirect Effects to the CRLF via Effects to Non-Vascular Aquatic Plants (diet of CRLF in tadpole life stage and habitat of aquatic-phase CRLF)

Uses	Application rate (lb ai/A) and type*	Peak EEC (µg/L)	Indirect effects RQ** (food and habitat)
Christmas trees	5.94 (liquid)	130.2	**3.62**
Berries[1]	4 (liquid)	108.4	**3.01**
	4 (granular)	103.4	**2.87**
Tree plantations	4 (liquid)	88.0	**2.44**
Tree nurseries	4 (liquid)	68.2	**1.89**
Non-cropland[2]	5 (liquid)	66.04	**1.83**
Non-bearing fruit[3]	8 (granular)	61.5	**1.71**
Avocados	4 (liquid)	53.5	**1.49**
Olives	4 (liquid)	33.9	0.94
Nuts (high rate)[4]	4 (liquid)	25.6	0.71
Grapes	4.8 (liquid)	18.2	0.51
Nuts (low rate)[5]	2 (liquid)	12.8	0.36
Corn	2 (liquid)	12.3	0.34
Shelterbelts	3 (granular)	12.0	0.33
Fruit (low and high rates)[6]	2 and 4 (liquid)	5.6 - 11.1	0.04 - 0.31
Citrus[7]	4 (liquid)	7.1	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

* Simazine is applied once/season via ground application, unless otherwise noted.
** = LOC exceedances (RQ $\geq$ 1) are bolded and shaded. RQ = use-specific peak EEC / blue green algae EC_{50} value of 36 µg/L (MRID 426624-01).
[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

Aquatic Invertebrates

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. 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 aquatic-phase CRLFs) is provided in Table 5.3. Acute RQs exceed the LOCs for listed species (RQ ≥ 0.05) 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). Although the range of acute RQs exceeding LOCs is from 0.05 to 0.13, all acute RQs are less than LOCs for non-listed species (RQ = 0.5). Resulting chronic RQs are less than the chronic LOC (RQ ≥ 1.0) for aquatic invertebrates for all modeled simazine uses. The preliminary effects determination is "may effect" for indirect effects to aquatic-phase CRLFs based on a reduction of freshwater invertebrates as prey (via direct acute toxicity to freshwater invertebrates). However, reduction in the freshwater invertebrate prey base via chronic toxicity is not expected.

Table 5.3 Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats)

Uses	Application rate (lb ai/A) and type*	Peak EEC (µg/L)	21-day EEC (µg/L)	Indirect Effects Acute RQ**	Indirect Effects Chronic RQ**
Christmas trees	5.94 (liquid)	130.2	127.2	**0.13**	0.06
Berries[1]	4 (liquid)	108.4	105.4	**0.11**	0.05
	4 (granular)	103.4	100.5	**0.10**	0.05
Tree plantations	4 (liquid)	88.0	85.6	**0.09**	0.04
Tree nurseries	4 (liquid)	68.2	66.3	**0.07**	0.03
Non-cropland[2]	5 (liquid)	66.0	64.6	**0.07**	0.03
Non-bearing fruit[3]	8 (granular)	61.5	59.8	**0.06**	0.03
Avocados	4 (liquid)	53.5	51.9	**0.05**	0.03
Olives	4 (liquid)	33.9	29.9	0.03	0.01
Nuts (high rate)[4]	4 (liquid)	25.6	25.0	0.03	0.01
Grapes	4.8 (liquid)	18.2	17.6	0.02	0.01
Nuts (low rate)[5]	2 (liquid)	12.8	12.5	0.01	0.01
Corn	2 (liquid)	12.3	11.9	0.01	0.01
Shelterbelts	3 (granular)	12.0	9.3	0.01	<0.01
Fruit (low and high rates)[6]	2 and 4 (liquid)	5.6 - 11.1	5.4 – 10.9	0.01	<0.01
Citrus[7]	4 (liquid)	7.1	6.9	0.01	<0.01
Turf (residential,	1 (2 liquid and	4.3 – 8.8	4.2 – 8.6	≤0.01	<0.01

recreational, and sod farm)	granular applications w/30 day interval)				

* Simazine is applied once/season via ground application, unless otherwise noted.
** = LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0) are bolded and shaded. Acute RQ = use-specific peak EEC / daphnia TL_{50} value of 1,000 µg/L (MRID 000436-76). Chronic RQ = use-specific 21-day EEC / daphnia NOAEC value of 2,000 µg/L (MRID 000436-76).
[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

Fish and Frogs

Fish and frogs also represent prey of the CRLF. RQs associated with acute and chronic direct toxicity to the CRLF (Table 5.1) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. Given that acute and chronic RQs for direct toxicity to the CRLF are less than LOCs, indirect effects based on a reduction of fish and frogs as prey items are not expected.

5.1.1.3 Indirect Effects to CRLF via Reduction in Habitat and/or Primary Productivity (Freshwater Aquatic Plants)

Indirect effects to the CRLF via direct toxicity to aquatic plants are estimated using the most sensitive non-vascular and vascular plant toxicity endpoints. Because there are no obligate relationships between the CRLF and any aquatic plant species, the most sensitive EC_{50} values, rather than NOAEC values, were used to derive RQs. As shown in Table 5.4, none of the RQs exceed the LOC of 1 for vascular aquatic plants. However, as previously discussed in Section 5.1.2.2 and summarized in Table 5.2, LOCs are exceeded for non-vascular aquatic 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). Therefore, the preliminary effects determination is “may effect”, based on indirect effects to habitat and/or primary productivity for the aquatic-phase CRLF.

Table 5.4 Summary of Acute RQs Used to Estimate Indirect Effects to the CRLF via Effects to Vascular Aquatic Plants (habitat of aquatic-phase CRLF)[a]

Uses	Application rate (lb ai/A) and type*	Peak EEC (µg/L)	Indirect effects RQ** (food and habitat)
Christmas trees	5.94 (liquid)	130.2	0.93
Berries[1]	4 (liquid)	108.4	0.77

	4 (granular)	103.4	0.74
Tree plantations	4 (liquid)	88.0	0.63
Tree nurseries	4 (liquid)	68.2	0.49
Non-cropland[2]	5 (liquid)	66.0	0.47
Non-bearing fruit[3]	8 (granular)	61.5	0.44
Avocados	4 (liquid)	53.5	0.38
Olives	4 (liquid)	33.9	0.24
Nuts (high rate)[4]	4 (liquid)	25.6	0.18
Grapes	4.8 (liquid)	18.2	0.13
Nuts (low rate)[5]	2 (liquid)	12.8	0.09
Corn	2 (liquid)	12.3	0.09
Shelterbelts	3 (granular)	12.0	0.09
Fruit (low and high rates)[6]	2 and 4 (liquid)	5.6 - 11.1	0.08
Citrus[7]	4 (liquid)	7.1	0.05
Turf (residential, recreational, and sod farm)	1 (2 liquid and granular applications w/30 day interval)	4.3 – 8.8	0.03 – 0.06

[a] RQs used to estimate indirect effects to the CRLF via toxicity to non-vascular aquatic plants are summarized in Table 5.2.
* Simazine is applied once/season via ground application, unless otherwise noted.
** = LOC exceedances (RQ $\geq$ 1) are bolded and shaded. RQ = use-specific peak EEC / duckweed EC_{50} value of 140 µg/L (MRID 425037-04).
[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

5.1.2 Exposures in the Terrestrial Habitat

5.1.2.1 Direct Effects to Terrestrial-phase CRLF

As previously discussed in Section 3.3, potential direct effects to terrestrial-phase CRLFs are based on liquid spray (*i.e.*, foliar) and granular applications of simazine.

5.1.2.1.1 <u>Foliar (non-granular liquid spray applications)</u>

Definitive acute RQ values for terrestrial-phase CRLFs could not be derived because the acute avian effects data, which are used as a surrogate for terrestrial-phase amphibians, show no mortality to both the mallard duck and bobwhite quail at the highest tested level of simazine (LC_{50} >5,000 mg/kg-diet). In addition, the LD_{50} value for the mallard duck (>4,640 mg/kg-bw) also indicates no mortality at the highest test concentration. None of the predicted dose- and dietary-based EECs (Table 3.7) exceed or approach the respective 5,000 mg/kg-diet and 4,640 mg/kg-bw test levels, suggesting that acute avian and terrestrial-phase CRLF mortality is unlikely. The preliminary effects determination for direct acute effects to the terrestrial-phase CRLF is “no effect”.

Potential direct chronic effects of non-granular simazine applications to the terrestrial-phase CRLF are derived by considering dietary-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates. Chronic effects are estimated using the lowest available toxicity data for birds. EECs are divided by toxicity values to estimate chronic dietary-based RQs. As shown in Table 5.5, chronic RQs, which range from 1.35 to 8.02, exceed LOCs for all modeled non-granular uses of simazine. Therefore, the preliminary effects determination is “may effect” for direct chronic effects to the terrestrial-phase CRLF.

Table 5.5 Summary of Chronic RQs* Used to Estimate Direct Effects to the Terrestrial-phase CRLF (non-granular application)

Use (Application Rate)	**Dietary-based Chronic RQ[1]**
Christmas trees (5.94 lb ai/A)	**8.02**
Non-cropland (5 lb ai/A)	**6.75**
Grapes (4.8 lb ai/A)	**6.48**
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, and Tree Plantations/Nurseries (4.0 lb ai/A)	**5.40**
Almonds, Nectarines, Peaches, and Corn (2.0 lb ai/A)	**2.70**
Turf (1.0 lb ai/A; 2 applications)	**1.35**

* = LOC exceedances (chronic RQ ≥ 1) are bolded and shaded.
[2] Based on bobwhite quail chronic reproduction NOAEC = 100 mg/kg-diet (MRID 001631-34).

5.1.2.1.2 Granular applications

As previously discussed in Section 3.3.2, direct effects to the terrestrial-phase CRLF via exposure to simazine granules are derived based on LD_{50}/ft^2 values. However, definitive LD_{50}/ft^2 values could not be derived because avian LD_{50} values were reported as greater than the highest treatment level of simazine (*i.e.*, 50% mortality was not observed in the highest treatment levels of simazine). Therefore, a comparison of granular EECs with adjusted avian LD_{50} values for two weight classes of 20g and 100g (representative of juvenile and adult terrestrial-phase CRLFs) was completed. As shown in Table 5.6, the predicted granular EECs in mg ai/ft^2 do not exceed or approach the adjusted LD_{50} value, which is based on a mallard duck study where no mortality was observed at the highest test level of simazine. Further qualitative discussion of potential acute risks to birds associated with exposure to granular simazine is provided in Section 5.2.1.2. The preliminary effects determination for direct effects to the terrestrial-phase CRLF via granular application of simazine is “no effect”.

Table 5.6 Comparison of Granular EECs to Adjusted LD_{50} Value Used to Estimate Direct Effects to the Terrestrial-phase CRLF (granular application)				
Use	**Application Rate (lb ai/A)**	**EEC (mg/ft^2)**	**Adjusted LD_{50} Value (mg/kg-bw)[1]**	
			20 g (juvenile)	**100g (adult)**
Non-bearing Fruit	8	83.3	2,409	3,067
Berries	4	41.7		
Shelterbelts	3	31.2		
Turf	1	10.4		
[1] Adjusted Avian $LD_{50} = LD_{50}\,(AW/TW)^{(1.15 - 1)}$				

Terrestrial chronic exposure estimates and risks for granular applications of simazine were derived according to the methodology presented in Appendix I. Exposure estimates and predicted chronic risks are based on direct ingestion of soil invertebrates that have bioaccumulated simazine residues of granules in soil. Chronic risks to birds associated with ingestion of earthworms that have bioaccumulated simazine granules are not expected because the estimated earthworm residue (4.74 mg ai/kg at an application rate of 8 lb ai/A) is well below the avian chronic endpoint (100 mg/kg-diet).

5.1.2.2 Indirect Effects to Terrestrial-Phase CRLF via Reduction in Prey (terrestrial invertebrates, mammals, and frogs)

5.1.2.2.1a Terrestrial Invertebrates (non-granular applications)

In order to assess the risks of foliar applications of simazine to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the honey bee is used as a surrogate for terrestrial invertebrates. The toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available acute contact LD_{50} of >96.7 µg a.i./bee by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs (µg a.i./g of bee) calculated by T-REX for small and large insects are divided by the calculated toxicity value for terrestrial invertebrates, which is >755 µg a.i./g of bee. Given that the toxicity endpoint is non-definitive (*i.e.*, the LD_{50} value is greater than the highest test concentration), the reported RQ values represent an upper bound. The resulting non-definitive RQ values for large insect and small insect exposures bound the potential range of exposures for terrestrial insects to simazine. With the exception of the 1 and 2 lb ai/A simazine use rates (for almonds, nectarines, peaches, corn, and turf) on large insects, RQ values may exceed the LOC (RQ $\geq$ 0.05) for both large and small terrestrial insects for all non-granular uses (Table 5.7). The preliminary effects determination for indirect effects to terrestrial-phase CRLFs via reduction in terrestrial invertebrates as dietary food items is “may affect”.

Table 5.7 Summary of RQs Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Terrestrial Invertebrates as Dietary Food Items		
Use	**Small Insect RQ***	**Large Insect RQ***
Christmas trees (5.94 lb ai/A)	**<1.06**	**<0.11**
Non-cropland (5 lb ai/A)	**<0.89**	**<0.10**
Grapes (4.8 lb ai/A)	**<0.86**	**<0.10**
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries (4.0 lb ai/A)	**<0.72**	**<0.08**
Almonds, Nectarines, Peaches, and Corn (2.0 lb ai/A)	**<0.35**	0.04
Turf (1.0 lb ai/A; 2 apps)	**<0.17**	0.02
* = LOC exceedances (RQ $\geq$ 0.05) are bolded and shaded. Because a definitive endpoint was not established for terrestrial invertebrates (*i.e.*, the value is greater than the highest test concentration), the RQ represents an upper bound value.		

5.1.2.2.1b Terrestrial Invertebrates (granular applications)

In order to assess the risks of granular applications of simazine to terrestrial invertebrates, the earthworm fugacity model (Appendix I) is used to calculate simazine concentrations in soil (mg/kg) and earthworms, which are used as a surrogate for terrestrial invertebrates that may be consumed by a terrestrial-phase CRLF. The concentration of simazine in soil from granular application rates associated with non-bearing fruit (8 lb ai/A) is 4.6 mg/kg (based on a soil depth of 15 cm). The estimated concentration of simazine in bulk soil is used to estimate simazine concentrations in a terrestrial invertebrate (*i.e.*, earthworm). Simazine is assumed to partition between soil organic carbon, the interstitial pore water, and air occupying the residual pore space not occupied by interstitial water. Earthworms dwelling in soil are assumed to be exposed to both soil pore-water and via the ingestion of soil (Belfroid et al., 1994). The concentration of simazine in earthworms (4.74 mg ai/kg) is calculated as a combination of uptake from soil pore water and ingested soil across the gastro-intestinal tract, based on information presented in Appendix I. Comparison of the acute oral LD_{50} value for the honey bee (>755 µg a.i./g of bee) with the estimated concentration of simazine in terrestrial insects (4.74 mg ai/kg) shows that adverse effects to terrestrial invertebrates are unlikely at the predicted level of simazine exposure. Therefore, terrestrial-phase CRLFs are not likely to be indirectly affected via reduction in terrestrial invertebrates (exposed to simazine granules) as a food source.

5.1.2.2.2a Mammals (Non-granular applications)

Risks associated with ingestion of small mammals by large terrestrial-phase CRLFs are derived for dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass. Acute and chronic effects are estimated using the most sensitive mammalian toxicity data for simazine. EECs are divided by the toxicity value to estimate acute and chronic dose-based RQs as well as chronic dietary-based RQs. As previously discussed in Section 4.1, indirect effects to terrestrial-phase CRLFs via direct acute effects to small mammals as prey items are evaluated using the acute toxicity data for simazine, rather than the more toxic DIA degradate, because DIA is not expected to form and persist in the environment at any substantial level. Definitive acute dose-based RQ values, based on toxicity data for parent simazine, could not be derived because the simazine LD_{50} value is >5,000 mg/kg-bw, and 30 percent mortality was observed at the highest test concentration. Therefore, the acute dose-based RQ values are representative of upper bound values. For the simazine, upper bound acute dose-based RQs exceed LOCs for only the highest application rate to Christmas trees (5.94 lb ai/A). Chronic dose-based and dietary-based RQ values exceed the chronic risk LOC (RQ ≥ 1.0) for mammals considered as potential prey species for CRLF for all modeled uses of simazine (Table 5.8). Therefore, the preliminary effects determination for indirect effects to terrestrial-phase CRLFs via reduction in small mammals (exposed to non-granular applications of simazine) as dietary food items is "may affect".

Table 5.8 Summary of Acute and Chronic RQs* Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Small Mammals as Dietary Food Items (non-granular application)

Use (Application Rate)	Chronic RQs		Dose-based Acute RQ[3]
	Dose-based Chronic RQ[1]	Dietary-based Chronic RQ[2]	
Christmas trees (5.94 lb ai/A)	**883**	**143**	**<0.12**
Non-cropland (5 lb ai/A)	**744**	**120**	<0.10
Grapes (4.8 lb ai/A)	**714**	**115**	<0.10
Apples, Pears, Sour Cherries, Avocados, Blueberries, Citrus, Filberts, Hazelnuts, Macadamia Nuts, Olives, Walnuts, Tree Plantations, and Tree Nurseries (4.0 lb ai/A)	**595**	**96**	<0.08
Almonds, Nectarines, Peaches, and Corn (2.0 lb ai/A)	**297**	**48**	<0.04
Turf (1.0 ai/A; 2 apps)	**149**	**24**	<0.02

* = LOC exceedances (acute RQ ≥ 0.1 and chronic RQ ≥ 1) are bolded and shaded.
[1] Based on dose-based EEC and simazine rat NOAEL = 0.7 mg/kg/day (MRID 418036-01).
[2] Based on dietary-based EEC and simazine rat NOAEC = 10 mg/kg-diet (MRID 418036-01).
[3] Based on dose-based EEC and simazine rat acute oral LD_{50} = >5,000 mg/kg-bw (MRID 001488-97).

Because a definitive endpoint was not established for mammals (*i.e.*, the value is greater than the highest test concentration), the acute RQ represents an upper bound value.

5.1.2.2.2a Mammals (granular applications)

Indirect effects to terrestrial-phase CRLFs via ingestion of small mammals that may consume simazine granules are based on LD_{50}/ft^2 values. However, definitive LD_{50}/ft^2 values could not be derived because the mammalian LD_{50} value was reported as > 5,000 mg/kg-bw (*i.e.*, 50% mortality was not observed in the highest treatment levels of simazine). Comparison of granular EECs with the adjusted mammalian LD_{50} value for the smallest weight class of 15g (representative of a small mammal that an adult terrestrial-phase CRLF could consume) was completed (Table 5.9). For mammals, the adjusted LD_{50} value is based on the converted dose at which 30% mortality occurred. Because the predicted EECs are well below the adjusted LD_{50} values for mammals, there is a low likelihood of acute mortality to mammals consuming granules at application rates $\leq$ 8 lb ai/A. Therefore, the preliminary effects determination for indirect effects to terrestrial-phase CRLFs via an acute reduction in small mammals (exposed to granular applications of simazine) as dietary food items is "no effect".

Table 5.9 Comparison of Granular EECs to Adjusted LD_{50} Value Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Small Mammals as Dietary Food Items (granular application)

Use	Application Rate (lb ai/A)	EEC (mg/ft^2)	Adjusted LD_{50} Value (mg/kg-bw)[1]
Non-bearing Fruit	8	83.3	>10,989
Berries	4	41.7	
Shelterbelts	3	31.2	
Turf	1	10.4	

[1] Adjusted Mammalian $LD_{50} = LD_{50}\,(TW/AW)^{(0.25)}$

Although the Agency has no standard methodology for assessing chronic risk to mammals from ingestion of granules, it is possible to estimate chronic granular exposure for mammals via direct ingestion of soil invertebrates that have bioconcentrated pesticide residues of granules in soil. Terrestrial chronic exposure estimates and risks for granular applications of simazine were derived according to the methodology presented in Appendix I. Based on the dietary method and a granular simazine application rate of 8 lb ai/A, chronic LOCs are not exceeded for insectivorous mammals because the respective earthworm residue concentration (4.74 mg ai/kg) is less than the mammalian NOAEC (10 mg/kg). However, chronic doses for insectivorous mammals, based on the two highest granular application rates of simazine (4 and 8 lb ai/A) and adjusted NOAEL for the smallest size class of mammals (15 g) exceeds chronic LOCs with RQ values ranging from 1.83 to 3.66 (see Appendix I). Therefore, the preliminary effects determination for indirect effects to terrestrial-phase CRLFs via a chronic reduction in small mammals (exposed to granular applications of simazine) as dietary food items is "may affect".

5.1.2.2.3 Frogs

An additional prey item of the adult terrestrial-phase CRLF is other species of frogs. In order to assess risks to these organisms, dietary-based and dose-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates are used. As previously discussed in Section 5.1.2.1, direct acute effects to frogs are unlikely, based on the available avian acute toxicity data. However, dietary-based chronic RQ values exceed the LOC for all modeled non-granular uses of simazine (Table 5.5). Therefore, the preliminary effects determination for indirect effects to terrestrial-phase CRLFs via reduction in other species of frogs as dietary food items is “may affect”.

5.1.2.3 Indirect Effects to CRLF via Reduction in Terrestrial Plant Community (Riparian and Upland Habitat)

Potential indirect effects to the CRLF resulting from direct effects on riparian and upland vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. 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 and upland zones may be sensitive to simazine exposure.

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 (Tables 5.10 and 5.11). 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 terrestrial- and aquatic-phase CRLFs via reduction in the terrestrial plant community is “may affect”.

Table 5.10 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	4	Foliar - ground	1	**2.0**	**4.0**	**22.0**

Plantations, and Tree Nurseries						
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 ≥ 1) are bolded and shaded.						

Table 5.11 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 ≥ 1) are bolded and shaded.						

5.1.3 Primary Constituent Elements of Designated Critical Habitat

5.1.3.1 Aquatic-Phase (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)

Three of the four assessment endpoints for the aquatic-phase primary constituent elements (PCEs) of designated critical habitat for the CRLF are related to potential effects to aquatic and/or terrestrial plants:

- Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.
- Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.
- Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae).

The preliminary effects determination for aquatic-phase PCEs of designated habitat related to potential effects on aquatic and/or terrestrial plants is "may affect", based on the risk estimation provided in Sections 5.1.1.2, 5.1.1.3, and 5.1.2.3.

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." To assess the impact of simazine on this PCE, acute and chronic freshwater fish and invertebrate toxicity endpoints, as well endpoints for aquatic non-vascular plants, are used as measures of effects. RQs for these endpoints were calculated in Sections 5.1.1.1 and 5.1.1.2. Based on these results, the preliminary effects determination for alteration of characteristics necessary for normal growth and viability of the CRLF is "no effect" (see Section 5.1.1.1). However, aquatic invertebrate and non-vascular aquatic plant food items of the CRLF may be affected; therefore the preliminary effects determination for potential impacts to these food items is "may affect" (see Section 5.1.1.2).

5.1.3.2 Terrestrial-Phase (Upland Habitat and Dispersal Habitat)

Two of the four assessment endpoints for the terrestrial-phase PCEs of designated critical habitat for the CRLF are related to potential effects to terrestrial plants:

- Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance.
- Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.

The preliminary effects determination for terrestrial-phase PCEs of designated habitat related to potential effects on terrestrial plants is "may affect", based on the risk estimation provided in Section 5.1.2.3.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of simazine on this PCE, acute and chronic toxicity endpoints for birds, mammals, and terrestrial invertebrates are used as measures of effects. RQs for these endpoints, which were calculated in Section 5.1.2.2, exceed the LOCs for all simazine non-granular uses. Granular uses of simazine are not expected to cause direct effects to terrestrial invertebrate and frog prey items of the terrestrial-phase CRLF; however, chronic effects to small insectivorous mammals that ingest granules may occur. The preliminary effects determination for adverse habitat modification via impacts of non-granular uses of simazine to terrestrial-phase CRLF food items is "may affect".

The fourth terrestrial-phase PC is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Direct acute effects, via mortality, are not expected for the terrestrial-phase CRLF (see Section 5.2.1.2); however, chronic reproductive effects are possible for all non-granular uses of simazine. Therefore the preliminary effects determinations for adverse habitat modification is "no effect" via direct acute effects to terrestrial-phase CRLFs and "may affect" based on chronic exposures to non-granular applications of simazine.

5.2 Risk Description

The risk description synthesizes an overall conclusion 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 CRLF and its designated critical habitat.

If the RQs presented in the Risk Estimation (Section 5.1) show no direct or indirect effects for the CRLF, and no modification to PCEs of the CRLF's designated critical habitat, a "no effect" determination is made, based on simazine's use within the action area. However, if direct or indirect effect LOCs are exceeded or effects may modify the PCEs of the CRLF's critical habitat, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding simazine. A summary of the results of the risk estimation (*i.e.*, "no effect" or "may affect" finding) is provided in Table 5.12 for direct and indirect effects to the CRLF and in Table 5.13 for the PCEs of designated critical habitat for the CRLF.

Table 5.12 Preliminary Effects Determination Summary for Simazine - Direct and Indirect Effects to CRLF

Assessment Endpoint	Preliminary Effects Determination	Basis For Preliminary Determination
Aquatic-Phase CRLF (eggs, larvae, juveniles, and adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	No effect	Using freshwater fish as a surrogate, no acute and chronic LOCs are exceeded (Table 5.1).

Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants)	Freshwater invertebrates and aquatic non-vascular plants : May affect	Acute freshwater invertebrate and aquatic non-vascular plant RQs exceed LOCs 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); acute LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) (Tables 5.2 and 5.3).
	Fish and frogs: No effect	No acute and chronic LOCs are exceeded based on the most sensitive toxicity data for freshwater fish (Table 5.1).
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	May affect	LOCs are exceeded for non-vascular aquatic plants 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 exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) (Table 5.2).
Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	May affect	LOCs are exceeded for both monocots and dicots for all modeled uses of simazine (Tables 5.10 and 5.11).
Terrestrial-Phase CRLF (Juveniles and adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Acute: No effect	Based on the available avian acute toxicity data, which is used as a surrogate for terrestrial-phase amphibians, no mortality was reported at the highest test concentrations of simazine. Predicted EECs, based on non-granular and granular uses of simazine, are well below reported non-definitive acute avian toxicity values for simazine (Section 5.1.2.1 and Table 5.6).
	Chronic: May affect for non-granular uses; No effect for granular uses	Using birds as a surrogate, chronic RQs exceed the LOC for all modeled non-granular uses of simazine (Tables 5.5). However, chronic risks to birds associated with ingestion of earthworms that have bioaccumulated simazine granules are not expected (Section 5.1.2.1.2).
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,* terrestrial invertebrates, small terrestrial mammals and terrestrial phase amphibians)	May affect	Chronic RQs for mammals and birds exceed the LOCs for all modeled non-granular uses of simazine (Tables 5.5 and 5.8). Acute RQs for mammals also exceed LOCs for liquid applications of simazine to Christmas trees (5.94 lb ai/A) (Table 5.8). Acute RQs for small terrestrial invertebrates exceed the LOC for all modeled uses of simazine (Table 5.7). Non-granular uses of simazine are not expected to cause direct effects to terrestrial invertebrate and frog food items of the terrestrial-phase CRLF (Tables 5.6 and 5.9); however, chronic effects are possible for small insectivorous mammals that are food items of the CRLF.

Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	May affect	LOCs are exceeded for both monocots and dicots for all modeled uses of simazine (Tables 5.10 and 5.11).

Table 5.13 Preliminary Effects Determination Summary for Simazine – PCEs of Designated Critical Habitat for the CRLF

Assessment Endpoint	Preliminary Effects Determination	Basis For Preliminary Determination
Aquatic-Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	May affect	LOCs are exceeded for both monocots and dicots for all modeled uses of simazine (Tables 5.10 and 5.11).
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	May affect	LOCs are exceeded for both monocots and dicots for all modeled uses of simazine (Tables 5.10 and 5.11).
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Growth and viability of CRLF: No effect	Using freshwater fish as a surrogate, no acute and chronic LOCs are exceeded (Table 5.1).
	Food source: May affect	Acute freshwater invertebrate and aquatic non-vascular plant RQs exceed LOCs 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); acute LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) (Tables 5.2 and 5.3).
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	May affect	LOCs are exceeded for non-vascular aquatic plants 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 exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A) (Table 5.2).
Terrestrial-Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter,	May affect	LOCs are exceeded for both monocots and dicots for all modeled uses of simazine (Tables 5.10 and 5.11).

Table 5.13 Preliminary Effects Determination Summary for Simazine – PCEs of Designated Critical Habitat for the CRLF		
Assessment Endpoint	**Preliminary Effects Determination**	**Basis For Preliminary Determination**
forage, and predator avoidance		
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	May affect	LOCs are exceeded for both monocots and dicots for all modeled uses of simazine (Tables 5.10 and 5.11).
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	May affect	Chronic RQs for mammals and birds exceed the LOCs for all modeled non-granular uses of simazine (Tables 5.5 and 5.8). Acute RQs for mammals also exceed LOCs for liquid applications of simazine to Christmas trees (5.94 lb ai/A) (Table 5.8). Acute RQs for small terrestrial invertebrates exceed the LOC for all modeled uses of simazine (Table 5.7). Non-granular uses of simazine are not expected to cause direct effects to terrestrial invertebrate and frog food items of the terrestrial-phase CRLF (Tables 5.6 and 5.9); however, chronic effects are possible for small insectivorous mammals that are food items of the CRLF.
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	May affect	Chronic RQs for mammals and birds exceed the LOCs for all modeled non-granular uses of simazine (Tables 5.5 and 5.8). Acute RQs for mammals also exceed LOCs for liquid applications of simazine to Christmas trees (5.94 lb ai/A) (Table 5.8). Acute RQs for small terrestrial invertebrates exceed the LOC for all modeled uses of simazine (Table 5.7). Non-granular uses of simazine are not expected to cause direct effects to terrestrial invertebrate and frog food items of the terrestrial-phase CRLF (Tables 5.6 and 5.9); however, chronic effects are possible for small insectivorous mammals that are food items of the CRLF.

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 CRLF. 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 CRLF and its designated critical habitat.

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

- Significance of Effect: Insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where "take" occurs for even a single individual. "Take" in this context means to harass or harm, defined as the following:

  - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.
  - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

- <u>Likelihood of the Effect Occurring</u>: Discountable effects are those that are extremely unlikely to occur.

- <u>Adverse Nature of Effect:</u> Effects that are wholly beneficial without any adverse effects are not considered adverse.

A description of the risk and effects determination for each of the established assessment endpoints for the CRLF and its designated critical habitat is provided in Sections 5.2.1 through 5.2.3.

5.2.1 Direct Effects

5.2.1.1 Aquatic-Phase CRLF

The aquatic-phase considers life stages of the frog that are obligatory aquatic organisms, including eggs, larvae, and tadpoles. It also considers submerged terrestrial-phase juveniles and adults, which spend a portion of their time in water bodies that may receive runoff and spray drift containing simazine. 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 (used as a surrogate for aquatic-phase amphibians) 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 aquatic-phase CRLFs.

Because raw data was not provided as part of the acute toxicity study for the fathead minnow used as a surrogate for the aquatic-phase CRLF, information is unavailable to estimate a slope for the dose response curve. Therefore, the probability of an individual effect to aquatic-phase CRLFs 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 aquatic-phase CRLF at an RQ level of 0.02 is 1 in 19.6 trillion (with respective upper and lower bounds of 1 in 2,950 to 1 in 2.3E+52). 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 aquatic-phase CRLFs.

No toxicity information on lethal and/or sublethal effects of simazine to aquatic-phase amphibians is available, based on a comprehensive search of the open literature. As discussed in Section 4.1.1.3, 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 Section A.4.3 of Appendix A, that preclude quantitative use of the data in this risk assessment. For example, Moore and Lower (2001) exposed epithelial tissue (after removal of skin and cartilage) and not intact fish to simazine, and potential solvent effects could not be reconciled (*i.e.*, no negative control was tested). Furthermore, no quantitative relationship is established between reduced olfactory response (measured as electrophysiological response) of epithelial tissue to the priming hormone 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. In summary, it is not possible to quantitatively link the sublethal effects to the selected endpoints for the CRLF (*i.e.*, survival, growth, and reproduction of individuals). Also, effects to reproduction, growth, and survival were not observed in the full life cycle studies at levels that produced the reported sublethal effects (Appendix A). Finally, the limitations in the study design (described further in Section A.4.3 of Appendix A) preclude the quantitative use of this data.

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 Section A.4.8 of Appendix A) , 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.

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. A complete list of all the aquatic incidents involving simazine is included in Appendix H.

In summary, the Agency concludes a "no effect" determination for direct effects to the aquatic-phase CRLF, via mortality, growth, or fecundity, based on all available lines of evidence.

5.2.1.2 Terrestrial-Phase CRLF

Based on acute avian toxicity data as a surrogate for the terrestrial-phase amphibians, direct acute mortality is not expected for the terrestrial-phase CRLF via exposure to non-granular and granular simazine applications. The acute avian effects data show no mortality at the highest treatment levels of simazine in both the acute oral (LD_{50} > 4,640 mg/kg-bw) and subacute dietary (LC_{50} > 5,000 mg/kg-diet) studies. In addition, the predicted granular EECs in mg ai/ft^2 are well below the adjusted LD_{50} values for two weight classes that are intended to be representative of juvenile and adult terrestrial-phase CRLFs. Therefore, direct effects to the terrestrial-phase CRLF via ingestion of terrestrial invertebrate food items are not expected.

It should be noted that sublethal effects were observed in the acute mallard duck gavage test at simazine concentrations ranging from 1,000 to 4,640 mg/kg-bw one hour after dosing. Observed sublethal effects included reduced reaction to external stimuli (sound and movement), wing droop, and depression. Although sublethal effects were noted, there is a high level of uncertainty associated with the mallard duck gavage study because the birds were 14 days old rather than 14 to 16 weeks when tested, and age is a significant factor in the sensitivity of birds. In addition, it is unclear whether the same types of sublethal effects, such as reduced reaction to sound and movement, would be observed in terrestrial-phase amphibians at similar levels of simazine exposure. In order to evaluate potential sublethal effects associated with acute exposure to simazine, the lowest simazine concentration where sublethal effects were observed (1,000 mg/kg-bw) is compared to predicted terrestrial-phase CRLF doses on small insect food residues following application of non-granular simazine at 5.94 lb ai/A (913 mg/kg-bw from Table 3.7). Because the predicted dose on food residues, based on the highest non-granular application rate, is less than the lowest avian sublethal effects value, sublethal effects are also unlikely for the terrestrial-phase CRLF. With respect to granular applications, predicted EECs ($\leq$ 83.3 mg ai/ft^2; see Table 3.9) are less than the avian sublethal effects value of 1,000 mg/kg-bw; therefore, sublethal effects are unlikely to be associated with exposure to simazine granules.

In summary, the Agency concludes a "no effect" determination for acute direct effects to the terrestrial-phase CRLF, via acute mortality, based on all available lines of evidence.

Chronic RQs exceed the Agency's LOCs for all of the non-granular uses of simazine based on the T-REX modeled dietary residues and avian chronic toxicity data. With chronic dietary-based RQ values ranging from approximately 1.35 to 8.02, terrestrial-phase CRLFs foraging on small insects may result in reduction in offspring survival via reproductive effects. Chronic risks to the terrestrial-phase CRLF were evaluated using a bobwhite quail NOAEC value of 100 mg/kg-diet, based on reproductive effects including reduction in the number of eggs laid, viable embryos, live embryos, hatchlings, and 14-day old chick survivors. The primary reproductive effect of simazine on avian reproduction appears to be reduction in the number of eggs laid. The number of eggs laid was reduced by 20% at the highest treatment level of 500 mg/kg-diet. Based on the bobwhite quail NOAEC value of 100 mg/kg-diet, chronic LOCs are exceeded for terrestrial-phase CRLFs that consume small insects for all modeled scenarios and application rates (1 to 5.94 lb ai/A). A non-granular simazine application rate of 0.7 lb ai/A would be required to achieve chronic RQ values for terrestrial-phase CRLFs that are less than chronic LOCs. This value is approximately 8.5 times less than the maximum non-granular application rate for simazine of 5.94 lb ai/A. The 5.94 lb ai/A application rate would have to be reduced by approximately 88% in order to achieve an application rate less than the chronic LOCs for birds, which are used as a surrogate for the terrestrial-phase CRLF.

One incident has been reported for birds. On June 26, 1998, five Canada geese were found dead in a corn field in Rockingham County, Virginia, following spray application of simazine as Princep 4L (#I008168-001). Soil and vegetative samples were collected along the bank near the creek in which the dead geese were found. Substantial concentrations of simazine and atrazine were found in the samples. Simazine detections ranged from 0.16 to 2.3 ppm in soil and 8.5 to 20.5 ppm in foliage. Although the certainty index for the corn field incident was reported as probable, it is uncertain whether geese mortality was due to simazine, given the relatively low concentrations of simazine detected in the soil and foliage.

Chronic risks to birds associated with ingestion of earthworms that have bioaccumulated simazine granules are not expected (see Appendix I for further details) because the estimated earthworm residue (4.74 mg ai/kg at a maximum granular application rate of 8 lb ai/A) is well below the avian chronic endpoint (100 mg/kg-diet).

Therefore, a "likely to adversely affect" or "LAA" effects determination is concluded for chronic direct effects to the terrestrial-phase CRLF via current non-granular uses of simazine. However, the effects determination for chronic direct effects to the CRLF exposed to granules is "may affect, but not likely to adversely affect" or "NLAA". This finding is based on discountable effects (*i.e.*, chronic effects to simazine granules are not likely to occur and/or result in a "take" of a single listed terrestrial-phase CRLF).

5.2.2 Indirect Effects (via Reductions in Prey Base)

5.2.2.1 Algae (non-vascular plants)

As discussed in Section 2.5.3, the diet of CRLF tadpoles is composed primarily of unicellular aquatic plants (*i.e.*, algae and diatoms) and detritus. Based on RQs for algae

(Table 5.2), 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.

Typically, algal populations are relatively dynamic, although the presence of simazine in the water may result in an overall reduction in biomass, and/or a shift in community composition as more sensitive species are eliminated. There is evidence to suggest that recovery occurs in algae upon removal of simazine from the site of action, with recovery inversely proportional to the prior exposure level. Although recovery of algal populations has been shown to occur, if the timing of simazine applications co-occur with the presence of tadpole life stages of the CRLF (from December to March), a reduction in algae as a food source for the tadpole may occur.

Therefore, the effects determination for indirect effects of simazine to CRLF tadpoles via reductions in non-vascular plants is “likely to adversely affect” or “LAA” 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).

As previously mentioned, the aerial non-cropland and non-residential granular uses of simazine will be cancelled 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 CRLF tadpoles (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 2.4.3 and summarized in Table 2.3, the highest simazine useage in California is reported for oranges and lemons (citrus), grapes, almonds and walnuts (nuts), avocados, olives, and peaches, which are not expected to direct effects to non-vascular plants as food for CRLF tadpoles.

5.2.2.2 Aquatic Invertebrates

As previously discussed in Section 5.1.1.2, acute RQs (ranging from 0.05 to 0.13; Table 5.3) calculated using modeled peak aquatic EECs and the 48-hour TL_{50} for the water flea, *Daphnia magna*, exceed the acute LOC 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). Although acute RQs for these simazine uses exceed the acute listed species LOC of 0.05, they are less than the non-listed acute LOC of 0.5.

Chronic RQs for invertebrates were less than the Agency's LOC, based on the highest 21-day modeled EECs for all simazine uses and a *Daphnia* NOAEC value of 2,000 μg/L for the 80% formulated product of simazine. As previously discussed in Section 4.1.2.2, chronic toxicity data for freshwater invertebrates using the TGAI are 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. In order to characterize this uncertainty, the highest 21-day modeled EEC for simazine is compared to the lower TL_{50} value; based on this comparison, the 21-day modeled EEC (127 μg/L) is well below the TL_{50} value of 1,000 μg/L. Chronic effects for freshwater invertebrates would have to be more than 7 times lower than the acute freshwater invertebrate endpoint to result in a level of effect that exceeds the LOC for freshwater invertebrates at the predicted levels of simazine exposure. Therefore, chronic risks to freshwater invertebrates and potential indirect effects to aquatic-phase CRLFs that consume them as prey are not expected.

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). At the lower RQ range of 0.05, the corresponding estimated chance of an individual acute mortality/immobilization to a freshwater invertebrate is 1 in 4.18E+08 (with bounds of 1 in 216 and 1 in 1.75E+31). Even at the highest probability of an individual effect (1 in 26), assuming that the CRLF consumes aquatic invertebrates that are equally as sensitive as the most sensitive water flea, potential reduction in abundance of aquatic invertebrates as food would be approximately 3.7 percent.

Further information on the diet of the CRLF indicates that the preferred prey species is the sowbug (Hayes and Tennant, 1985). Based on the available freshwater invertebrate toxicity data, simazine has no effect on the sowbug (*Asellus brevicaudus*) with a corresponding 48-hour TL_{50} value of >100,000 μg/L. In addition, acute TL_{50} and EC_{50} values for other freshwater invertebrate food items, including the stonefly (*Pteronarcys californica*), range from 1,900 to >100,000 μg/L. As previously mentioned, acute toxicity values that are >100,000 μg/L are uncertain because they exceed the level of simazine's solubility in water (~3,500 μg/L) by a wide margin. However, given that no adverse effects were observed at these concentrations, it is reasonable to assume that simazine is not toxic to the sowbug at the limit of its water solubility.

The potential for simazine to elicit indirect effects to the CRLF via effects on freshwater invertebrate food items is dependent on several factors including: (1) the potential magnitude of effect on freshwater invertebrate individuals and populations; and (2) the number of prey species potentially affected relative to the expected number of species needed to maintain the dietary needs of the CRLF. Together, these data provide a basis to evaluate whether the number of individuals within a prey species is likely to be reduced such that it may indirectly affect the CRLF. Table 5.14 presents acute RQs and the probability of individual effects for other freshwater invertebrate dietary items of the CRLF, including the sowbug and stonefly.

Table 5.14 Summary of RQs Used to Assess Potential Risk to Freshwater Invertebrate Food Items of the CRLF

CRLF Aquatic Invertebrate Food Item Species	Range of Acute Toxicity Values (µg/L) (No. of Studies)[1]	RQ Range (based on an EEC of 130 µg/L)	Probability of Individual Effect[2]	Risk Interpretation
Stonefly	1,900 - 3,500 (2)	0.04 - 0.07	Up to 1 in 9.88E+06 (1.0E-05%) (1 in 96 to 1 in 7.58E+24)	Simazine may affect sensitive food items, such as the stonefly; however the low probability of an individual effect to the stonefly is not likely to indirectly affect the CRLF via reduction in freshwater invertebrate prey items.
Sowbug	3,500 (1)	0.04	1 in 6.3E+09 (1 in 386 to 1 in 7.49E+35)	RQ is less than the acute LOC, which is interpreted to represent no direct effect; therefore, simazine is not likely to indirectly affect the CRLF via reduction in its preferred food item.

[1] Given the uncertainties associated with toxicity values >100,000 µg/L, the solubility limit of simazine (3,500 µg/L) is used as a surrogate acute toxicity value
[2] The probability of an individual effect was calculated using a default probit slope of 4.5 (and lower and upper bounds of 2 and 9).

As shown in Table 5.14, the listed species LOC, based on use of simazine on Christmas trees at 5.94 lb ai/A, is exceeded for the stonefly (RQ = 0.07), based on the LC_{50} value of 1,900 µg/L. However, the acute RQ (based on the limit of simazine's solubility in water as a surrogate for the acute toxicity data for the preferred sowbug food item) is 0.04, less than the acute endangered species LOC. Based on the default probit slope of 4.5, the probability of an individual mortality/immobilization to aquatic invertebrate food items of the CRLF ranges from 1 in 9.9 million to 1 in 6.3 trillion at respective RQ values of 0.07 and 0.04.

Simazine may affect sensitive aquatic invertebrates, such as the water flea; however, the low probability (<4%) of an individual effect to the water flea is not likely to indirectly affect the CRLF, given the wide range of other types of freshwater invertebrates that the species consumes. Based on the non-selective nature of feeding behavior in the CRLF, the low magnitude of anticipated acute individual effects to preferred aquatic invertebrate prey species (<0.1%), simazine is not likely to indirectly affect the CRLF via reduction in freshwater invertebrate food items. Therefore, the effects determination for indirect effects to the CRLF via direct acute effects on freshwater invertebrates as prey is "may affect, but not likely to adversely affect" or "NLAA". This finding is based on insignificant effects. The effects are insignificant because the probability of an individual effect level to freshwater invertebrates (< 4% at predicted levels of exposure) is low and use of toxicity data from the most sensitive species of freshwater invertebrate species is likely to overestimate the sensitivity of the majority of freshwater invertebrate food items in the CRLF's diet. Therefore, any predicted effects are expected to be insignificant in the context of a "take" of a single CRLF via direct acute effects on prey (*i.e.*, freshwater invertebrates).

5.2.2.3 Fish and Aquatic-phase Frogs

No endangered species acute or chronic LOCs were exceeded for freshwater fish, which are used as a surrogate for aquatic-phase amphibians. Therefore, indirect effects to the CRLF via a reduction in freshwater fish and other aquatic-phase frog species as prey items is not expected, and the effects determination for this assessment endpoint is "no effect".

5.2.2.4 Terrestrial Invertebrates

When the terrestrial-phase CRLF reaches juvenile and adult stages, its diet is mainly composed of terrestrial invertebrates. As previously discussed in Section 5.1.2.2.1b, indirect effects to the CRLF via reduction in terrestrial invertebrates prey items that are exposed to simazine granules are not expected.

RQ values representing acute exposures to terrestrial invertebrates (Table 5.7) indicate that all non-granular uses of simazine may potentially result in adverse effects to small invertebrates. However, the acute RQ values are non-definitive (*i.e.*, "less than" values) because the acute contact toxicity value for the honey bee is >96.7 μg/bee (based on 6.5 percent mortality in the highest treatment group of 96.7 μg/bee). The extent to which the acute RQs, ranging from <0.17 to <1.06, may fall below the terrestrial invertebrate LOC of 0.05 is uncertain. Further examination of the open literature data on simazine effects to non-target insects including earthworms and beetles indicates that simazine is non-toxic to terrestrial insects at concentrations well above environmentally-relevant levels. Based on the maximum application rate of non-granular simazine (5.94 lb ai/A), the concentration of simazine in soil (conservatively assuming a depth of 1 cm) is 68.5 mg/kg. In a study by Martin (1982), no adverse effects to mortality or growth of juvenile earthworms were observed following a 7 day exposure to 100 mg/kg simazine in soil. In addition, no mortality or reduction in egg production were observed in simazine-treated adult female beetles at an application rate (>500 lb ai/A) well above the maximum current rate (Samsoe-Peterson, 1987). The IOBC classifies simazine as "harmless to the rove beetle", and the Agency classifies simazine as practically non-toxic to honeybees on an acute contact basis. Based on the available toxicity data, which shows that simazine is non-toxic to terrestrial invertebrates at environmentally relevant concentrations, the effects determination for indirect effects to the CRLF via a reduction in terrestrial invertebrates is "may affect, but not likely to adversely affect" or "NLAA". This finding is based on discountable effects (*i.e.*, acute effects to simazine at the expected levels of exposure are not likely to occur and/or result in a "take" of a single listed CRLF via a reduction in terrestrial invertebrates as food items).

5.2.2.5 Mammals

Life history data for terrestrial-phase CRLFs indicate that large adult frogs consume terrestrial vertebrates, including mice. RQs representing exposures of simazine to mice (small mammals) indicate chronic risks resulting from all foliar (non-granular) uses of simazine. In addition, acute risks are also possible, based on foliar uses of simazine to Christmas trees (5.94 lb ai/A).

With respect to acute risks from non-granular applications, dose-based RQs, which range from <0.02 to <0.12, are based on acute toxicity data for simazine. As previously discussed, definitive acute RQ values could not be derived because the simazine LD_{50} value is >5,000 mg/kg-bw, and 30 percent mortality was observed at the highest test concentration. Although the acute RQ for foliar simazine use on Christmas trees (< 0.12) may exceed the LOC of 0.1, the level and/or extent of the exceedance is uncertain, given the non-definitive value. Based on an analysis of the likelihood of individual mortality using the highest RQ value for small mammals (RQ=0.12) and an assumed probit dose-response slope of 4.5 (with lower and upper confidence intervals of 2 and 9), the likelihood of an individual mortality to a mammal is 1 in 58,500 (<0.1%) with upper and lower confidence intervals of 1 in 30 (3%) to 1 in 1.73E+16 (<0.1%). Granular formulations of simazine are not expected to cause acute mortality to mammals because predicted EECs are well below the adjusted LD_{50} values for mammals.

Simazine may affect small mammals at the highest foliar application rate of 5.94 lb ai/A; however, the low probability (<0.1 to 3%) of an acute effect to small mammals is not likely to affect adult terrestrial-phase CRLFs, given the wide range of other terrestrial prey items, including terrestrial invertebrates, that the species consumes. Based on the non-selective nature of feeding behavior in the CRLF, the low magnitude of anticipated acute individual effects to mammals (≤ 3%), simazine is not likely to indirectly affect the CRLF via acute reduction in mammalian food items. Therefore, the effects determination for indirect effects to the CRLF via direct acute effects on mammals as prey is "may affect, but not likely to adversely affect" or "NLAA". This finding is based on insignificant effects because the probability of an effect to mammals is low (≤3%) and any predicted effects are expected to be insignificant in the context of a "take" of a single terrestrial-phase CRLF via direct acute effects on mammalian prey.

With respect to chronic risks associated with non-granular applications of simazine, dose-based and dietary-based RQs are well above the Agency's LOCs, with dose-based values ranging from 149 to 883 and dietary-values ranging from 24 to143. Based on the available toxicity data, chronic exposure of simazine to laboratory rats results in consistent reductions in adult body weight at 100 mg/kg-diet, with a corresponding NOAEC of 10 mg/kg-diet.

Chronic toxicity to small insectivorous mammals that ingest soil invertebrates that have bioconcentrated pesticide residues of granules in soil is possible (see Appendix I). The results of the assessment indicate that, when growth effect risks for mammals are assessed on the basis of a daily ingested dose, the accumulation of simazine in terrestrial invertebrates may represent, by itself, a biologically significant pathway for exposure for insectivorous mammals. It should be noted, however, that chronic LOCs are exceeded only for the two highest granular application rates of simazine (4 and 8 lb ai/A), which will both be cancelled as part of the RED mitigation in 2010.

In summary, indirect effects are possible for large CRLF adults through decreases in mammalian prey via chronic exposure to non-granular and granular uses of simazine. Therefore, the effects determination for indirect effects to terrestrial-phase CRLFs via reduction in small mammals as prey is "likely to adversely affect" or "LAA" for all simazine uses. The maximum application rate of non-granular uses of simazine would have to be reduced to < 0.1 lb ai/A to eliminate potential chronic risks to mammals and associated indirect dietary effects to terrestrial-phase CRLFs.

5.2.2.6 Terrestrial-phase Amphibians

Terrestrial-phase adult CRLFs also consume frogs. RQ values representing direct exposures of simazine to terrestrial-phase CRLFs are used to represent exposures of simazine to frogs in terrestrial habitats. Based on estimated exposures resulting from granular and non-granular use of simazine, chronic risks to frogs are possible, although acute mortality is not expected. Therefore, the effects determination for indirect effects to large CRLF adults that feed on other species of frogs as prey, via chronic exposure to simazine, is "likely to adversely affect" or "LAA."

5.2.3 Indirect Effects (via Habitat Effects)

5.2.3.1 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 and frogs. 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 CRLFs.

Potential indirect effects to the CRLF 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 5.2.2.1 and summarized in Table 5.2), 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 CRLF via direct effects to vascular plants as habitat are not expected.

With respect to indirect effects to CRLFs 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 5.2.2.1, 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, it should be noted that 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 effects determination for indirect effects of simazine to CRLFs via impacts to habitat and/or primary production through direct effects to non-vascular plants is "likely to adversely affect" or "LAA" for 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 non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A). However, the aerial non-cropland and non-residential granular uses of simazine will be cancelled in 2010.

5.2.3.2 Terrestrial Plants

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

Loss, destruction, and alteration of habitat were identified as a threat to the CRLF in the USFWS Recovery Plan (USFWS, 2002). 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. Frogs spend a considerable amount of time resting and feeding in riparian vegetation; the moisture and cover of the riparian plant community provides good foraging habitat, and may facilitate dispersal in addition to providing pools and backwater aquatic areas for breeding (USFWS, 2002). According to Hayes and Jennings (1988), the CRLF tends to occupy waterbodies with dense riparian vegetation including willows (*Salix* sp.). Upland habitat includes grassland and woodlands, as well as scrub/shrub habitat. 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. 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 Tables 5.10 and 5.11, 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, upland and 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 both upland and riparian areas are comprised of a mixture of both non-sensitive woody (trees and shrubs) and sensitive grassy herbaceous vegetation, CRLFs may be indirectly affected by adverse effects to herbaceous vegetation which provides habitat and cover for the CRLF and its prey. Therefore, the effects determination for this assessment endpoint is "likely to adversely affect" or "LAA" for all assessed simazine use patterns.

As previously described in Section 3.2.5, 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 considered as the action area for simazine. However, because no obligate relationship exists between the CRLF and terrestrial plants, the portion of the action area that is relevant to the CRLF 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). The spray drift distances presented in Table 3.4 were derived based on the most sensitive EC_{25} value for dicots in the seedling emergence test (0.009 lb ai/A). 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 the portion of the action area that is relevant to the CRLF). 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 5.15. As discussed in Section 3.2.5, the drift buffers for the more sensitive seedling emergence endpoint for dicots were derived using the AgDISP model with the Gaussian extension because the 1,000 foot limit of the AgDrift model was exceeded. However, spray drift dissipation distances reported for the vegetative vigor endpoints and for the monocot seedling emergence endpoint were based on the Agdrift model because the limits of the model were not exceeded using the spray drift parameters provided in Section 3.2.5. As shown in Table 5.15, 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 cancelling aerial applications and incorporating spray drift language are implemented 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 the frog habitat) could affect the estimates presented in Table 5.15. However, analysis of these site-specific details is beyond the scope of this assessment.

Table 5.15 Spray Drift Dissipation Distances

Use	Application Rate (lb ai/A)	Dissipation Distance (ft)		
		Seedling Emergence		Vegetative Vigor (Monocots and Dicots)
		Monocot	Dicot	
Ground Applications				
Christmas trees	5.94	315	2765	184
Grapes	4.8	253	2628	144
Apples, Pears, Sour Cherries, Avocados, Berries, Citrus, Filberts, Hazelnuts,	4	207	2523	118

Macadamia Nuts, Olives, Walnuts, and Tree Plantations and Nurseries				
Almonds, Nectarines, Peaches, Corn, and Turf	2	95	2198	56
Aerial Applications				
Non-cropland	5	2,890*	3,891*	850
* = Derived using the Gaussian extension in the AgDISP model.				

5.2.4 Modification to Designated Critical Habitat

5.2.4.1 Aquatic-Phase PCEs

Three of the four assessment endpoints for the aquatic-phase primary constituent elements (PCEs) of designated critical habitat for the CRLF are related to potential effects to aquatic and/or terrestrial plants:

- Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.
- Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.
- Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae).

The effects determinations for indirect effects to the CRLF via direct effects to aquatic and terrestrial plants are used to determine whether modification to critical habitat may occur. Based on the results of the effects determinations for aquatic plants (see Sections 5.2.2.1 and 5.2.3.1), critical habitat of the CRLF may be modified via simazine-related impacts to non-vascular aquatic plants as food items for tadpoles and habitat for aquatic-phase CRLFs. Critical habitat may be modified by an increase in sediment deposition and associated turbidity (via impacts to herbaceous riparian vegetation), potential reduction in oxygen (via impacts to the aquatic plant community and primary productivity), and reduction in herbaceous riparian vegetation that provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult aquatic-phase CRLFs. Simazine uses that may result in modification to critical habitat via direct effects to non-vascular plants include 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). Based on the results of the effects determination for terrestrial plants (see Section 5.2.3.2), simazine-related effects on shading (*i.e.*, temperature), bank stabilization, and structural diversity (height classes) of vegetation are not expected because woody plants are generally not sensitive to environmentally-relevant concentrations of simazine. However, modification to critical habitat may occur via simazine-related impacts to sensitive herbaceous vegetation, which provide habitat and cover for the CRLF and its prey, based on all assessed uses of simazine.

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." Other than impacts to algae as food items for tadpoles (discussed above), this PCE was assessed by considering direct and indirect effects to the aquatic-phase CRLF via acute and chronic freshwater fish and invertebrate toxicity endpoints as measures of effects. As discussed in Section 5.2.1.1, direct effects to the aquatic-phase CRLF, via mortality, growth, and/or fecundity, are not expected. In addition, simazine-related effects to freshwater invertebrates and freshwater fish as food items are also not likely to occur (see Sections 5.2.2.2 and 5.2.2.3). Therefore, simazine is not likely to adversely critical habitat by altering chemical characteristics necessary for normal growth and viability of aquatic-phase CRLFs and their non-plant food sources.

5.2.4.2 Terrestrial-Phase PCEs

Two of the four assessment endpoints for the terrestrial-phase PCEs of designated critical habitat for the CRLF are related to potential effects to terrestrial plants:

- Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or drip line surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance.

- Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.

As discussed above, modification to critical habitat may occur via simazine-related impacts to sensitive herbaceous vegetation, which provides habitat, cover, and a means of dispersal for the terrestrial-phase CRLF and its prey, based on all assessed uses of simazine. Modification to critical habitat is not expected to occur in woodland areas because woody plants are not sensitive to environmentally relevant concentrations of simazine.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of simazine on this PCE, acute and chronic toxicity endpoints for terrestrial invertebrates, mammals, and terrestrial-phase frogs are used as measures of effects. Based on the characterization of indirect effects to terrestrial-phase CRLFs via reduction in the prey base (see Section 5.2.2.4 for terrestrial invertebrates, Section 5.2.2.5 for mammals, and 5.2.2.6 for frogs), critical habitat may be modified via a reduction in mammals and terrestrial-phase amphibians as food items.

The fourth terrestrial-phase PCE is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. As discussed in Section 5.2.1.2, direct acute effects, via mortality, are not expected for the terrestrial-phase CRLF; however, chronic reproductive effects are possible for all non-granular uses of simazine. Therefore, simazine may adversely critical habitat by altering chemical characteristics necessary for normal growth and viability of terrestrial-phase CRLFs and their mammalian and amphibian food sources.

6. Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

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

6.1.2 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. For example, aquatic-phase CRLFs may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than the EXAMS pond. The Agency does not currently have sufficient information regarding the hydrology of these aquatic habitats to develop a specific alternate scenario for the CRLF. CRLFs prefer habitat with perennial (present year-round) or near-perennial water and do not frequently inhabit vernal (temporary) pools because conditions in these habitats are generally not suitable (Hayes and Jennings 1988). Therefore, the EXAMS pond is assumed to be representative of exposure to aquatic-phase CRLFs. 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.

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 (2000-2005) (36.1µg/L) is roughly four times less than the highest peak EEC. Therefore, use of the PRZM/EXAMS EECs is assumed to represent a conservative measure of exposure.

6.1.3 Action Area

An example of an important simplifying assumption that may require future refinement is the assumption of uniform runoff characteristics throughout a landscape. It is well documented that runoff characteristics are highly non-uniform and anisotropic, and become increasingly so as the area under consideration becomes larger. The assumption made for estimating the aquatic action area (based on predicted in-stream dilution) was that the entire landscape exhibited runoff properties identical to those commonly found in agricultural lands in this region. However, considering the vastly different runoff characteristics of: a) undeveloped (especially forested) areas, which exhibit the least amount of surface runoff but the greatest amount of groundwater recharge; b) suburban/residential areas, which are dominated by the relationship between impermeable surfaces (roads, lots) and grassed/other areas (lawns) plus local drainage management; c) urban areas, that are dominated by managed storm drainage and impermeable surfaces; and d) agricultural areas dominated by Hortonian and focused runoff (especially with row crops), a refined assessment should incorporate these differences for modeled stream flow generation. As the zone around the immediate (application) target area expands, there will be greater variability in the landscape; in the context of a risk assessment, the runoff potential that is assumed for the expanding area will be a crucial variable (since dilution at the outflow point is determined by the size of the expanding area). Thus, it important to know at least some approximate estimate of types of land use within that region. Runoff from forested areas ranges from 45 – 2,700% less than from agricultural areas; in most studies, runoff was 2.5 to 7 times higher in agricultural areas (*e.g.*, Okisaka et al., 1997; Karvonen et al., 1999; McDonald et al., 2002; Phuong and van Dam 2002). Differences in runoff potential between urban/suburban areas and agricultural areas are generally less than between agricultural and forested areas. In terms of likely runoff potential (other variables – such as topography and rainfall – being equal), the relationship is generally as follows (going from lowest to highest runoff potential):

Three-tiered forest < agroforestry < suburban < row-crop agriculture < urban.

There are, however, other uncertainties that should serve to counteract the effects of the aforementioned issue. For example, the dilution model considers that 100% of the agricultural area has the chemical applied, which is almost certainly a gross over-estimation. Thus, there will be assumed chemical contributions from agricultural areas that will actually be contributing only runoff water (dilutant); so some contributions to total contaminant load will really serve to lessen rather than increase aquatic concentrations. In light of these (and other) confounding factors, Agency believes that this model gives us the best available estimates under current circumstances.

6.1.4 Usage Uncertainties

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

6.1.5 Terrestrial Exposure Modeling of Simazine

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

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

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

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

Using the TREX model to estimate risk to the terrestrial-phase of the CRLF may overestimate risk because the CRLF is not expected to readily ingest as many granules as a foraging bird (as simulated by the TREX model) which may either: 1) mistakenly select a simazine granule to consume instead of grit that will aid in digestion, or 2) incidentally consume simazine granules while ingesting other food items on the ground. The CRLF does not intentionally ingest grit; therefore, it is unlikely it would mistakenly ingest a simazine granule for grit. However, the CRLF may incidentally ingest simazine granules that are attached to a prey item such as a mammal, frog, or terrestrial insect. Because amphibians typically have a slower metabolism than avian species, they also have lower feeding rates than birds. Therefore, the CRLF is not expected to consume as many granules as a bird. Consequently, the TREX model may overestimate the risk of simazine granule exposure to the CRLF. It should be noted, however, that the CRLF may potentially be exposed to simazine via other routes such as thru the skin or via ingestion of drinking water contaminated with simazine. However, there are no approved methods or models available to the Agency for characterizing these routes of exposure. The TREX model is assumed to provide a reasonable representation of exposure and risk, given the best available information and associated uncertainties that may lead to an overestimation and an underestimation of risk.

6.2 Effects Assessment Uncertainties

6.2.1 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 as measures of effect for surrogate aquatic animals, and is therefore, considered as protective of the CRLF.

6.2.2 Use of surrogate species effects data

Guideline toxicity tests and open literature data on simazine are not available for frogs or any other aquatic-phase amphibian; therefore, freshwater fish are used as surrogate species for aquatic-phase amphibians. Although no data is available for simazine, the available open literature information on atrazine (a closely related triazine herbicide) toxicity to aquatic-phase amphibians shows that acute and chronic ecotoxicity endpoints for aquatic-phase amphibians are generally about 3 to 4 times less sensitive than freshwater fish. Given that atrazine and simazine share a similar mode of action, it is assumed that same relationship in toxicity between freshwater fish and aquatic-phase amphibians would apply to simazine. Therefore, endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase amphibians including the CRLF, and extrapolation of the risk conclusions from the most sensitive tested species to the aquatic-phase CRLF is likely to overestimate the potential risks to those species. Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency's LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

6.2.3 Sublethal Effects

For an acute risk assessment, 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 assessment 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.

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 CRLF 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 the CRLF and its designated critical habitat. The best available data suggest that simazine may affect and is likely to adversely affect the CRLF, based on direct chronic effects to terrestrial-phase CRLF and indirect effects to both aquatic- and terrestrial phase CRLFs (via reduction in algae, mammals, and frogs as food and habitat modification based on effects to non-vascular aquatic plants and herbaceous terrestrial vegetation). In addition, these effects also constitute modification to critical habitat. These effects are anticipated to occur only for those occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that are located ≤ 850 feet from legal use sites where simazine is applied aerially and ≤ 184 feet from use sites where simazine is applied with ground-based equipment. Given the LAA determination for the CRLF and potential modification of designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in Attachment II.

Using ARCGIS9, the National Land-Cover Dataset (NLCD, 2001), and the CRLF habitat information provided by the USFWS, the Agency has identified the areas where indirect effects to the CRLF and modification to designated critical habitat are anticipated to occur. These areas are depicted for aerial application of simazine on rights-of-way in Figure 7.1 and for ground-based application of simazine on other uses (*i.e.*, Christmas trees, cultivated crops, orchards, and turf) in Figure 7.2. Indirect effects (habitat modification based on effects to the herbaceous terrestrial plant community) could potentially occur in 52% of the CRLF range assessed (approximately 3.63 million out of 6.97 million acres). The percentage of "LAA" habitat was derived by dividing the sum of the "LAA area" for the eight recovery units by the total CRLF habitat within the eight recovery units; the CRLF habitat and "LAA" area values are provided on page 9 of Appendix D. Modification to CRLF designated critical habitat could potentially occur in 58% (approximately 260,202 out of 450,300 acres) of the currently designated habitat area. Based on the results of this effects determination, the CRLF may be indirectly affected within various portions of all of the core areas within the eight recovery units. In addition, modification of designated critical habitat is likely to occur in 36 out of the 37 critical habitat units (all critical habitat units with the exception of ALA-1B in Recovery Unit 4). According to the information provided in Appendix D, 37 counties within California include CRLF habitat that may be adversely affected by simazine use.

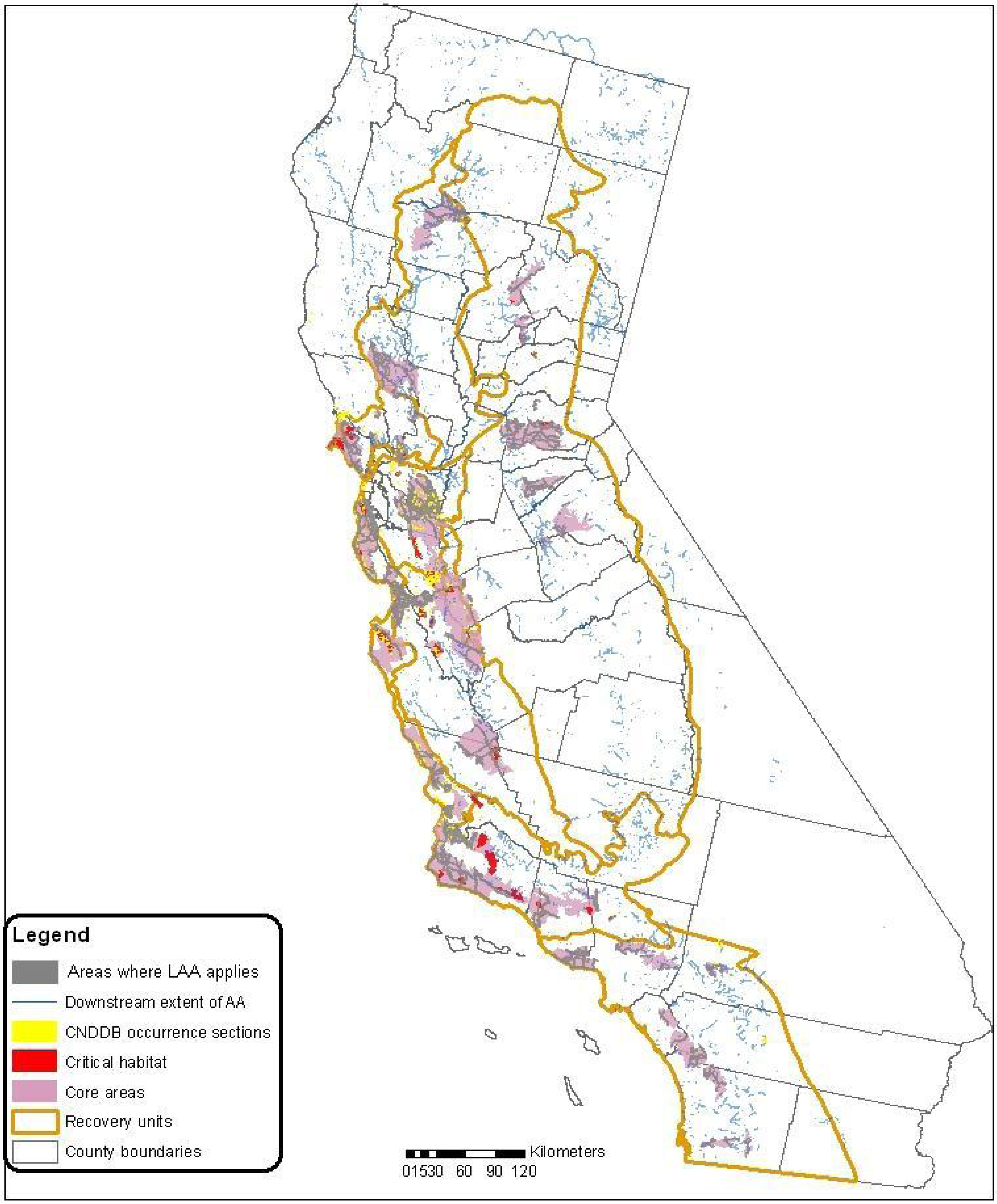


Figure 7.1 Locations Where Aerial Application of Simazine on Rights-of-Way is Likely to Adversely Affect the CRLF and Cause Modification to Critical Habitat

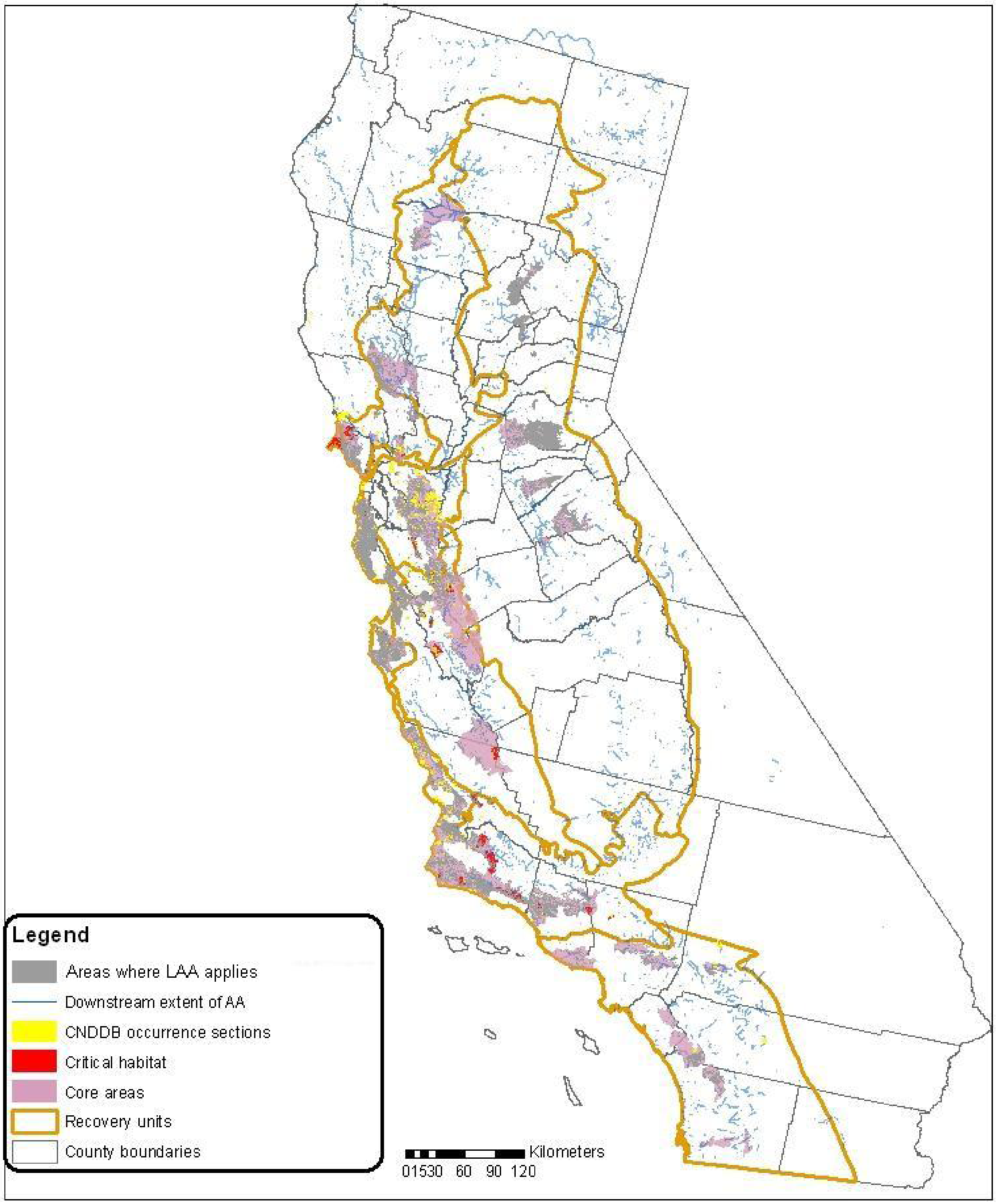


Figure 7.2 Locations Where Ground Applications of Simazine on Cultivated Crops, Orchards, Turf, and Forestry is Likely to Adversely Affect the CRLF and Cause Modification to Critical Habitat

A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat, given the uncertainties discussed in Section 6, is presented in Tables 7.1 and 7.2.

Table 7.1 Effects Determination Summary for Direct and Indirect Effects of Simazine on the CRLF		
Assessment Endpoint	**Effects Determination[1]**	**Basis for Determination**
Aquatic-PhaseCRLF (Eggs, Larvae, Adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	No effect	Using freshwater fish as a surrogate, no acute and chronic LOCs are exceeded.
Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants, fish, and frogs)	<u>Freshwater invertebrates</u>: NLAA	Simazine may affect sensitive aquatic invertebrates, such as the water flea; however, the low probability (<4%) of an individual effect to the water flea is not likely to indirectly affect the CRLF, given the wide range of other types of freshwater invertebrates that the species consumes. Based on the non-selective nature of feeding behavior in the CRLF, the low magnitude of anticipated acute individual effects to preferred aquatic invertebrate prey species (<0.1%), simazine is not likely to indirectly affect the CRLF via reduction in freshwater invertebrate food items. This finding is based on insignificant effects. The effects are insignificant because the probability of an individual effect level to freshwater invertebrates (< 4% at predicted levels of exposure) is low and the most sensitive species of freshwater invertebrate species is likely to overestimate the sensitivity of the majority of freshwater invertebrate food items in the CRLF's diet.
	<u>Non-vascular aquatic plants</u>: LAA	Simazine uses related to liquid applications on 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) exceed LOCs; therefore, indirect effects to tadpoles that feed on algae are possible.
	<u>Fish and frogs</u>: No effect	Using freshwater fish as a surrogate, no acute and chronic LOCs are exceeded.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	<u>Non-vascular aquatic plants</u>: LAA	LOCs are exceeded for non-vascular aquatic 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); LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).
	<u>Vascular aquatic plants:</u> No effect	RQs for vascular plants are less than LOCs for all simazine use patterns
Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	<u>Direct effects to forested riparian vegetation:</u> NLAA <u>Direct effects to grassy/herbaceous riparian vegetation:</u>	Riparian vegetation may be affected because terrestrial plant RQs are above LOCs. However, woody plants are generally not sensitive to environmentally-relevant concentrations of simazine; therefore, effects on shading, bank stabilization, and structural diversity of riparian areas in the action area are not expected. Aquatic-phase CRLFs may be indirectly affected by adverse effects to

	LAA < 184 ft (ground) NLAA ≥ 184 ft (ground) LAA < 850 ft (aerial); NLAA ≥ 850 ft (aerial)	sensitive herbaceous vegetation (based on all simazine non-granular and granular uses), which provides habitat and cover for the CRLF and attachment sites for its egg masses.
Terrestrial-Phase CRLF (Juveniles and adults)		
Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Acute: No effect	The acute avian effects data (used as a surrogate for the terrestrial-phase CRLF) show no mortality at the highest treatment levels of simazine in both the acute oral and subacute dietary studies. In addition, the predicted granular EECs in mg ai/ft^2 are well below the adjusted LD_{50} values for two weight classes that are intended to be representative of juvenile and adult terrestrial-phase CRLFs.
	Chronic: LAA (for non-granular simazine uses) NLAA (for granular simazine uses)	Chronic reproductive effects are possible, based on non-granular uses of simazine. However, chronic direct effects to the CRLF exposed to granules are unlikely. This finding is based on discountable effects (*i.e.*, chronic effects to simazine granules are not likely to occur and/or result in a "take" of a single listed terrestrial-phase CRLF).
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	Terrestrial invertebrates: NLAA	Simazine is non-toxic to terrestrial invertebrates at environmentally relevant concentrations. This finding is based on discountable effects (*i.e.*, acute effects to simazine at the expected levels of exposure are not likely to occur and/or result in a "take" of a single listed CRLF via a reduction in terrestrial invertebrates as food items).
	Mammals: LAA	Chronic RQs for non-granular formulations exceed LOCs. Chronic effects to insectivorous mammals that consume invertebrates exposed to simazine granules are also possible.
	Frogs: LAA	Chronic risks for terrestrial-phase frogs exposed to non-granular uses of simazine may occur, although acute mortality is not likely.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	Direct effects to forested riparian vegetation: NLAA Direct effects to grassy/herbaceous riparian vegetation: LAA < 184 ft (ground) NLAA ≥ 184 ft (ground) LAA < 850 ft (aerial); NLAA ≥ 850 ft (aerial)	Riparian vegetation may be affected because terrestrial plant RQs are above LOCs. However, woody plants are generally not sensitive to environmentally-relevant concentrations of simazine; therefore, effects to woodlands within the action area are not expected. Terrestrial-phase CRLFs may be indirectly affected by adverse effects to sensitive herbaceous vegetation (based on all simazine non-granular and granular uses), which provides habitat and cover for the CRLF and its prey.

Table 7.2 Effects Determination Summary for the Critical Habitat Impact Analysis		
Assessment Endpoint	**Effects Determination**	**Basis for Determination**
Aquatic-Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Habitat modification	Sensitive herbaceous riparian vegetation may be affected based on all granular and non-granular uses of simazine; therefore, critical habitat may be modified by an increase in sediment deposition and reduction in herbaceous riparian vegetation that provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult aquatic-phase CRLFs.
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[7]	Habitat modification	Sensitive herbaceous riparian vegetation and non-vascular aquatic plants may be affected; therefore, critical habitat may be modified via turbidity and reduction in oxygen content necessary for normal growth and viability of juvenile and adult aquatic-phase CRLFs.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	No effect to growth and viability Habitat modification based on alteration of food source	Direct effects to the aquatic-phase CRLF, via mortality, growth, and/or fecundity, are not expected. However, critical habitat of the CRLF may be modified via simazine-related impacts to non-vascular aquatic plants as food items for tadpoles. LOCs are exceeded for non-vascular aquatic 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); LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	Habitat modification	Based on the results of the effects determinations for aquatic plants, critical habitat of the CRLF may be modified via simazine-related impacts to non-vascular aquatic plants as food items for tadpoles. LOCs are exceeded for non-vascular aquatic 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); LOCs are also exceeded for granular applications of simazine to non-bearing fruit (8 lb ai/A) and berries (4 lb ai/A).
Terrestrial-Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	Habitat modification	Modification to critical habitat may occur via simazine-related impacts to sensitive herbaceous vegetation, which provide habitat and cover for the terrestrial-phase CRLF and its prey, based on all assessed uses of simazine. Modification to critical habitat is not expected to occur in woodland areas because woody plants are not sensitive to environmentally relevant concentrations of

[7] Physico-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.

Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	Habitat modification	simazine.
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Habitat modification	Based on the characterization of indirect effects to terrestrial-phase CRLFs via reduction in the prey base, critical habitat may be modified via a reduction in mammals and terrestrial-phase amphibians as food items.
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Habitat modification	Direct acute effects, via mortality, are not expected for the terrestrial-phase CRLF; however, chronic reproductive effects are possible for all non-granular uses of simazine. Therefore, simazine may adversely critical habitat by altering chemical characteristics necessary for normal growth and viability of terrestrial-phase CRLFs and their mammalian and amphibian food sources.

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 CRLF life stages within specific recovery units and/or designated critical habitat within the action area. 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 species.
- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, 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 frogs and potential modification to critical habitat.

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