Risks of Bensulide Use to Federally Listed California Red Legged Frog

(*Rana aurora draytonii*)

Pesticide Effects Determination

Environmental Fate and Effects Division
Office of Pesticide Programs
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1.0 Executive Summary

The purpose of this assessment is to make an "effects determination" by evaluating the potential direct and indirect effects of the herbicide, bensulide, on the survival, growth, and reproduction of the California red legged frog (*Rana aurora draytonii*). In addition, this assessment evaluates the potential for bensulide use to result in the modification of designated critical habitat for the California red legged frog (CRLF). 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).

Bensulide is a pre-emergent organophosphate herbicide which inhibits meristematic root tissues and inhibits seedling growth. It is usually applied to bare ground before crops are planted. It is registered for the control of grasses and broadleaf weeds in agricultural crops, residential grass lawns, golf courses, turf farms, rights-of-way, and in landscaping applications. Bensulide is used in a wide variety of different application amounts and is used both as an emulsifiable concentrate and as a granular application.

Bensulide may move through the environment and be transported away from the site of application by run-off or spray drift (in the case of the EC formulation). The major degradate, bensulide oxon is not considered in this assessment because (1) due to the persistence of the parent, very little of the oxon is expected to form, and (2) no oxon toxicity data is available. A parent-only exposure assessment is equivalent to a total-toxic-residue assessment because of the persistence of the parent compound. The oxon is not expected to be more toxic than the parent; therefore no further assessment is needed.

The initial area of concern for bensulide is limited to those agricultural lands and turf and lawns where it is applied within the state of California. The initial area of concern represents the "footprint" of where bensulide could potentially be used based on land cover information. The initial area of concern is then expanded as necessary based on the potential for direct and indirect effects above levels of concern (LOCs) which considers the fate and transport properties of the compound. The action area is defined by the land use classes designated to represent the crops where bensulide is used in a conservative fashion and account for the fate and transport characteristics of the pesticide, including transport in streams and rivers, spray drift, and long-range transport. In general, the action area is defined as the general agricultural cropland and orchard land classes within the state of California plus those areas beyond this initial area of concern where effects above Agency levels of concern may occur. For bensulide these areas beyond the initial area of concern are defined by the distance spray drift exposure to CRLF habitat components that will exceed the Agency LOC. Based on EFED's spray drift analysis this distance is a 2792 foot wide buffer around the habitat of the CRLF.

Consistent with the methodology specified in the Agency's Overview Document (U.S. EPA, 2004a), screening-level Estimated Environmental Concentrations (EECs), based on the PRZM/EXAMS static water body scenario, were used to derive risk quotients (RQs) for all relevant agricultural bensulide uses within the action area. RQs based on screening-level EECs were used to distinguish “no effect” from “may effect” determinations for direct/indirect effects to the CRLFs and the critical habitat impact analysis.

The assessment endpoints for the CRLF included direct toxic effects on survival, reproduction, and growth of individual frogs, as well as indirect effects, such as reduction of the food source and/or modification of habitat. Risk quotients (RQs) for direct acute effects to the CRLF were calculated using acute toxicity data from the registrant submitted fish (CRLF surrogate species) acute toxicity data. See table below RQS for direct chronic (reproductive, growth) effects were calculated using an estimated chronic NOAEC for amphibians based on the acute-to-chronic ratio for rainbow trout. To assess potential indirect effects to the CRLF via effects to potential prey (and consequently a reduction of available food items), toxicity data for freshwater fish and invertebrates as well as birds and mammals were considered. The available registrant submitted phytotoxicity studies were used to determine the potential risk to primary producers, and in turn, potential indirect effects to the CRLF.

Federally designated critical habitat has been established for the CRLF. Adverse modifications to the primary constituent elements of designated critical habitat, as defined in 50 CFR 414.12(b), were also evaluated. PCEs evaluated as part of this assessment include the following:

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

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 bensulide use within the action area has the potential to adversely affect the CRLF or modify designated critical habitat. When RQs for a particular type of effect are below LOCs, the pesticide’s use is considered to have “no effect” on the CRLF or its designated critical habitat. Where RQs exceed LOCs, a potential to cause adverse effects or habitat modification is identified, leading to a conclusion of “may affect”. If bensulide use “may affect” the CRLF, and/or cause modification to designated critical habitat, the best available information and data are considered to refine the potential for exposure and effects, and distinguish actions that are Not Likely to Adversely Affect (NLAA) from those that are Likely to Adversely Affect (LAA). Effects determinations for direct/indirect effects to the CRLF and the critical habitat impact analysis are summarized below and presented in Tables 1.1.

Table 1.1 Summary of effects determinations for direct/indirect effects to the CRLF and its critical habitat.		
Assessment Endpoint	Effects determination	Basis for Determination
Aquatic Phase (Eggs, larvae, tadpoles, juveniles, and adults)		
Direct Effects		
Survival, growth, and reproduction of CRLF	LAA	All acute RQs are above the listed LOC for surrogate species (rainbow trout) for all the modeled bensulide uses.
Indirect Effects and Critical Habitat Effects		
Reduction or modification of invertebrate aquatic prey base	LAA	The Agency presumed risk of chronic effects to the CRLF aquatic invertebrate prey for all modeled uses (See Risk Description Sec. 5.2.2.1 for explanation of presumption).
Reduction or modification of aquatic vertebrate prey base	NLAA	No LOC exceedance for acute or chronic risks to fish or amphibian prey base.
Reduction or modification of aquatic plant community	No Effect	No LOC Exceedances for any aquatic plant species
Degradation of riparian vegetation	LAA	The levels of concern for risk to nonlisted plants in semiaquatic areas (which may include plants inhabiting riparian areas) are exceeded for bensulide granular and EC formulation uses on turf and lawn.
Terrestrial Phase (Juveniles and Adults)		
Direct Effects		
Survival, growth, and reproduction of CRLF	LAA	The dietary based RQs calculated by TREX and THERPS (as a refinement) exceed the acute and chronic LOC for all modeled bensulide uses.
Indirect Effects and Critical Habitat Effects		
Reduction or modification of terrestrial prey base	LAA	The level of concern is exceeded for risk to invertebrate, mammalian and amphibian prey of the CRLF.
Degradation of riparian vegetation	LAA	The levels of concern for risk to nonlisted plants in semiaquatic areas (which may include plants inhabiting riparian areas) are exceeded for bensulide granular and EC formulation uses on turf and lawn.

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.

2.0 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 listed species assessment is to evaluate potential direct and indirect effects on individuals of the federally listed "Threatened" California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of Bensulide, which is registered for the control of grasses and broadleaf weeds in agricultural crops, rights-of-way, landscaping applications and in lawn care (professional and homeowner) applications. In addition, this assessment evaluates whether these actions can be expected to result in the modification of the species' critical habitat. Key biological information for the CRLF is included in Section 2.5, and designated critical habitat information for the species is provided in Section 2.6 of this assessment. This ecological risk assessment has been prepared as part of the *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW (JL)) settlement entered in the Federal District Court for the Northern District of California on October 20, 2006.

In this listed species assessment, direct and indirect effects to the CRLF and potential modification to its critical habitat are evaluated in accordance with the methods (both screening-level and species-specific refinements, when appropriate) described in the Agency's Overview Document (U.S. EPA, 2004). In addition, in accordance with two interim policies, terrestrial invertebrate LOCs will be used and terrestrial amphibian modeling will be used as a refinement. Use of such information is consistent with the guidance provided 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 Bensulide are based on an action area. The action area is considered to be the area directly or indirectly affected by the federal action, as indicated by the exceedance of Agency Levels of Concern (LOCs) used to evaluate direct or indirect effects. It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of bensulide 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 for registration of Bensulide at the use sites described in this document to affect CRLF individuals and/or result in the modification of designated CRLF critical habitat:

- "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 CRLF's are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat (Section 2.6).

If the results of initial screening-level assessment methods show no direct or indirect effects (no LOC exceedances) upon individual CRLF's or upon the PCEs of the species' designated critical habitat, a "no effect" determination is made for the FIFRA regulatory action regarding Bensulide as it relates to this species and its designated critical habitat. If, however, direct or indirect effects to individual CRLF's are anticipated and/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 Bensulide.

If a determination is made that use of Bensulide within the action area(s) associated with the CRLF "may affect" this species and/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 Bensulide use sites) and further evaluation of the potential impact of Bensulide on the PCEs is also used to determine whether modification to 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 and/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 bensulide is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for Bensulide 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 destroy or adversely modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of Bensulide 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

Bensulide [S-(O,O-Diisopropyl phosphorodithioate) ester of N-(2- mercapto) benzene-sulfonamide] is a pre-emergent herbicide registered for the control of grasses and broadleaf weeds in agricultural crops such as kohl crops, cucurbits, leafy vegetables, legume, onion and garlic. It is also used on residential grass lawns, golf courses, turf farms, rights-of-way and in landscaping applications. County level usage data for bensulide were obtained from California's Department of Pesticide Regulation Use Reporting (CDPR PUR) database. Reported usage information considered in this assessment spans from 2001-2005.

There are a number of uses reported in the CDPR PUR database that either are misuses or entry errors in the database for they are not supported by past or current state (Section 24c) or national (Section 3) labels for bensulide. These uses are not part of the FIFRA regulatory action and have not been included in this assessment but are identified here for completeness. Between 2002-2005 these combined uses comprised a total of approximately 0.40% of all bensulide applied in CA: uncultivated non-agricultural (<0.01%), vertebrate control (<0.01%), commodity fumigation (<0.01%), rangeland (<0.01%),water area (<0.01%), unspecified vegetable (<0.01%), structural pest control (<0.01%), uncultivated agricultural (0.02%), soil fumigation (0.08%), unknown (0.09%) and unspecified leafy vegetable (0.14%). Some uses may potentially be emergency uses, which are federal actions which are typically of limited use and duration. ESA effects would be considered at the time when the emergency use(s) were granted and are not included in this assessment. Bensulide was also used in research (i.e. research commodity record) (0.02%); this research occurred in Fresno, Monterey, San Benito, Solano, Tulare and Yolo Counties. This use will be excluded as well from this assessment. Experimental use permits are federal actions that are taken for specific research projects which are typically of limited use and acreage. Each experimental use is considered on a case-by-case basis, limited to the year that the permit was granted; ESA effects would be considered at the time when the experimental use permit was granted.

The end result of the EPA pesticide registration process (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 bensulide in accordance with the approved product labels for California is "the action" being assessed.

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

This assessment concentrates on the parent bensulide (Figure 1) because it is persistent, as is also its major degradate bensulide oxon (Figure 2) (N-[(2-(diisopropoxyphosphinoylthio)-1-ethyl] -benzenesulfonamide). The minor degradate benzenesulphonamide (Figure 3) concentrations are expected to be low. In an aerobic soil metabolism study, bensulide oxon reached a maximum concentration of 13.8% of the applied at 270 days post treatment and decreased to 10.1% at 360 days, and benzenesulfonamide reached a maximum level of 0.52% at 360 days. Because the inherent toxicity of the oxon is unknown, the ecological relevance of oxon residues potentially present in the environment cannot be assessed. It is therefore assumed that the toxicity of the oxon is equivalent to that of the parent.

The Agency does not routinely include, in its risk assessments, an evaluation of mixtures of active ingredients, either those of multiple active ingredients in product formulations or those produced by the applicator. With regards to 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 regarding each active ingredient separately, for use on a particular site. If effects data are available for a formulated product containing more than one active ingredient, they may be used qualitatively or quantitatively in accordance with the Agency's Overview Document and the Services' Evaluation Memorandum (U.S. EPA, 2004; USFWS/NMFS, 2004). There are two registered products that contain bensulide as one of two active ingredients. Proturf Goosegrass and Crabgrass Control (EPA Reg. No. 00053800164) and Anderson's Goose and Crabgrass control (EPA Reg. No. 00919800176) are both mixtures of bensulide and the oxadiazole herbicide oxadiazon at 5.25% and 1.31% respectively

There are many variables within the landscape covered by this risk assessment that can affect predicted exposures and effects of bensulide in any given area. Even within contiguous Red-Legged Frog critical habitats in California there is great variability in land use and cover, topography, and precipitation.

Figure 1 Bensulide (pc code: 009801) Chemical Structure

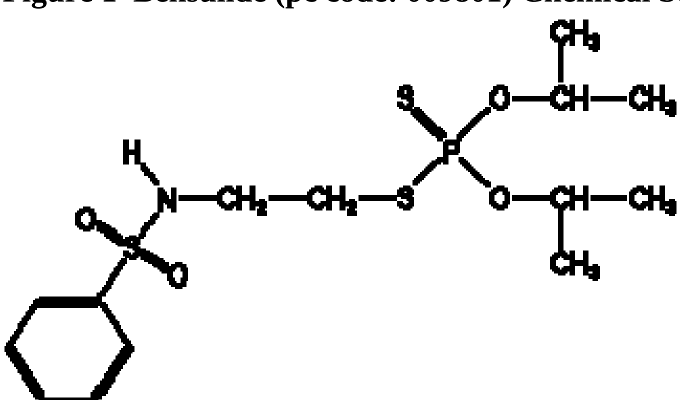


Figure 2. Bensulide oxon Chemical Structure

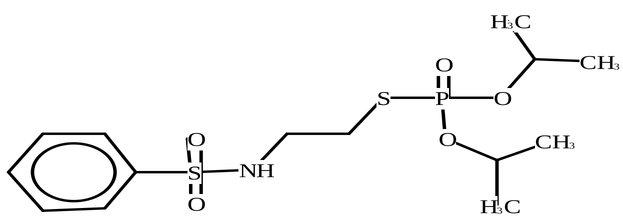
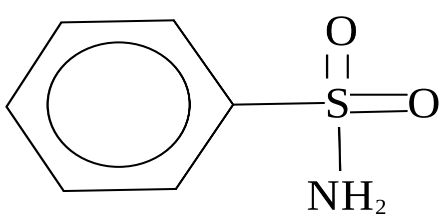


Figure 3. Benzenesulphonamide Chemical Structure



2.3 Previous Assessments

Three previously published, relevant risk assessments for Bensulide are the 1998 Bensulide Reregistration Eligibility Document (EPA, 1998), the 2000 Interim Reregistration Eligibility Decision (U.S. EPA, 2000) and the 2000 Addendum to the Bensulide RED: Revised Risk Assessment and Risk Characterization for Risk to Aquatic Organisms from Use on Turf (U.S. EPA, 2000). No comparison was made to the labeled usages for the previous assessments to current ones. This assessment focuses only on current label usage information. For specific details not mentioned in this assessment, these documents can be consulted.

2.4 Stressor Source and Distribution

2.4.1 Environmental Fate Assessment

Although the environmental fate data base for bensulide is not complete, information from acceptable laboratory studies indicates bensulide is persistent. Neither abiotic hydrolysis nor photolysis are major degradation processes in water or on soil surfaces. The main route of dissipation of bensulide appears to be aerobic soil metabolism with a reported half-life of 1 year. Under aerobic conditions it appears that mineralization of bensulide to carbon dioxide (CO_2) and immobilization as unextractable residues are the major mechanisms of dissipation in the soil. Under anaerobic soil conditions bensulide did not degrade. Based on the lack of degradation under laboratory conditions, it is predicted that bensulide will be extremely persistent in anaerobic terrestrial ecosystems.

Information from acceptable laboratory studies indicates that bensulide is not mobile in the four soils tested (K_{oc}'s ranged from 1,433 to 4,326 ml/g); however, the major degradates bensulide oxon (N-[(2-(diisopropoxyphosphinoy1thio) - 1 -ethyl] - benzenesulfonamide) and benzenesulphonamide ranged from mobile to highly mobile in the same four test soils. Bensulide has the potential to be transported dissolved in water and on suspended sediment in runoff to surface waters where, based on laboratory data, it is expected to persist.

The environmental fate assessment developed from the results of the laboratory studies has not been confirmed by acceptable field dissipation information. Of eight field dissipation studies submitted none were acceptable. While half-life of bensulide was reported in these studies to range from 8-34 days in California and from 91-210 days in Mississippi, these values are questionable given none of the studies exhibited a consistent decline of parent compound. Additionally, none of the studies is acceptable because the application rate could not be confirmed and bare ground plots were not used. The study plots had been planted to turf, and no mention was made of how the turf and thatch in the samples were separated from the soil or of any attempt to extract residues from the turf or thatch. In a currently unacceptable but upgradeable field dissipation study, calculated first order half-lives for bensulide in the top 6 inches of soil was 80.4 days. Bensulide and its major degradate bensulide oxon were found only in the top 6 inches of the soil.

With a reported fish whole body bioconcentration factor (BCF) of 550 and a whole body elimination of 98% after 14 days depuration, bensulide does not appear to have the potential to significantly bioaccumulate in fish.

2.4.2 Environmental Transport Assessment

Ground spray applications may potentially result in transport and loading of bensulide to off-field soil and foliage via spray drift. Granular ground application methods are not expected to result in granules being distributed to off-field soil; however on-field bensulide soil residues, from either ground spray or granular application methods, have the potential to be transported both dissolved in water and on suspended soil in runoff to off-field terrestrial areas and to surface waters. Once in the aquatic system it is expected to partition primarily to sediment where it will be relatively stable. However as discussed in the fate section above, based on results of a fish bioconcentration study in which the BCF was not significant and the depuration rate was relatively fast, biomagnification up through the food web is not expected to be a significant transport pathway. In general deposition of drifting or run-off loads are expected to be greatest close to the site of application As discussed in the previous fate section, bensulide is not expected to leach to ground water.

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 or AgDISP) are used to determine if the exposures to aquatic and terrestrial organisms are below the Agency's Levels of Concern (LOCs). If the limit of exposure that is below the LOC can be determined using AgDRIFT or AgDISP, longer-range transport is not considered in defining the action area. For example, if a buffer zone <1,000 feet (the optimal range for AgDRIFT and AgDISP models) results in terrestrial and aquatic exposures that are below LOCs, no further drift analysis is required. If exposures exceeding LOCs are expected beyond the standard modeling range of AgDRIFT or AGDISP, the Gaussian extension feature of AgDISP may be used. In addition to the use of spray drift models to determine potential off-site transport of pesticides, other factors such as available air monitoring data and the physicochemical properties of the chemical are also considered.

- Due to model limitations, it may not be possible to provide a quantitative estimate of exposure with known uncertainty, beyond the range of Ag-Drift v. 2.1 or Ag-DISP.

- Cannot model aquatic concentrations resulting from long range transport beyond the range of the Gaussian extension of Ag-Disp; therefore, analysis will be qualitative if exposures exceed LOC at the limit of the Gaussian extension range.

2.4.3 Mechanism of Action

Bensulide is a pre-emergent organophosphate herbicide which inhibits meristematic root tissues (inhibits cell division in root tips) and inhibits seedling growth by conjugation of acetyl co-

enzyme A, specific site unknown (Ware, 1978; Martin, 2000). It is usually applied to bare ground before crops are planted. It is not translocated from foliage into plants.
The mode of toxic action to non-target organisms (*e.g.*, mammals) is via the inhibition of cholinesterase and accumulation of acetylcholine at the nerve synapses, resulting in classic symptoms of organophosphate poisoning.

2.4.4 Use Characterization

The California usages for bensulide are presented in Table 1. California Bensulide Use by Crop: 2002-2005[ab].The agricultural use rate is typically 5-6 lbs ai acre, and the 6 ai lb rate is often used. An exception to this occurs in southwest deserts, where it is usually applied in the fall and again to a second crop (usually lettuce) about 120 days later. Up to 6 lbs ai/acre can be applied for each crop for a maximum of 12 lbs ai/acre/year. Sprinkler and chemigation systems are used in Southwest deserts to deliver bensulide and often use rates as low as 4 lb ai/acre per application. The highest application rate is a ground application of 32 lb ai/A on golf course turf.

Table 1. California Bensulide Use by Crop: 2002-2005[ab].

Crop	Total Pounds 2002-2005	AVG Annual Pounds Applied per Year	Mean Annual Area Treated (acres)	AVG Annual Pounds Applied per AVG Annual Area Treated (acres)
Grand Total	**900200.8**	**225367.9**	**81772.63**	**309.37**
LETTUCE, LEAF	263815.17	65953.79	18874.32	3.49
LETTUCE, HEAD	208478.64	52119.66	16271.99	3.20
BROCCOLI	110619.30	27654.83	8433.56	3.28
MUSTARD	53692.27	13423.07	2549.14	5.27
ONION, DRY	49933.00	12483.25	4632.15	2.69
CANTALOUPE	47899.43	11974.86	5203.29	2.30
CABBAGE	20053.50	5013.37	1175.46	4.27
CHINESE CABBAGE (NAPPA)	19449.96	4862.49	1004.47	4.84
MELON	16112.43	4028.11	2545.79	1.58
LANDSCAPE MAINTENANCE	14329.29	3582.32	37.56	95.38
PEPPER, FRUITING	12812.80	3203.20	779.03	4.11
BOK CHOY	10341.03	2585.26	554.96	4.66
CILANTRO	7990.42	1997.60	496.04	4.03
WATERMELON	6110.11	1527.53	387.56	3.94
CHINESE GREENS	5579.13	1394.78	276.74	5.04
ENDIVE (ESCAROLE)	5334.52	1333.63	476.65	2.80
COLLARD	4772.29	1193.07	236.53	5.04
GAI LON	4215.62	1371.63	268.35	5.11
CAULIFLOWER	3997.65	999.41	375.29	2.66
KALE	3421.83	855.46	208.15	4.11
FENNEL	3178.09	794.52	141.92	5.60
CHICORY	2678.45	669.61	263.98	2.54
ARRUGULA	2560.02	640.00	137.94	4.64

Crop	Total Pounds 2002-2005	AVG Annual Pounds Applied per Year	Mean Annual Area Treated (acres)	AVG Annual Pounds Applied per AVG Annual Area Treated (acres)
CUCUMBER	2471.41	617.85	163.40	3.78
MIZUNA	2463.63	615.91	135.42	4.55
RAPPINI	1896.26	474.07	107.06	4.43
SQUASH, SUMMER	1704.42	426.11	144.32	2.95
N-OUTDR FLOWER	1673.81	418.45	76.51	5.47
PARSLEY	1629.79	407.45	78.51	5.19
SQUASH	1412.12	353.03	86.89	4.06
VEGETABLES, LEAFY[a]	1296.08	324.02	72.99	4.44
CANOLA (RAPE)	1226.46	306.61	94.50	3.24
CELERY	1136.23	284.06	52.08	5.45
PUMPKIN	1115.92	278.98	54.01	5.17
EGGPLANT	547.56	136.89	29.36	4.66
BRUSSELS SPROUT	536.51	134.13	60.42	2.22
PEAS	474.92	118.73	29.75	3.99
KOHLRABI	468.63	117.16	36.13	3.24
CARDOON	432.56	108.14	24.34	4.44
DANDELION GREEN	418.68	104.67	16.39	6.39
PEPPER, SPICE	417.45	104.36	33.18	3.15
SPINACH	382.53	95.63	29.69	3.22
SQUASH, ZUCCHINI	312.32	78.08	26.25	2.97
BEET	208.92	52.23	10.40	5.02
TURF/SOD	100.01	25.00	3.75	6.67
RADISH	80.31	20.08	4.63	4.34
ARTICHOKE, GLOBE	79.32	19.83	5.00	3.97
HERB, SPICE	65.44	16.36	8.25	1.98
VEGETABLE[a]	60.48	15.12	3.63	4.17
SQUASH, WINTER	55.52	13.88	2.80	4.96
COTTON	44.67	11.17	25.25	0.44
GAI CHOY	40.65	10.16	1.95	5.21
SWISS CHARD	23.80	5.95	1.50	3.97
CORN, HUMAN CONSUMPTION	19.15	4.79	1.61	2.97
GRAPE, WINE	12.94	3.24	9.38	0.35
N-GRNHS FLOWER[b]	10.21	2.55	8.73	0.29
ONION, GREEN	4.17	1.04	3.00	0.35
N-OUTDR PLANTS IN CONTAINERS[b]	2.73	0.68	0.63	1.09
N-GRNHS PLANTS IN CONTAINERS[b]	0.19	0.05	15000.05	0.00

(a) Use reports in CA DPR PUR that represent misuse or misreporting and are excluded in this assessment
(b) Use excluded in this assessment because it will not affect CRLF.

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for bensulide represents the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs. The use analysis is summarized in Appendix B.

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (LUIS report, 12/08/2006) using state-level usage data obtained from USDA-NASS[1], Doane (www.doane.com); the full dataset is not provided due to its proprietary nature), and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[2]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for Bensulide by county in this California-specific assessment were generated using CDPR PUR data. Usage data are averaged together over the years 2000 to 2005 to calculate average annual usage statistics by county and crop for Bensulide, including pounds of active ingredient applied and base acres treated. California State law requires that every pesticide application be reported to the state and made available to the public. The summary of Bensulide usage for all use sites, including both agricultural and non-agricultural, is provided in Appendix B.

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.

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 (See Figure 5).

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 elevation 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 CRLF's are located between Marin and Santa Barbara Counties (Jennings and Hayes, 1994). A total of

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

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

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 CRLF's (*i.e.*, streams, creeks, tributaries, associated natural and artificial ponds, and adjacent drainages), and habitats through which CRLF's can move (*i.e.*, riparian vegetation, uplands) (USFWS, 2002).

The distribution of CRLF's 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 5). 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

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 status, 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 and shown in Figure 5.

Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see Table 2). Figure 5 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 spatial information is evaluated within the broader context of recovery units. For example, if no labeled uses of Bensulide 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 CRLF's are extirpated from these areas. A summary of currently and historically occupied core areas is provided in Table 2 (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.

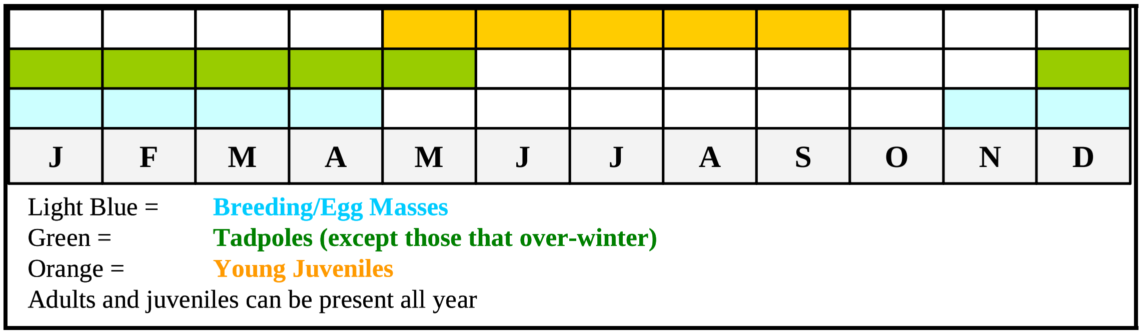
Other Known Occurrences from the CNDBB

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 CRLF's 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

CRLF's breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers, 2005a). According to the Recovery Plan (USFWS, 2002), CRLF's 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 4 depicts CRLF annual reproductive timing.

Figure 4. CRLF Reproductive Events by Month



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 CRLF's 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 CRLF's 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 CRLF's, 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 CRLF's forage primarily above water, although the authors note other data reporting that adults also feed under water, are cannibalistic, and consume fish. For larger CRLF's, 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

CRLF's 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, CRLF's 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 CRLF's do not frequently inhabit vernal pools, as conditions in these habitats generally are not suitable (Hayes and Jennings, 1988).

CRLF's 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 CRLF's 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. CRLF's 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), CRLF's also use small mammal burrows and moist leaf litter as habitat. In addition, CRLF's 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.

Table 2. California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat

Recovery Unit [1]	Core Areas [2,7] (Figure 5)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
Sierra Nevada Foothills and Central Valley (1) (eastern boundary is the 1,500 m elevation	**Cottonwood Creek (partial) (8)**	--	✓	
	Feather River (1)	BUT-1A-B	✓	
	Yuba River-S. Fork Feather River (2)	YUB-1	✓	
	--	NEV-1[6]		

Recovery Unit [1]	Core Areas [2,7] (Figure 5)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
line)	**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 (partial) (18)	SNM-1A	✓	
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	✓	

Recovery Unit [1]	**Core Areas** [2,7] **(Figure 5)**	**Critical Habitat Units** [3]	**Currently Occupied (post-1985)** [4]	**Historically Occupied** [4]
	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 5. Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

Recovery Units

1. Sierra Nevada Foothills and Central Valley
2. North Coast Range Foothills and Western Sacramento River Valley
3. North Coast and North San Francisco Bay
4. South and East San Francisco Bay
5. Central Coast
6. Diablo Range and Salinas Valley
7. Northern Transverse Ranges and Tehachapi Mountains
8. Southern Transverse and Peninsular Ranges

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

‘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.

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.

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 Bensulide 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 affect 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 bensulide is expected to directly impact living organisms within the action area, critical habitat analysis for bensulide 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 Bensulide is likely to encompass considerable portions of the United States based on the large array of agricultural and non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the state of California. Deriving the geographical extent of this portion of the action area is the product of consideration of the types of effects that bensulide may be expected to have on the environment, the exposure levels to Bensulide that are associated with those effects, and the best available information concerning the use of bensulide and its fate and transport within the state of California.

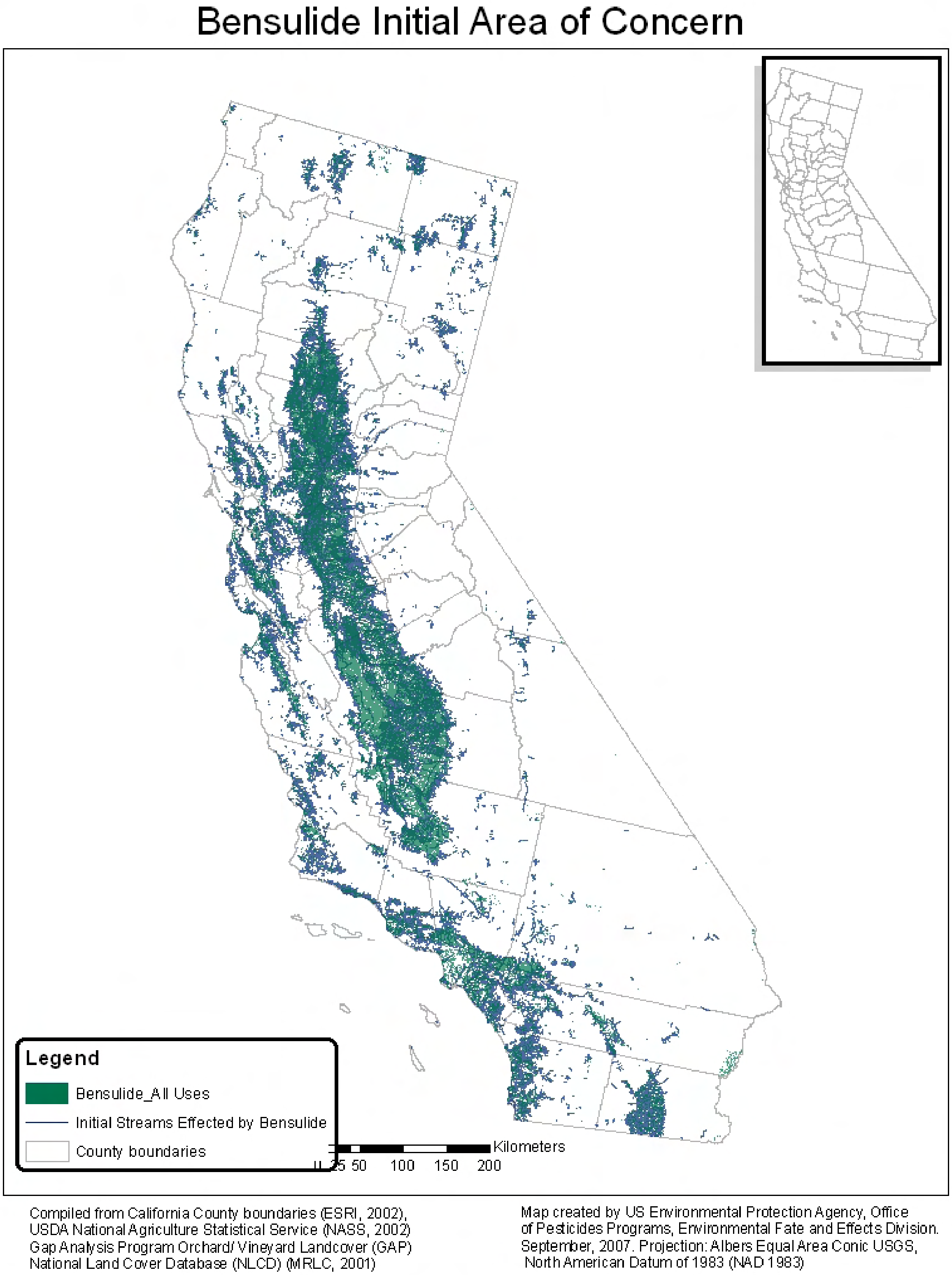
The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for bensulide. An analysis of labeled uses and review of available product labels was completed. This analysis indicates that, for bensulide, the following uses are considered as part of the federal action evaluated in this assessment. As explained in section 2.2, there are a number of uses reported in the CDPR PUR database that may be entry errors in the database for they are not supported by past or current state (Section 2.4.c) or national (Section 3) labels for bensulide. These uses are not part of the FIFRA regulatory action and have not been included in this assessment. Labeled uses for bensulide are listed in Table 3.

Table 3. Labeled Uses of Concern for Bensulide in California

• Arugula	• Cotton	• Onion (dry)
• Artichoke (globe)	• Cucumber	• Onion (green)
• Beet	• Dandelion green	• Parsley
• Bok choy	• Eggplant	• Peas
• Broccoli	• Endive	• Pepper (fruiting)
• Brussels Sprouts	• Fennel	• Pepper (spice)
• Cabbage	• Gai Choy	• Pumpkin
• Canola	• Gai Lon	• Radish
• Cantaloupe	• Grape (wine)	• Rapini
• Cardoon	• Herbs and spices	• Rights of way
• Cauliflower	• Kale	• Spinach
• Celery	• Kohlrabi	• Squash
• Chicory	• Landscape maintenance	• Summer squash
• Chinese cabbage (Napa)	• Lettuce (head)	• Swiss chard
• Chinese greens	• Lettuce (leaf)	• Turf/sod
• Cilantro	• Melon	• Watermelon
• Collard	• Mizuna	• Winter squash
• Corn (human consumption)	• Mustard	• Zucchini squash
	• Ornamentals (field grown)	

After a determination of which uses will be assessed, an evaluation of the potential “footprint” of the use pattern should be determined. This “footprint” represents the initial area of concern and is typically based on available land cover data. Local land cover data available for the state of California were analyzed to refine the understanding of potential Bensulide use. However, no areas are excluded from the final action area based on usage and land cover data. 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 is presented in Figure 6.

Figure 6. Bensulide Initial Area of Concern



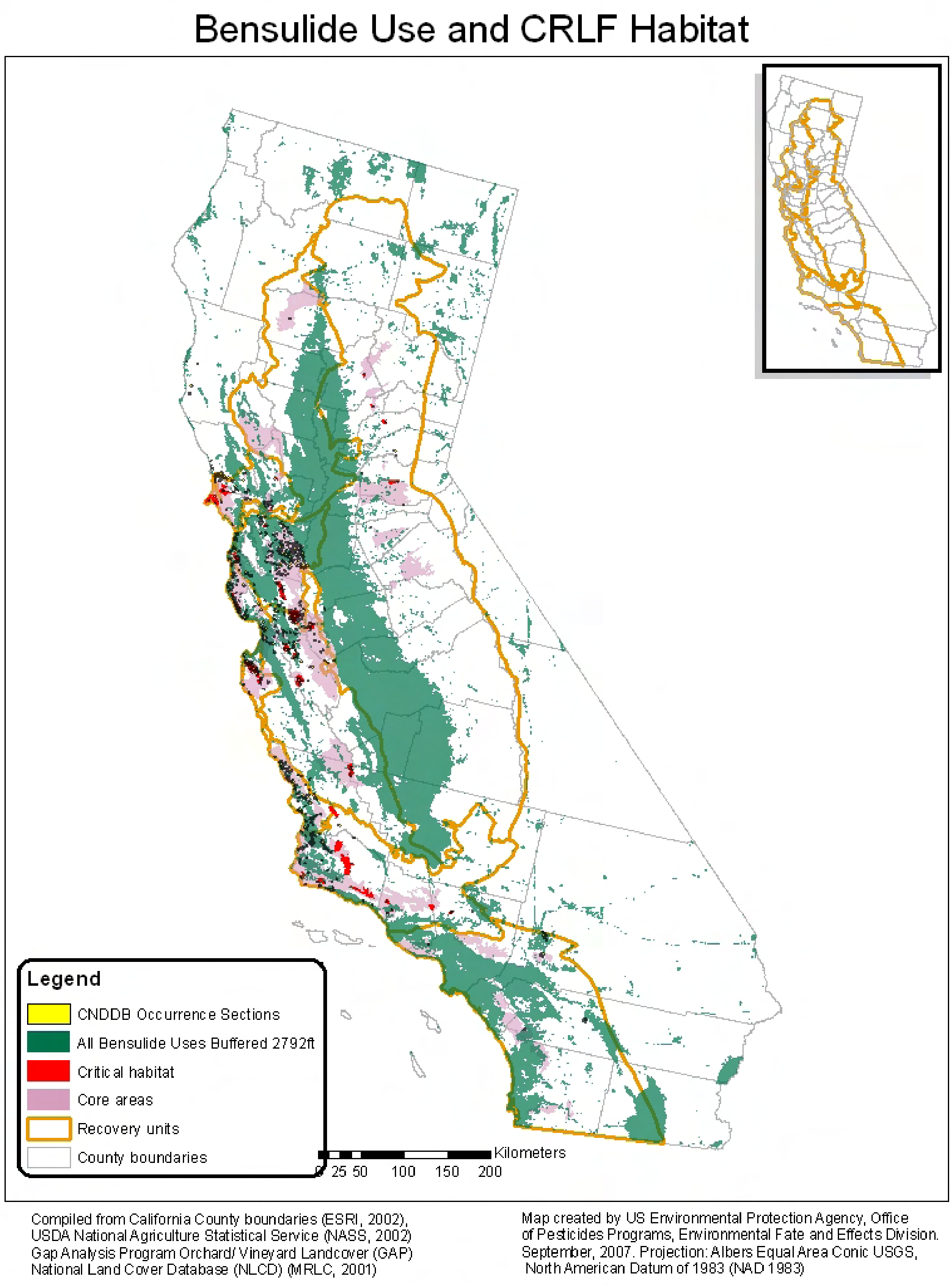
Once the initial area of concern is defined, the next step is to compare the extent of that area with the results of the screening level risk assessment. The screening-level risk assessment will define which taxa, if any, are predicted to be exposed at concentrations above the Agency's Levels of Concern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

Review of the environmental fate data as well as physical-chemical properties of Bensulide indicate that spray drift and runoff is likely to be the dominant exposure pathway to plants and animals off the treated site and residues on soil invertebrates is likely to be the dominant exposure pathway to animals on the treated site. Because this product is applied to bare ground, residues on foliage onsite is an incomplete pathway as no plants are present. Insects exposed to bensulide in treated areas may be a significant exposure pathway.

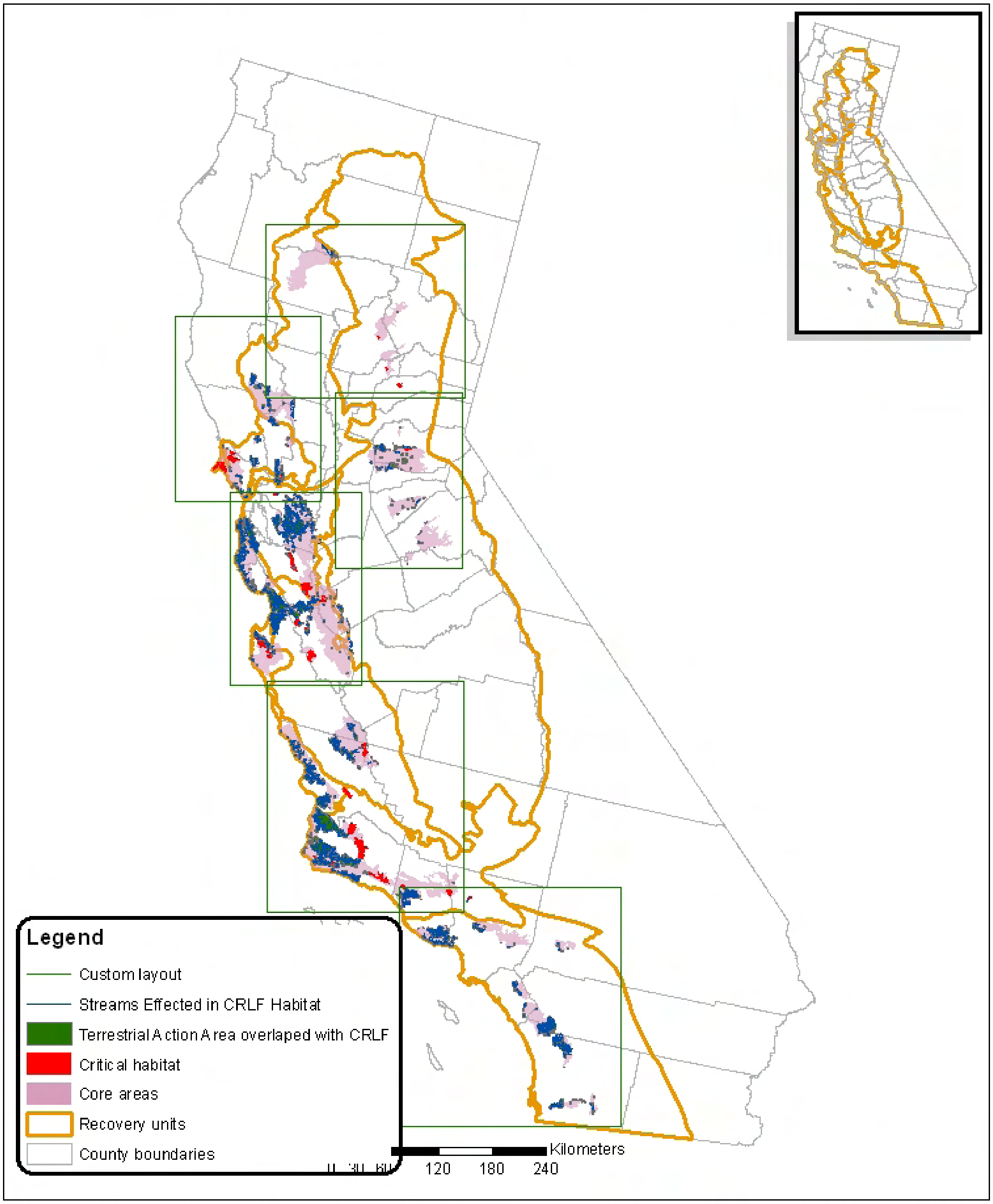
LOC exceedances are then used to describe how far outside the initial area of concern effects may be seen. For example, Ag-Drift v. 2.1 modeling can be used to define how far from the initial area of concern an effect to non-target terrestrial plants may be expected. Other processes considered in expanding the initial area of concern can include downstream distance where concentrations are expected to be above the LOC, long-range transport, and secondary exposure through biological vectors. The process of expanding the initial area of concern is repeated for all taxa where exceedances of the LOC occur, and the greatest expansion of the initial area of concern is considered the action area.

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. This information is incorporated into GIS and a map of the action area is created Figure 7.

Figure 7. Bensulide Action Area Maps



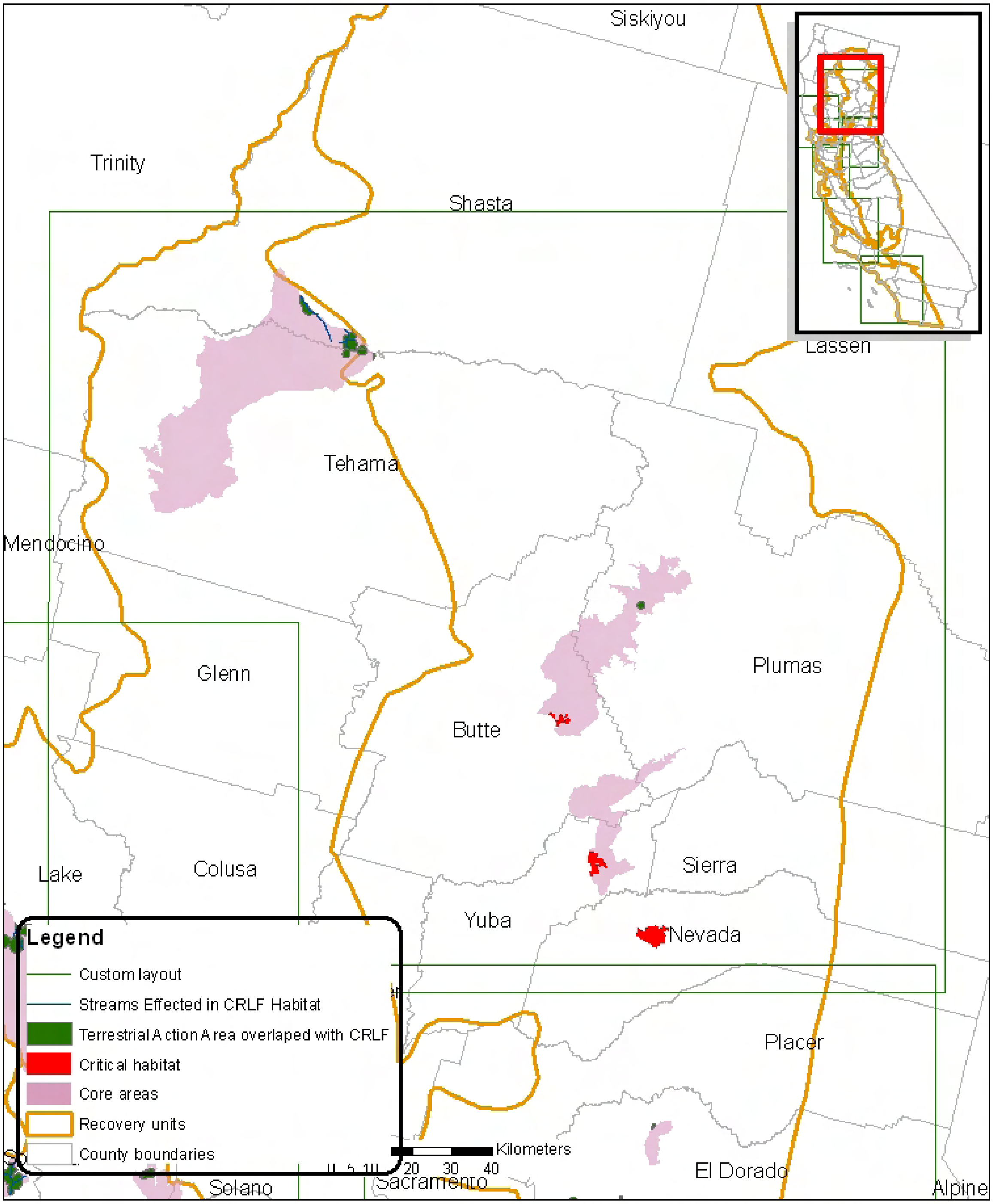
Action Area and CRLF Habitat Overlap



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

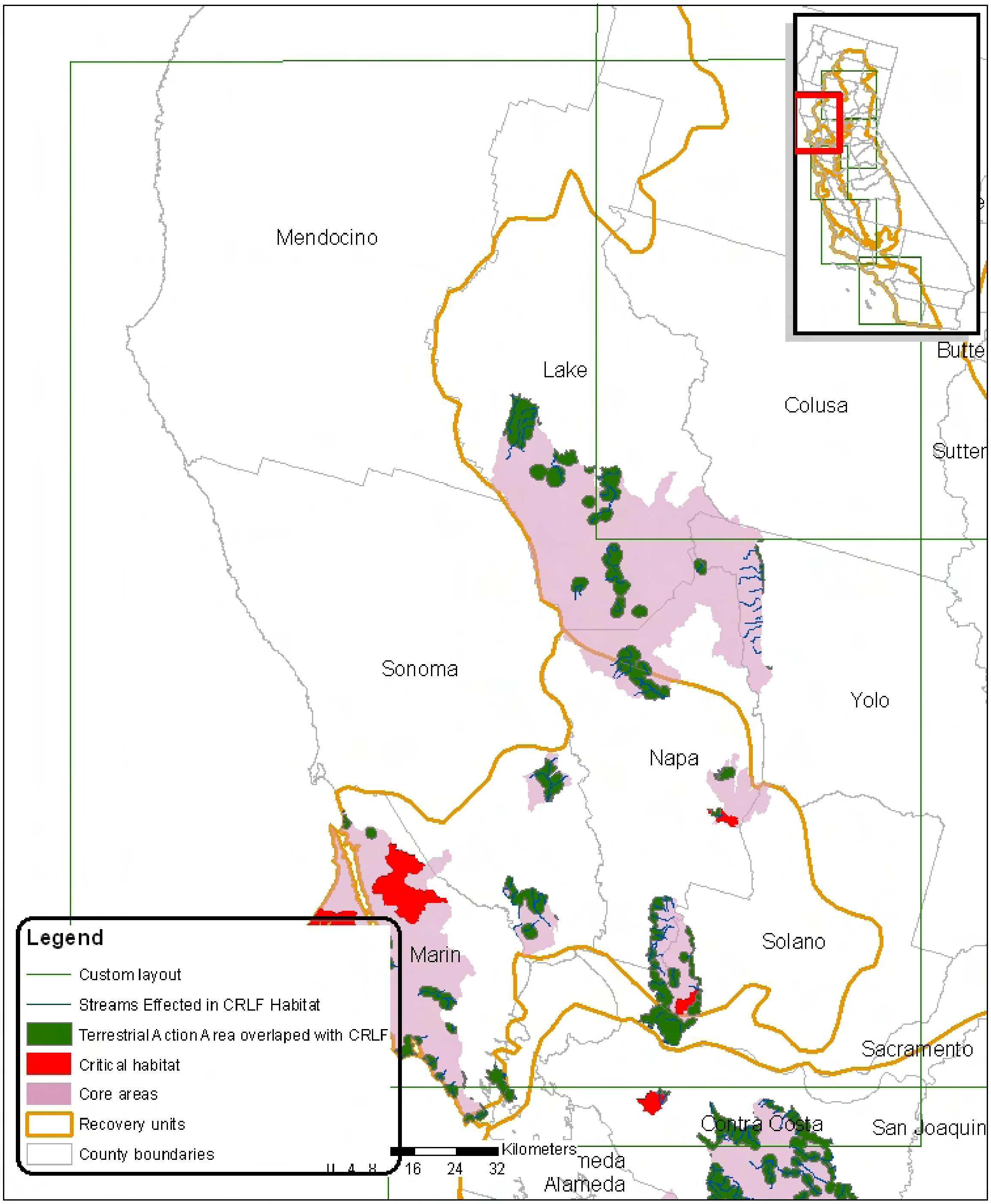
Action Area and CRLF Habitat Overlap - RU1



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

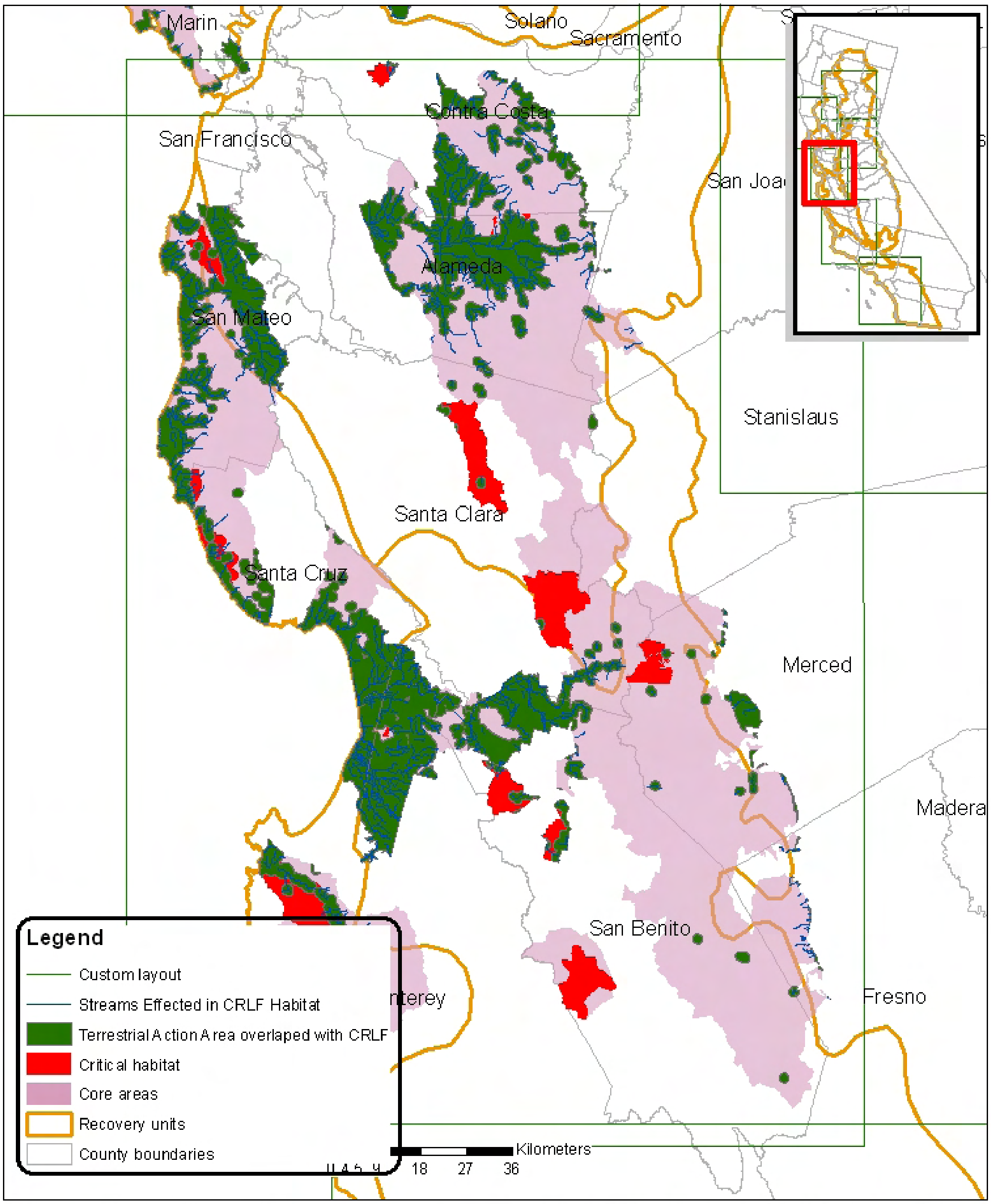
Action Area and CRLF Habitat Overlap - RU2



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

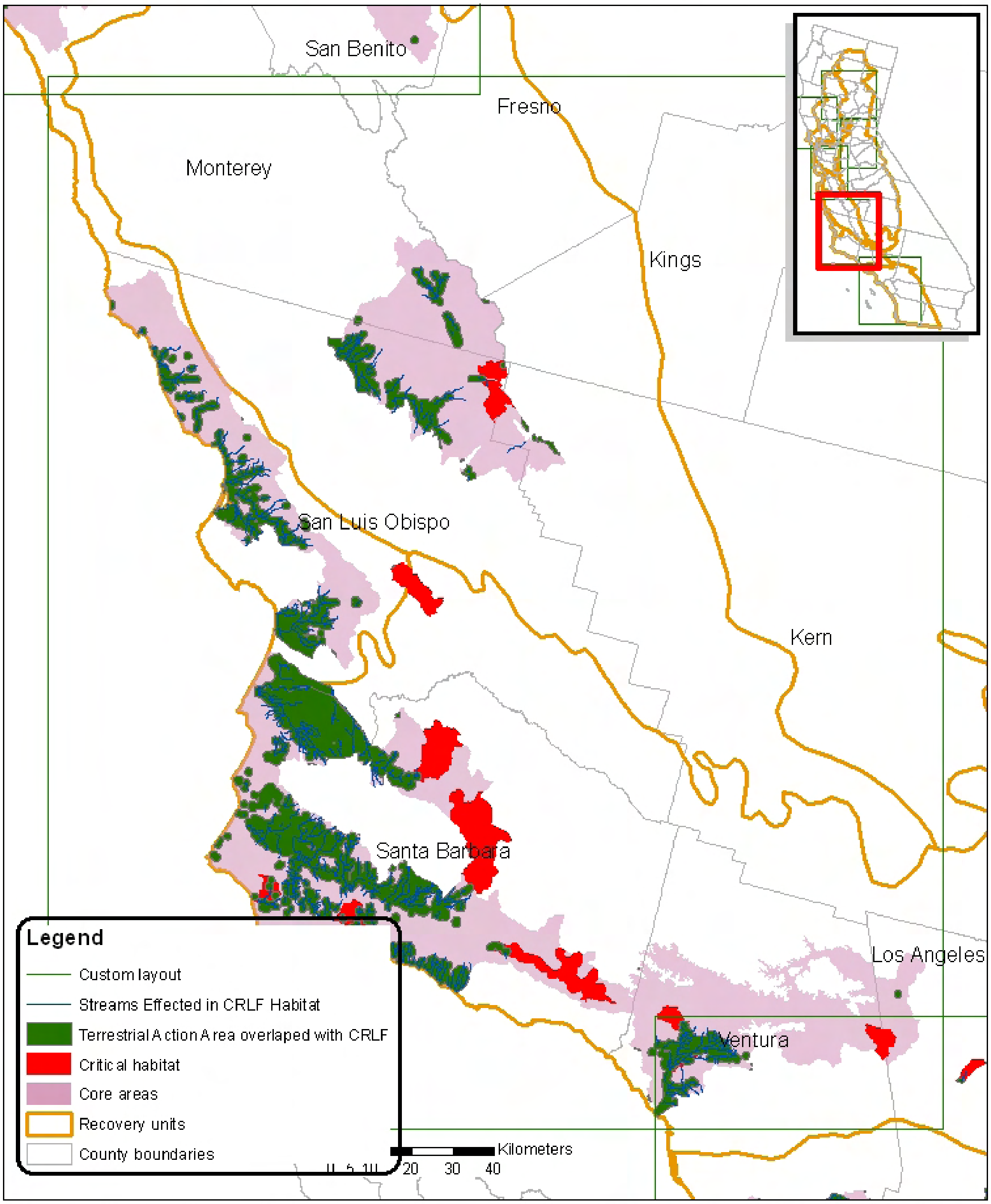
Action Area and CRLF Habitat Overlap - RU3



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

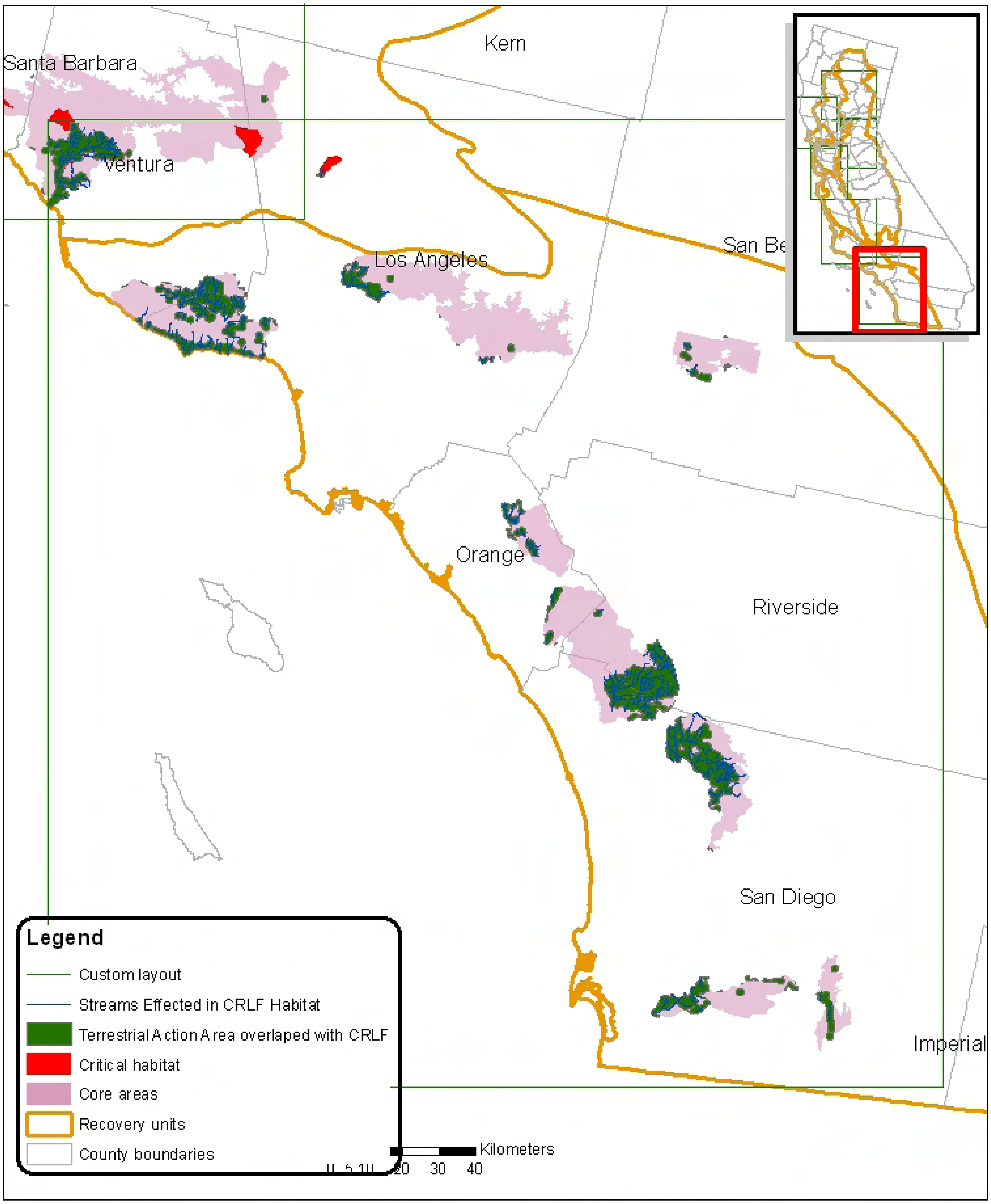
Action Area and CRLF Habitat Overlap - RU4



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

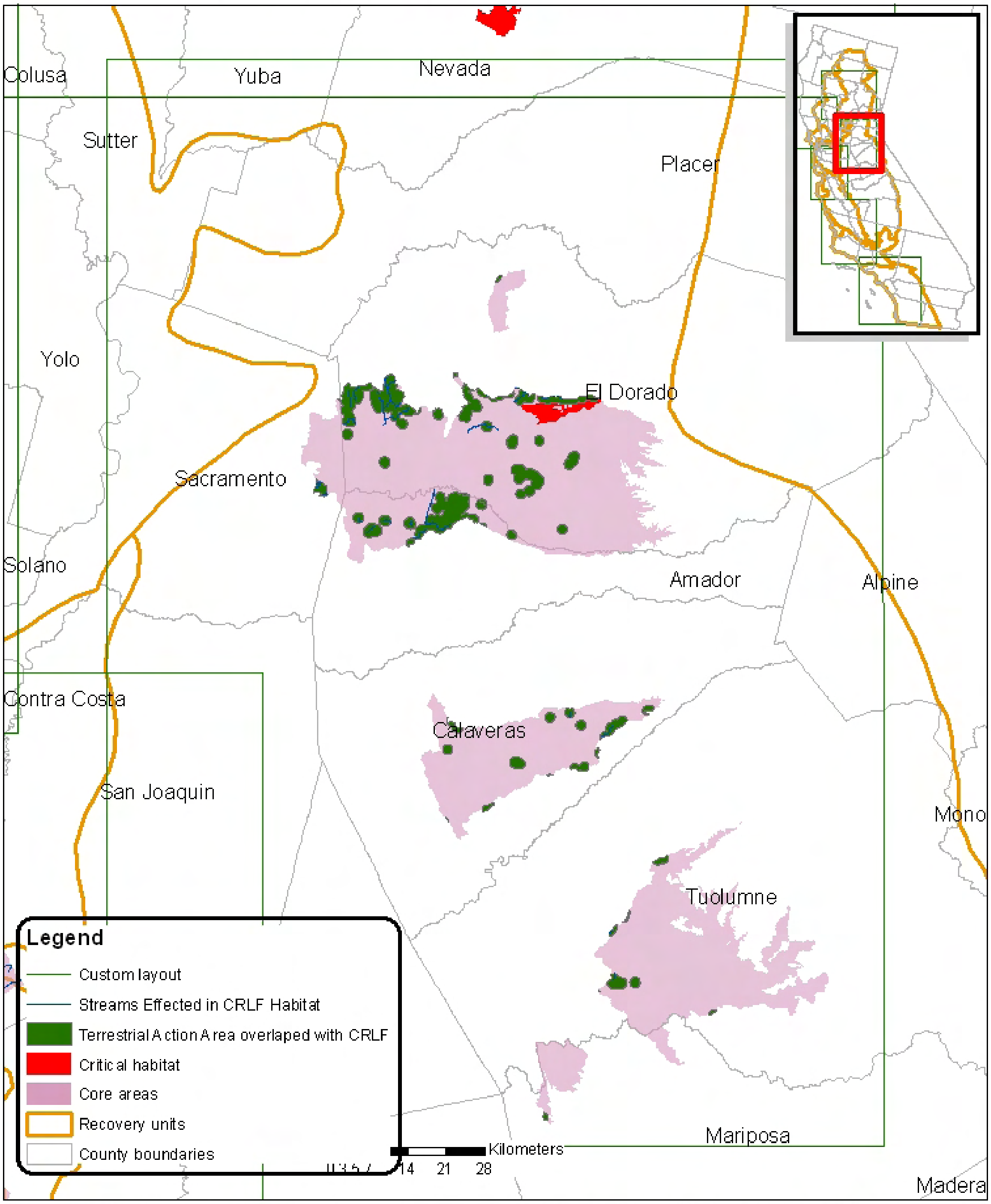
Action Area and CRLF Habitat Overlap - RU5



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Action Area and CRLF Habitat Overlap - RU6



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. September, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Subsequent to defining the action area, an evaluation of usage information was conducted to determine area where use of Bensulide 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 and is represented in Table 4. More information may be found in Appendix H.

Table 4. California Average Bensulide Use per County 2002-2005*.

County	AVG Annual Pounds Applied	County	AVG Annual Pounds Applied
IMPERIAL	110576.50		
MONTEREY	42955.34	ORANGE	105.49
SAN BENITO	20316.03	SOLANO	101.95
RIVERSIDE	16291.57	EL DORADO	65.32
SAN BERNARDINO	7600.48	SAN DIEGO	63.88
VENTURA	7548.35	PLACER	63.29
STANISLAUS	5304.86	TUOLUMNE	49.22
SANTA BARBARA	3823.24	TULARE	42.47
FRESNO	3045.66	YOLO	35.51
SANTA CLARA	2740.15	CALAVERAS	35.51
SAN LUIS OBISPO	1128.65	TEHAMA	31.21
SACRAMENTO	1071.46	GLENN	19.29
KERN	746.42	COLUSA	15.08
LOS ANGELES	480.86	SAN FRANCISCO	11.02
SANTA CRUZ	455.01	SISKIYOU	10.02
ALAMEDA	225.99	SAN MATEO	7.39
MERCED	213.43	NEVADA	4.96
SAN JOAQUIN	199.38	MENDOCINO	3.13
BUTTE	183.48	SUTTER	2.38
SHASTA	152.57	NAPA	1.36
MADERA	134.28	HUMBOLDT	1.12
CONTRA COSTA	108.98	PLUMAS	0.70

*There are no data listed in the PUR data base for Alpine, Amador, Del Norte, Inyo, Kings, Lake, Lassen, Marin, Mariposa, Modoc, Mono, Sierra, Sonoma, Trinity and Yuba Counties.

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."[3] 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 Bensulide (*e.g.*, runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to bensulide-related contamination (*e.g.*, direct contact, etc).

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

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 bensulide is provided in Table 5.

Table 5. Summary of Assessment Endpoints and measures of Ecological Effects for direct and Indirect Effects of Bensulide on the CRLF

Assessment Endpoint	Measures of Ecological Effects[4]	Toxicity Endpoint (see effects table for endpoint selection, Section 4)
Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)[a]		
1. Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	1a. Most sensitive amphibian acute LC_{50} or if no suitable amphibian data are available, fish acute LC_{50} (source: guideline or ECOTOX data)	1a. Rainbow trout (*Oncorrhynchus mykiss*) acute 96-hr LC_{50} = 0.72 ppm a.i.
	1b. Most sensitive amphibian chronic NOAEC or if no suitable amphibian data are available, fish chronic NOAEC (source: guideline or ECOTOX)	1b. Fathead minnow (*Pimephales promelas*) early life-stage NOAEC = 0.374 ppm a.i.
	1c. Most sensitive amphibian early-life NOAEC or if no suitable amphibian data are available, fish early-life stage NOAEC (source: guideline or ECOTOX)	1c. Same as 1b.
2. Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	2a. Most sensitive *(1)* fish LC_{50}; *(2)* aquatic invertebrate LC_{50} or EC_{50}; and (3) aquatic plant EC_{50} (source: guideline or ECOTOX))	2a1. Rainbow trout (*Oncorrhynchus mykiss*) acute 96-hr LC_{50} = 0.72 ppm a.i. 2a2. Water flea (*Daphnia magna*) Acute 48-hr EC_{50} = 0.58 ppm ai.

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

Assessment Endpoint	Measures of Ecological Effects[4]	Toxicity Endpoint (see effects table for endpoint selection, Section 4)
		2a.3. Green Alga, (*Pseudokirchneriella subcapitata*) EC_{50} = 1.5 ppm a.i.
	2b. Most sensitive *(1)* aquatic invertebrate chronic NOAEC; and *(2)* fish chronic NOAEC (source: guideline or ECOTOX)	2b1. No Data Available 2b2. Fathead minnow (*Pimephales promelas*) early life-stage NOAEC = 0.374 ppm a.i.
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Most sensitive vascular plant EC_{50} (source: duckweed guideline test or ECOTOX vascular plant)	3a. No aquatic plant vascular data available
	3b. Most sensitive non-vascular plant EC_{50} (source: guideline test or ECOTOX reference no. is 2478)	3b. Green Alga, (*Pseudokirchneriella subcapitata*) 72 hr EC_{50} value of 1.5 ppm
4. 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.	4a. Distribution of monocot *(1)* seedling emergence EC_{25} values and (2) vegetative vigor EC_{25} values (source: guidelines and ECOTOX)	4a1. Monocot Seedling emergence EC_{25} range from 2.1 lb a.i./A to > 6.0 lb a.i./A 4a2. All monocots tested vegetative EC_{25} > 6.0 lb a.i./A
	4b. Distribution of dicot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)[5]	4b1. All dicots tested EC_{25} > 6 lb a.i./A 4b2. Dicot Vegetative vigor EC_{25} range from 1.3 lb a.i./A > 6 lb a.i./A
Terrestrial Phase (Juveniles and adults)		
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Most sensitive terrestrial-phase amphibian acute LC_{50} or LD_{50} or if no suitable amphibian data are available, bird[b] acute LC_{50} or LD_{50} (source: guideline or ECOTOX)	5a. Northern Bobwhite quail *(Colinus virginianus)* Avian (single dose) acute oral LD_{50} = 1386 mg/kg-bw
	5b. Most sensitive terrestrial-phase amphibian chronic NOAEL or if no suitable amphibian data are available, bird[b] chronic NOAEC (source: guideline or ECOTOX)	5b. Mallard duck (*Anas platyrhynchos)* Reproductive study NOAEL = 2.5 ppm a.i.
6. Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	6a. Most sensitive *(1)* terrestrial invertebrate LD_{50} or ED_{50}; and *(2)* terrestrial vertebrate acute LD_{50} or LC_{50} (source: guideline or ECOTOX)[c]	6a1. Honey bee (*Apis* sp.) Acute contact LD_{50} = 1.6 ug a.i./bee 6a2. Rat (*Rattus norvegicus*) acute oral (single dose) LD_{50} value = 270 mg/kg-bw
	6b. Most sensitive *(1)* terrestrial invertebrate chronic NOAEL; and *(2)* terrestrial vertebrate chronic NOAEC (source: guideline or ECOTOX)	6b1. No Data Available 6b2. Rat (*Rattus norvegicus*) F2 pup survival: NOAEL = 150 ppm a.i
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	7a. Distribution of monocot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)	7a1. Monocot Seedling emergence EC_{25} range from 2.1 lb a.i./A to > 6 lb a.i./A 7a2. All monocots tested vegetative EC_{25} > 6.0 lb a.i./A

[5] The available information indicates that the California red-legged frog does not have any obligate relationships.

Assessment Endpoint	Measures of Ecological Effects[4]	Toxicity Endpoint (see effects table for endpoint selection, Section 4)
	7b. Distribution of dicot *(1)* seedling emergence EC_{25} values, and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)[5]	7b1. All dicots tested EC_{25} > 6 lb a.i./A 7b2. Dicot seedling emergence EC_{25} ranges from 1.3 lb a.i./A to > 6 lb a.i./A

[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.
[c] Although the most sensitive toxicity value is initially used to evaluate potential indirect effects, sensitivity distribution is used (if sufficient data are available) to evaluate the potential impact to food items of the CRLF.

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 Bensulide 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 destroy or adversely modify critical habitat are those that alter the PCEs. 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 Bensulide effects data are available.

Assessment endpoints and measures of ecological effect selected to characterize potential modification to designated critical habitat associated with exposure to Bensulide are provided in Table 6. Adverse modification to the critical habitat of the CRLF includes the following, as specified by USFWS (2006) and previously discussed in Section 2.6:

1. Alteration of water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLF's.
2. Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLF's.
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.

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 6. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary constituent Elements of Designated Critical Habitat

Assessment Endpoint	Measures of Ecological Effect[6]	Toxicity Endpoint (see effects table for endpoint selection, Section 4)
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 CRLF's.	a. Most sensitive aquatic plant EC_{50} (source: guideline or ECOTOX) b. Distribution of terrestrial monocot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX) c. Distribution of terrestrial dicot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)	a. Green Alga, (*Pseudokirchneriella subcapitata*) EC_{50} = 1.5 ppm a.i. b1. Monocot Seedling emergence EC_{25} ranges from 2.1 lb a.i./A to > 6 lb a.i./A b2. All monocots tested vegetative EC_{25} > 6.0 lb a.i./A c1. All dicots tested EC_{25} > 6 lb a.i./A c2. Dicot seedling emergence EC_{25} ranges from 1.3 lb a.i./A to > 6 lb a.i./A
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLF's and their food source.[7]	a. Most sensitive EC_{50} value for aquatic plants (source; guideline or ECOTOX) b. Distribution of terrestrial monocot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX) c. Distribution of terrestrial dicot *(1)* seedling emergence EC_{25} values; and *(2)* vegetative vigor EC_{25} values (source: guidelines or ECOTOX)	a. Green Alga, (*Selenastrum capriconutum*) EC_{50} = 1.8 ppm a.i. b1. Monocot Seedling emergence EC_{25} values range from 2.1 lb a.i./A > 6 lb a.i./A b2. All monocots tested Vegetative EC_{25} > 6.0 lb a.i./A c1. All dicots tested EC_{25} > 6 lb a.i./A c2. Dicot vegetative vigor EC_{25} values ranges from 1.3 lb a.i./A to > 6 lb a.i.A
Alteration of other chemical characteristics necessary for normal growth and viability of CRLF's and their food source.	a. Most sensitive *(1)* LC_{50} values for fish or aquatic-phase amphibians; and *(2)* LC_{50} or EC_{50} values for aquatic invertebrates (source: guidelines or ECOTOX) b. Most sensitive NOAEC values for *(1)* fish or aquatic-phase amphibians; and *(2)* aquatic invertebrates (source: guideline or ECOTOX)	a1. Rainbow trout acute 96-hr LC_{50} (*Oncorrhynchus mykiss*)LC_{50} 0.72 ppm a.i. a2. Water flea (*Daphnia magna*) Acute 48-hr EC_{50} = 0.58 ppm ai. b1. Fathead minnow early life-stage (*Pimephales promelas*) NOAEC = 0.374 ppm a.i. b2. No Data Available
Reduction and/or modification of aquatic-based food sources for pre-metamorphosis (*e.g.*, algae)	a. Most sensitive aquatic plant EC_{50} (source: guideline or ECOTOX)	a. Green Alga, (*Pseudokirchneriella subcapitata*) EC_{50} = 1.5 ppm a.i.

[6] All toxicity data reviewed for this assessment are included in Appendix A.
[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.

Terrestrial Phase PCEs *(Upland Habitat and Dispersal Habitat)*		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLF’s: 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 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 CRLF’s and their food source.	a. Distribution of terrestrial monocot (1) seedling emergence EC_{25} values; and (2) vegetative vigor EC_{25} values (source: guidelines or ECOTOX) b. Distribution of terrestrial dicot *(1)* seedling emergence EC_{25} values; and vegetative vigor EC_{25} values (source: guidelines or ECOTOX) c. Most sensitive terrestrial food source*(1)* acute LC_{50} or LD_{50} and chronic NOAEL values for mammals; *(2)* acute LC_{50} or LD_{50} and chronic NOAEL for terrestrial-phase amphibians or birds; *(3)* acute LC_{50} or LD_{50} and chronic NOAEL for terrestrial invertebrates; *(4)* acute LC_{50} and chronic NOAEC for freshwater fish; and *(5)* acute LC_{50} or EC_{50} and chronic NOAEC for aquatic invertebrates	a1. Monocot seedling emergence EC_{25} values ranges from 2.1 lb a.i./A to > 6 lb a.i./A a2. All dicots tested vegetative vigor study EC_{25} > 6 lbs a.i./acre b1. All dicots tested seedling emergence EC25 > 6 lbs a.i./acre b2. Dicot vegetative EC_{25} values ranges from 1.3 lb a.i./A to > 6 lb a.i./A c1. Rat (*Rattus norvegicus*) acute oral (single dose) LD_{50} value = 270 mg/kg c2. Northern Bobwhite quail *(Colinus virginianus)* Avian (single dose) acute oral LD_{50} = 1386 mg/kg Mallard duck (*Anas platyrhynchos)* Reproductive study NOAEL = 2.5 ppm a.i. c3. Honey bee (*Apis sp.*) Acute contact LD_{50} = 1.6 ug a.i./bee No terrestrial invertebrate chronic toxicity data Available c4. . Rainbow trout acute 96-hr LC_{50} (*Oncorrhynchus mykiss*) LC50 0.72 ppm a.i. Fathead minnow early life-stage (*Pimephales promelas*) NOAEC = 0.374 ppm a.i. c5. Water flea (*Daphnia magna*) Acute 48-hr EC_{50} = 0.58 ppm ai. No aquatic invertebrate chronic toxicity data available

2.9 Conceptual Model

2.9.1 Risk Hypotheses

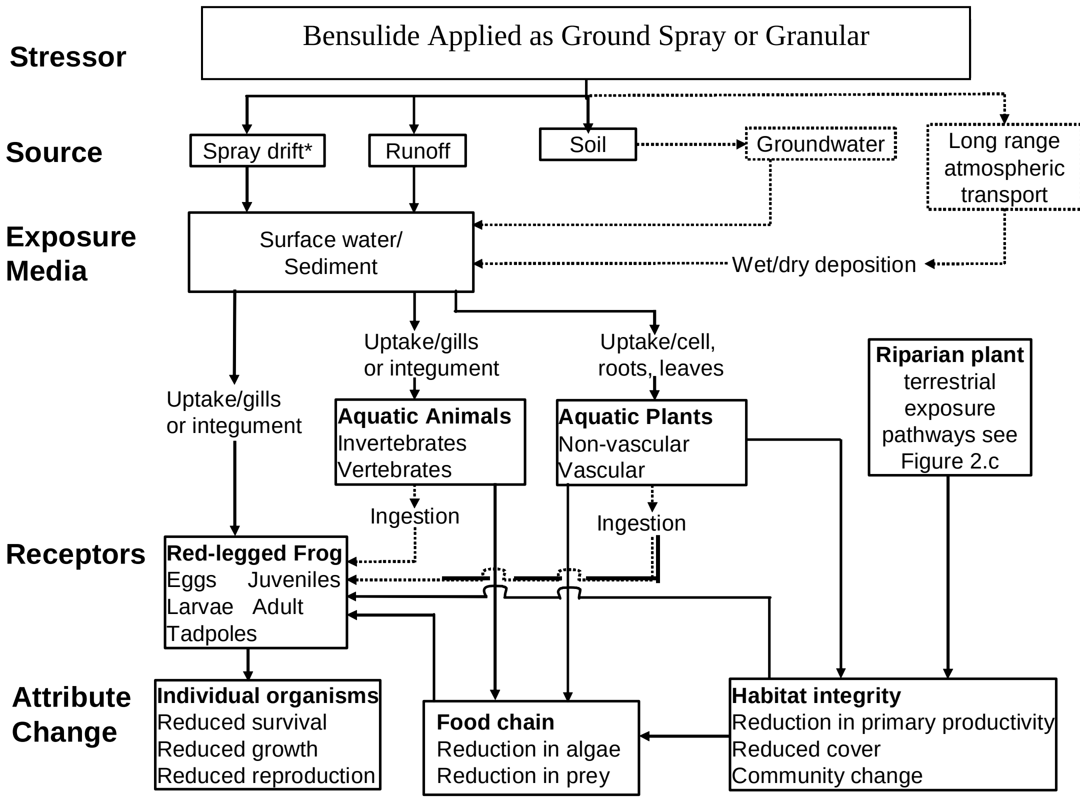
Risk hypotheses are specific assumptions about potential adverse effects (*i.e.*, changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (U.S. EPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is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

- Labeled uses of Bensulide within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- Labeled uses of Bensulide within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;
- or modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;
- 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 Bensulide 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);
- or by reducing the food supply required for normal growth and viability of juvenile and adult CRLF's;
- or by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- or 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.
- or by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLF's.

2.9.2 Diagram

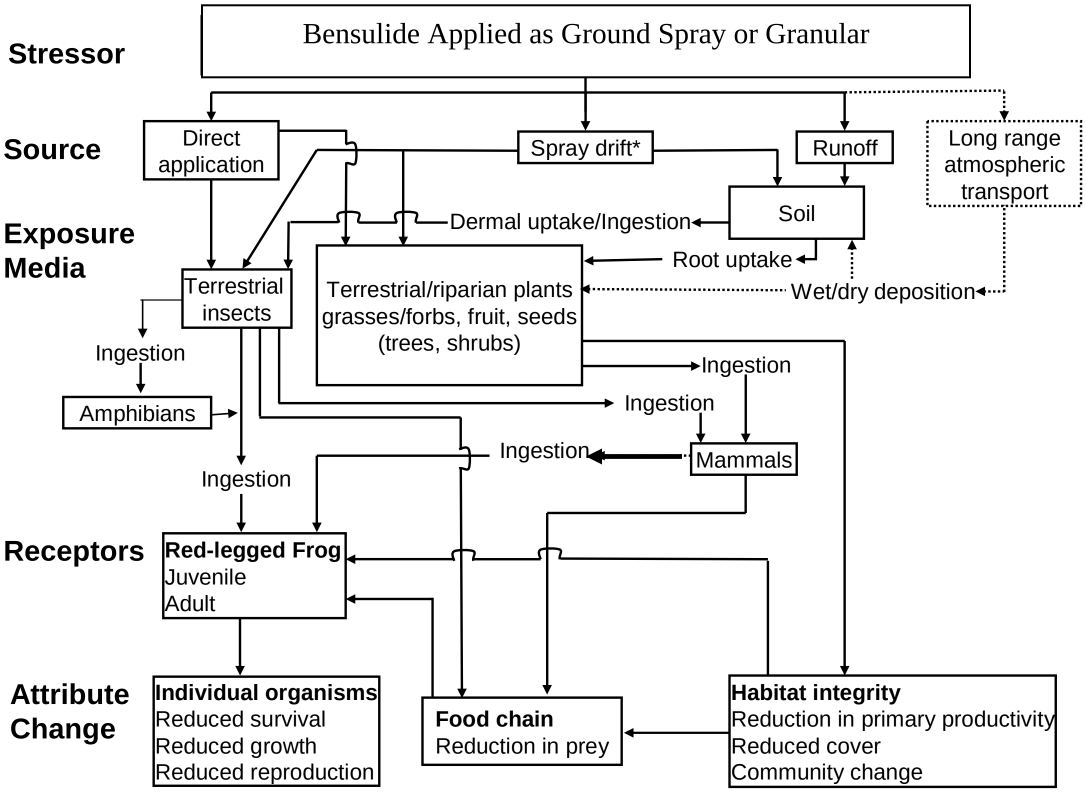
The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor (bensulide), release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial phases of the CRLF are shown in Figure 8, Figure 9, Figure 10 and Figure 11.

Figure 8. Conceptual Model for Pesticide Effects on Aquatic Phase of the CRLF



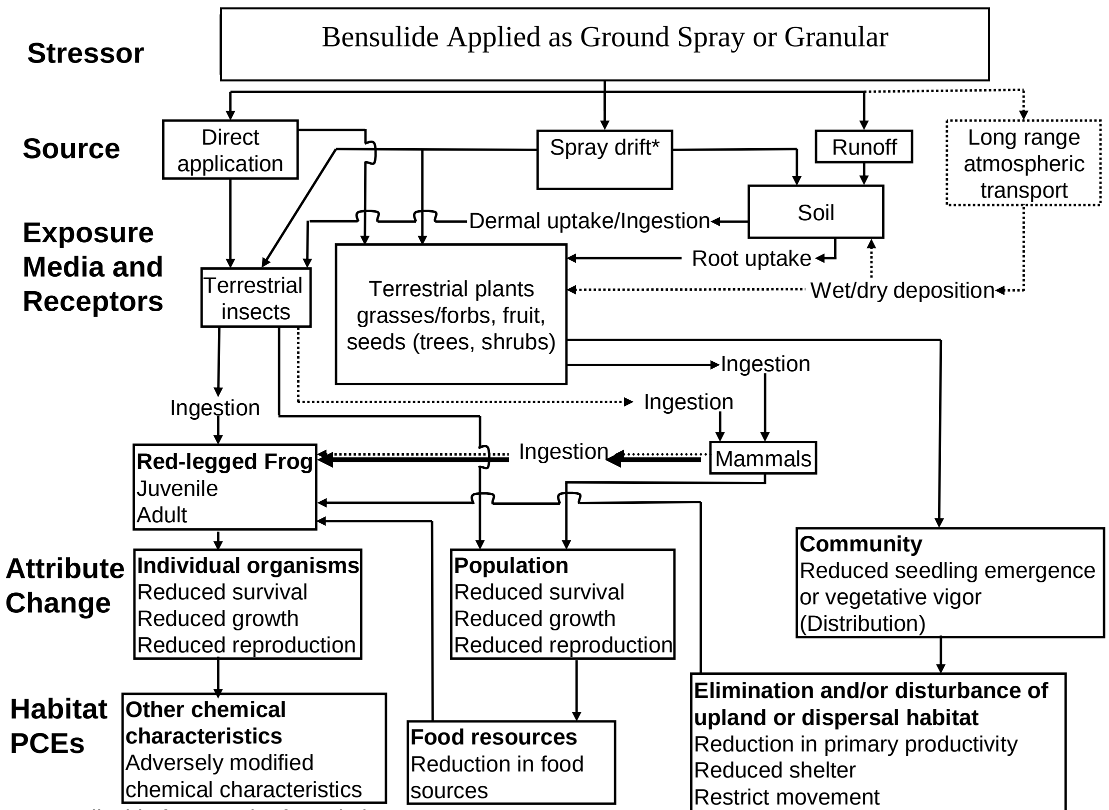
*: Not applicable for granular formulation

Figure 9. Conceptual Model for Pesticide Effects on Terrestrial Phase of the CRLF



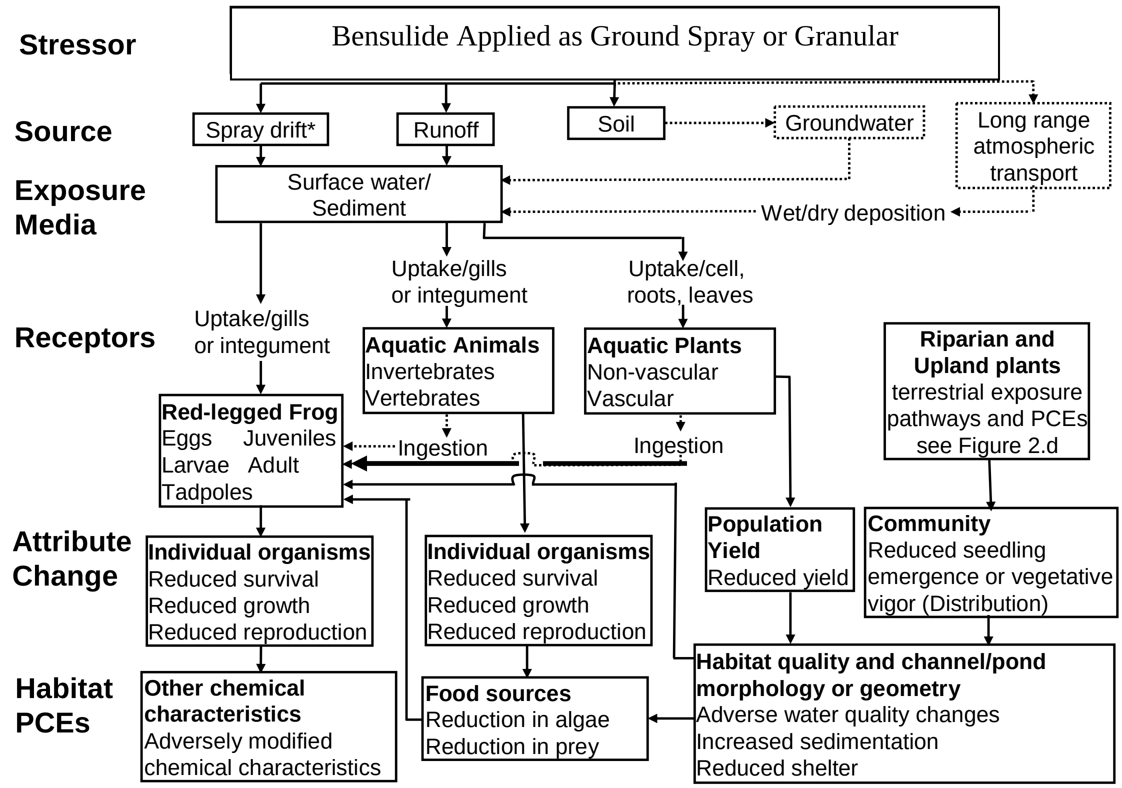
*: Not applicable for granular formulation

Figure 10. Conceptual Model for Pesticide Effects on Terrestrial Components of the CRLF Critical Habitat



*: Not applicable for granular formulation

Figure 11. Conceptual Model for Pesticide Effects on Aquatic Components of CRLF Critical Habitat



*: Not applicable for granular formulation

2.10 Analysis Plan

Analysis of risks to the California Red-Legged Frog (both direct and indirect) and to its critical habitat will be assessed according to the Overview Document (EPA, 2004) and Agency guidance for ecological risk assessments.

2.10.1 Exposure Analysis

Risks (direct effects) to the aquatic phase CRLF will be assessed by comparing modeled surface water exposure concentrations of bensulide and its degradates to acute and chronic (early life stage hatching success and growth) effect concentrations for aquatic phase amphibians (or surrogate freshwater fish) from laboratory studies (see the Effects Analysis section below). Risks (direct effects) to aquatic dietary food resources (aquatic invertebrates, algae) of the aquatic phase CRLF or risks (direct effects) to aquatic habitat that support the CRLF will also be assessed by comparing modeled surface water exposure concentrations of total bensulide residues to laboratory established effect levels appropriate for the taxa.

Surface water concentrations of bensulide residues will be quantified using a model, PRZM-EXAMS. For the screening assessment, the standard EXAMS water body of 2 meters maximum depth, and 20,000 cubic meters volume, will be used. Agricultural scenarios appropriate for labeled bensulide uses will be used to account for local soils, weather and growing practices which impact the magnitude and frequency of bensulide loading to the surface water. Maximum labeled application rates, with maximum number of applications and shortest intervals, will be used to help define (1) the Action Area within California for the Federal Action and (2) for evaluating effects to the CRLF.

Risks to the terrestrial phase CRLF will be assessed by comparing modeled exposure to effect concentrations from laboratory studies. Exposure in the terrestrial phase will be quantified using the T-REX V. 1.3.1 model, which automates the calculation of dietary exposure according to the Hoerger-Kenaga nomogram, as modified by Fletcher *et al*., 1994. The nomogram tabulates the 90th and 50th percentile exposure expected on various classes of food items, and scales the exposure (in dietary terms) to the size and daily food intake of several size classes of birds and mammals. Birds are also used as surrogates to represent reptiles and terrestrial-phase amphibians.

2.10.2 Effects Analysis

Bensulide Toxicity (Including Major Toxic Degradates):

As previously discussed in Section 2.8.1 and 2.8.2, assessment endpoints for the CRLF include direct toxic effects on survival, reproduction, and growth of the species itself, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. Direct effects to the CRLF are based on toxicity information for freshwater fish and birds, which are generally used as a surrogate for aquatic and terrestrial phase amphibians, respectively. The open literature will be screened also for available amphibian toxicity data. Indirect effects to the CRLF are assessed by looking at available toxicity information of the frog's prey and habitat requirements (freshwater invertebrates, freshwater vertebrates, aquatic plants, terrestrial invertebrates, terrestrial vertebrates, and terrestrial plants).

Acute (short-term) and chronic (long-term) toxicity information for bensulide and its degradates is characterized based on registrant-submitted studies and an updated review of the open literature. A summary of the available freshwater and terrestrial ecotoxicity information, the community-level endpoints, species' sensitivity distributions and the incident information for bensulide are provided in Sections 4.1 through 4.4.

Toxicity studies for bensulide degradates (where available) will be discussed for exposure to the aquatic phase of the CRLF and incorporated into this risk assessment.

Product Formulations Containing Multiple Active Ingredients:

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

2.10.3 Action Area Analysis

The Action Area for the federal action is the geographic extent of exceedance of Listed species Levels of Concern (LOC) for any taxon or effect (plant or animal, acute or chronic, direct or indirect) resulting from the maximum label-allowed use of bensulide. To define the extent of the Action Area, the following exposure assessment tools will be used where appropriate: PRZM-EXAMS, T-REX V. 1.3.1, Ag-Drift v. 2.1, T-Herps v. 1.0, TerrPlant v. 1.2.2 and ArcGIS (a geographic information system [GIS] program). Other tools may be used as required if these are inadequate to define the maximum extent of the Action Area.

In order to determine the extent of the action area downstream from the initial area of concern, the Agency will need to complete the screening level risk assessment. Once all aquatic risk quotients (RQs) are calculated, the Agency determines which RQ to level of concern (LOC) ratio is greatest for all aquatic organisms (plant and animal).

3.0 Exposure Assessment

3.1 Label Application Rates and Intervals

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for bensulide represents the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs.

Currently, labeled uses of bensulide include turf, ornamentals, and vegetable crops. There are 17 active Section 3 labels of products containing bensulide. The EPA registration numbers for these labels are 538-26, 538-155, 538-164, 869-212, 2217-696, 2217-778, 2217-838, 9798-172, 9798-176, 10163-196, 10163-198, 10163-199, 10163-200, 10163-201, 10163-204, 10163-205.

A comprehensive list of these uses, along with the methods and rates associated with applications of bensulide are available in Appendix B. Crops are grouped based on similar forms and application practices.

3.2 Aquatic Exposure Assessment

3.2.1 Conceptual Model of Exposure

Aquatic exposure of the CRLF is estimated with the PRZM-EXAMS model (EPA, 2004). Estimated environmental concentrations (EEC) are produced using the standard screening-level 20,000 cubic meters surface water body. Watersheds where bensulide is used are assumed to have 100% cropped area. The downstream extent of streams with exposures above the Level of Concern (LOC) is estimated (using GIS methods) by expanding the watershed considered until uncontaminated stream flow dilutes the initial pond concentration to below the LOC.

Standard assumptions of 1% spray drift for ground application are used. If the pond concentration from PRZM-EXAMS exceeds the LOC, a spray drift buffer is calculated (using Ag-Drift v. 2.1 model) that will reduce the pond concentration to below the LOC. If a spray drift buffer cannot be used to reduce the pond concentration to below the LOC, then a separate spray drift buffer (neglecting run-off) is calculated with Ag-Drift v. 2.1 to ensure that pond concentrations are below the LOC (see Section 2.10.3 above).

3.2.2 Existing Monitoring Data

The California Department of Pesticide Regulation Surface Water Database and the USGS National Water Quality Assessment program (NAWQA) database were searched for bensulide. No monitoring data for either ground or surface water were available; therefore, modeling alone was used to estimate the aquatic exposure for bensulide. Above, it was stated that data are available

3.2.3 Modeling Approach

Use sites and the PRZM scenarios used to represent them are given in Table 7.

Risk quotients (RQs) were initially based on EECs derived using the Pesticide Root Zone Model/Exposure Analysis Modeling System (PRZM/EXAMS) standard ecological pond scenario according to the methodology specified in the Overview Document (U.S. EPA, 2004). Where LOCs for direct/indirect effects and/or adverse habitat modification are exceeded based on the modeled EEC using the static water body (*i.e.*, "may affect"), refined modeling may be used to differentiate "may affect, but not likely to adversely affect" from "may affect and likely to adversely affect" determinations for the CRLF and its designated critical habitat.

The general conceptual model of exposure for this assessment is that the highest exposures are expected to occur in the headwater streams adjacent to agricultural fields. Many of the streams and rivers within the action area defined for this assessment are in close proximity to agricultural use sites.

California PRZM scenarios were chosen for this assessment, include: lettuce, row crop (representing beans, celery, and peppers), melon, cotton, turf (representing Bermuda grass for seed and landscape maintenance), almond (representing nut trees), fruit (representing various fruit trees)garlic, onion, and cole crops (broccoli, cauliflower).

Structural pest control was not modeled due to lack of an appropriate PRZM scenario, and the low likelihood of exposure. All scenarios were used within the standard framework of PRZM/EXAMS modeling using the standard graphical user interface (GUI) shell, PE4v01.pl.

3.2.3.1 Model Inputs

The estimated water concentrations from surface water sources were calculated using Tier 2 PRZM (Pesticide Root Zone Model) and EXAMS (Exposure Analysis Modeling System). PRZM is used to simulate pesticide transport as a result of runoff and erosion from a standardized watershed, and EXAMS estimates environmental fate and transport of pesticides in surface waters. The linkage program shell (PE4v01.pl) that incorporates the site-specific scenarios was used to run these models.

The PRZM/EXAMS model was used to calculate concentrations using the standard ecological water body scenario in EXAMS. Weather and agricultural practices were simulated over 30 years so that the 1 in 10 year exceedance probability at the site was estimated for the standard ecological water body.

Models to estimate the effect of setbacks on load reduction for runoff are not currently available. It is well documented that vegetated setbacks can result in a substantial reduction in pesticide load to surface water (USDA, NRCS, 2000). Therefore, the aquatic EECs presented in this assessment are likely to over-estimate exposure in areas with well-vegetated setbacks. While the extent of load reduction cannot be accurately predicted through each relevant stream reach in the action area, data from USDA (USDA, 2000) suggest reductions could range from 11 to 100%.

The date of first application was set at March 1 in all PRZM/EXAMS model runs, because most uses, for which there are use reporting data (PUR), in California show applications of bensulide occur in most months of the year, and March corresponds to both a rainy part of the year (thereby capturing higher run-off values), and the reproductive season of the frog.

PRZM input parameters were selected from the environmental fate data submitted by the registrant and in accordance with US EPA-OPP EFED water model parameter selection guidelines, Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version 2.3, February 28, 2002.

This product may only be applied by chemigation in Arizona and California. Bensulide is applied through sprinkler, including center pivot, lateral move, end tow, side (wheel) roll, traveler, big gun, solid set or hand move; or drip (trickle), including surface and subsurface drip irrigation systems. Bensulide should not be through any other type of irrigation system.

Table 7 Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Bensulide CRLF Assessment

Input variable (Units)	Input value and calculations	Source/Quality of data
Crop name	See table 8	EPA Reg. No. 10163-222
Application method	See table 8	EPA Reg. No. 10163-222
application rate (lb ai/acre)	See table 8	EPA Reg. No. 10163-222
Interval between appl. (d)	See table 8	EPA Reg. No. 10163-222
Application efficiency	0.99	Input parameters guideline (2/28/2002)
Spray drift fraction	0.01	Input parameters guideline (2/28/2002)
Aerobic soil met. $t_{1/2}$(day)	363	MRID# 40460302
Hydrolysis $t_{1/2}$(day)	220	MRID# 00160074
Aerobic aquatic met. $t_{1/2}$(day)	693	No data; soil aerobic met. rate multiplied by 0.5; Input parameters guideline
Solubility @ 25 ^{0}C (mg/L)	56	MRID# 41532001
Vapor pressure (torr)	8.2×10^{-7}	MRID# 41532001
K_{oc} $^{(mL/g)}$	2943	MRID# 43180701 (avg of 4 values.); Input parameters guideline
Henry's Law Const. (atm.m^3/mole)	7.7×10^{-8}	MRID# 41532001
Aquatic photolysis $t_{1/2}$ (day)	200	MRID# 40513401
MWT (g/mole)	397.5	RED (1998)

3.2.3.2 PRZM/EXAMS results

Table 8 PRZM/EXAMS results

(Crop/Use)	PRZM Scenario	Formulation	Application Rate (lb/acre)	Number of Applications @ interval (day)	Peak EEC (ppb)	21-day avg EEC (ppb)	0-day avg ppb)
golf course turf	CA turf RLF	Granular	32	2 (120)	87.54	73.7	6.9
		EC	13.5	2 (120)	51.9	49.2	7.8
Ornamental [1]	CA nursery	EC	9	1	168	138	15
		Granular	6	1	231	191	60
Residential lawns	CA residential RLF	Granular	32	2 (120)	192	185	81
		EC	13.5	2 (120)	52.1	50.1	9.1
Broccoli[2]	CA cole crop RLF	EC	9	1	112	100.0	8.1
Broccoli raab, broccoli, Chinese,	CA cole crop RLF	EC	6	1	71.0	64.0	2.1
Lettuce[3]	CA lettuce no-irrg.	EC	9	1	135	113.3	9.0
chard (Swiss)[4]	CA lettuce no-irrg.	EC	6	1	89.7	75.3	5.8
Celery, pepper, cardoon, dock (sorrel)	CA row crop RLD	EC	9	2 (120)	85.84	79.4	7.8
Celtuce[5]	CA row crop RLF	EC	6	2 (120)	58.3	53.7	4.8
Melon[6]	CA melon RLF	EC	9	2 (120)	88.8	71.8	3.0
Eggplant[7]	CA melon RLF	EC	6	2 (120)	59.2	47.9	2.0
Garlic	CA garlic RLF	EC	6	1	41.9	33.0	7.4
Tomatillo	CA tomato no-irrg.	EC	9	2 (120)	84.0	71.7	6.2
okra (Chinese)		EC	6	2 (120)	126	108	9.3
Onion[8]	CA onion no-irrg.	EC	6	4 (120)	67.8	54.5	6.5
Radish/daikon Chinese	CA onion no-irrg.	EC	9	3 (120)	83.9	62.8	2.8

a. Ornamental, herbaceous plants, Ornamental and/or shade trees, Ornamental ground cover, Ornamental woody shrubs and vines
b. Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables.
c. Lettuce (head, leaf), Brussels sprout, endive, parsley, spinach
d. chard (Swiss) , chicory, corn salad, dandelion, fennel, roquette (arugula)
e. Celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili)
f. Melon , cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash)
g. Eggplant , gourd cherry (strawberry tomato/tomatillo), pepino (melon pear).
h. Onion , orach (mountain spinach), shallot

3.2.3.3 Residential Uses

It is likely that some overspray may reach impervious surfaces in the residential setting. In order to account for overspray, the impervious surface was modeled using three separate assumptions. For the purposes of risk assessment, it is assumed that 1% of the application rate could reach the impervious surfaces surrounding each residential lot, it is also assumed that 50% of the ¼ acre lot is treated with bensulide. In addition to the footprint of the typical house, it is also assumed that a typical house has a driveway of approximately 25 by 30 feet or 750 square feet and roughly 250 square feet of sidewalk.

The first assumption may result in an underestimation of exposure, given that more overspray of impervious surfaces is possible. In order to account for the variability in overspray, the residential scenario was modeled assuming two alternate scenarios of 0% and 10% overspray to impervious surfaces. The alternate assumptions are intended to provide a bound on the 1% assumption. Because both the residential and rights-of-way scenarios were modeled using the paired pervious/impervious approach, the alternate scenarios were modeled for both scenarios (residential was modeled for both granular and liquid formulations). The conservativeness of these assumptions is unknown, given a lack of data on this phenomenon. However, given that the impervious scenario is intended to represent nontarget surfaces such as roads, parking lots and buildings, it is seems reasonable to assume that 10% overspray is an over-estimation of what would likely occur to these off-site areas, while 0% may be an under-estimation.

In order to model the overspray, the binding coefficient was set to zero and the aerobic soil metabolism half-life was set to stable in lieu of actual data for the impervious scenario. It is assumed that non-binding would occur on these surfaces and that limited degradation would occur. The percentage overspray was then multiplied by the total application rate to yield an effective application rate for the overspray to impervious surfaces. Without actual data on these processes, it is impossible to determine whether these exposures reflect reality, especially given that no monitoring data is available

This impact of a decrease in impervious surface will hold only with the assumption of limited overspray. This assumption was explored by comparing the impact of the change in percentage of impervious surface on the 10% overspray scenario discussed above. In this case, peak EECs increase by roughly 50% while the averages are only slightly increased.

Finally, in this assessment it is assumed that 50% of the ¼ acre lot is treated. In order to test the significance of this assumption, the exposure scenario was re-run using a different assumption of 10% treatment of the ¼ acre lot. As expected, peak EECs are reduced by roughly a factor of five, while the longer term exposures are reduced by a factor of two to three times.

Note that this scenario represents general impervious surfaces within a watershed not part of the ¼ acre lot and includes roads, parking lots, and buildings among others where overspray from residential lots is expected to be minimal. The ¼ acre lot, by comparison, was developed with a curve number reflective of the fact that the lot is covered with both pervious surfaces (grass and landscaped gardens) and impervious surfaces (driveways, sidewalks, and buildings). In this case, the assumption that 50% of the lot is treated likely overestimates the amount of landscaped area treated, but underestimates unintentional overspray of driveways and sidewalks. The impact of this assumption is also evaluated in Section 3.2.7. Overall, these are simplifying assumptions that are likely to provide a reasonable high-end estimate of exposure, given the limitations of modeling approach. The combined edge of field concentrations are estimated using the *.zts output from PRZM as described above. In this paired scenario approach, the *.zts output from both the impervious and residential scenarios are weighted and added together to provide an overall estimate of exposure.

Two categories of formulations are currently registered for bensulide use on residential sites, including granular and liquid formulations. Both formulations were modeled separately because application rates are different and the standard assumption for modeling granular formulations is different from liquid formulations. Granular formulations are typically modeled as soil applied (CAM is set to 8 with a minimized incorporation depth of 1 cm and 0% spray drift), which assumes the standard spray drift of 1% for ground applications. However, because spray drift is not assumed to contribute to the loadings in the spring and some overspray is expected to impervious surfaces, both residential scenarios (liquid and granular) were modeled assuming that 1% of the application rate is applied to the impervious surface.

3.2.3.4 Comparison of Modeled EECs with Available Monitoring Data

There is no available monitoring data from California to allow a meaningful comparison with modeled EECs

3.3 Terrestrial Plant Exposure Assessment

TerrPlant v. 1.2.2 (v.1.2.2) was used to estimate loading to off-site soils, which includes both a terrestrial plant upland (dry) habitat model and a semi-aquatic area habitat model, to evaluate effects on seedling emergence. For liquid formulations, loading is determined based on both run-off and spray drift inputs. For granular formulations, only loading to soils due to run-off is estimated. Additionally TerrPlant v. 1.2.2 models loading to foliage (on lb a.i./A basis) due to spray drift to evaluate effects on vegetative vigor. For exposure estimates TerrPlant v. 1.2.2 input parameters include: (1) application rate; (2) runoff, based on chemical solubility; and (3) soil incorporation depth. A detailed explanation of the model as well as the modeling inputs and outputs for estimating terrestrial and semi-aquatic plant exposure risks to bensulide are summarized in Appendix C.

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4.0 Effects Assessment

This assessment evaluates the potential for bensulide to adversely affect the California Red-Legged Frog (CRLF). As previously discussed in Section 2.8, selected assessment endpoints for the CRLF include assessment of direct toxic effects on the survival, reproduction, and growth of the frog itself, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat (Table 4). Taxa selected as measurement endpoints include freshwater fish as a prey item and also as a surrogate for aquatic phase of CRLF (since no amphibian toxicity data are available); freshwater aquatic invertebrates (prey item); birds as surrogates for terrestrial phase of CRLF and other amphibians (prey item) (since no terrestrial amphibian toxicity data are available); small mammals (prey item); terrestrial invertebrates (prey item); aquatic plants, and terrestrial plants (essential component CRLF habitat). Toxicity data for freshwater fish and birds are used as surrogate data for aquatic-phase and terrestrial-phase amphibians (U.S. EPA, 2004).

Information on the toxicity of bensulide to selected taxa is characterized based on registrant-submitted studies and a comprehensive review of the open literature on bensulide (obtained from the ECOTOX database). Values used for each measurement endpoint identified in Table 9 are selected from this data. A summary of the available ecotoxicity information; the selected individual, population, and community-level endpoints for characterizing risks; and interpretation of the LOC, in terms of the probability of an individual effect based on probit dose response relationship are provided in Sections 4.1 through 4.3, respectively.

4.1 Evaluation of Aquatic Ecotoxicity Studies

Toxicity measurement endpoints are selected from data 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 a search of the ECOTOX database (5/31/2007). Table 9 summarizes the most sensitive results for each measurement endpoint, based on an evaluation of both the submitted studies and the open literature, as previously discussed. Table 10 summarizes the agency’s LOCs. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment is presented below.

Table 9 Bensulide Measurement Endpoints and Values Selected for Use in RQ Calculations for the Effects Determination

Assessment Endpoint	Measures of Effect	Species	Toxicity Value	Study classification (Selection basis)	Reference
Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	Most sensitive amphibian acute LC_{50} or if no suitable amphibian data are available, fish acute LC_{50} (source: guideline or ECOTOX data)	Rainbow trout (*Oncorhynchus mykiss*)	0.72 ppm a.i.	Supplemental (Most sensitive)	40098001 (Mayer and Ellersiek, 1986)
	1b. Most sensitive amphibian chronic NOAEC or if no suitable amphibian data are available, fish chronic NOAEC (source: guideline or ECOTOX)	Fathead minnow (*Pimephales promelas*)	NOAEC = 0.374 ppm a.i.	Acceptable (Only fish early life-stage study available)	MRID 447204-08 Kranzfelder, 1998
Survival, growth, and reproduction of CRLF individuals via effects to freshwater invertebrates prey.	Freshwater invertebrate acute 96-h LC_{50} (for cladocerans 48-h LC_{50} or EC_{50} where the effect measured is surrogate)	Water flea (*Daphnia magna*)	Acute 48-hr EC_{50} = 0.58 ppm a.i.	Supplemental [1] (Most sensitive)	MRID 47116601 (McCann, 1978)
	Freshwater invertebrate reproductive NOAEC	No Data Available	No Data Available	No Data Available	No Data available
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	Freshwater green algae, cyanobacteria or diatom 96-h IC_{50} for biomass.	Green Alga, (*Pseudokirchneriella subcapitata*)	72 hr EC_{50} = 1.5 ppm a.i.	Pending Review (Most sensitive)	ECOTOX Open Literature Reference: no. 2478
	Freshwater green algae, cyanobacteria or diatom 96-h NOAEC (or EC_{05}) for biomass	Green Alga, (*Selenastrum capriconutum*)	120 hr EC_{05} = 0.93 ppm a.i.	Acceptable (Most sensitive)	MRID 447204-02 (Kranfelder, 1998)
Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Avian (single dose) acute oral LD_{50}	Northern Bobwhite quail *(Colinus virginianus)*	LD_{50} = 1386 mg/kg-bw	Acceptable (Only avian acute oral study available)	MRID 158455 (Grimes, 1986)
	Avian subacute 5-day dietary LC_{50}	Northern bobwhite quail *(Colinus virginianus)* and Mallard duck (*Anas platyrhynchos*)	LC_{50} > 5620 ppm a.i.	Acceptable (Only studies available and most sensitive endpoints)	MRID 158456 (Grimes, 1986)

Assessment Endpoint	Measures of Effect	Species	Toxicity Value	Study classification (Selection basis)	Reference
Survival, growth, and reproduction of CRLF individuals via effects on terrestrial vertebrate prey	Avian reproduction NOAEL	Mallard duck	Reproductive study NOAEL = 2.5 ppm a.i.	Acceptable (Most sensitive)	MRID 44486901 (Mansell, 1998)
	Mammalian acute oral (single dose) LD_{50}	Rat (*Rattus norvegicus*)	LD_{50} value = 270 mg/kg-bw	Acceptable (Most sensitive endpoint)	MRID 92005011 (Velez, 1990)
	Mammalian reproductive NOAEC or NOAEL	Rat	F2 pup survival: NOAEL = 150 ppm a.i.;	Acceptable (Most sensitive)	MRID 00146585
Survival, growth, and reproduction of CRLF individuals via effects on terrestrial invertebrate prey	Honey bee acute contact LD_{50}	Honey bee	Acute contact LD_{50} = 1.6 ug a.i./bee	Acceptable (Most sensitive)	MRID 00036935 (Atkins *et al*, 1975)
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.	6a. Seedling emergence EC_{25}	Ryegrass	EC_{25} : 1.9 lb a.i./A	Acceptable (Most sensitive endpoint of multiple species tested)	MRID No. 447463-01 (Schwab, 1998)
	6b. Seedling emergence NOAEC	Ryegrass	NOAEC: 0.38 lb a.i./A	Acceptable (Most sensitive endpoint of multiple species tested)	MRID No. 447463-01 (Schwab, 1998)
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	6c. Vegetative vigor EC_{25}	Cucumber	EC_{25}: 1.3 lb a.i./A	Acceptable (Most sensitive endpoint of multiple species tested)	MRID 447463-01 (Schwab, 1998)
	6d. Vegetative vigor NOAEC	Cucumber	NOAEL: 0.38 lb. a.i./A		

Note 1: The dissolved oxygen at the four highest test concentrations were unacceptably low (27.2%-48.9%)

Table 10 Specific LOCs Used in this Assessment

Taxa	Listed Acute LOC	Nonlisted Acute LOC	Listed and Nonlisted Chronic LOC
Avian[1] (terrestrial phase amphibians)	0.1	0.2	1
Mammalian[2]	0.1	0.2	1
Terrestrial plants[3]	1	1	-----
Aquatic animals [4]	0.05	0.1	1
Aquatic plants [5]	1	1	-----
Terrestrial insects [6]	0.05*	------	-------

*The Agency has not established LOCs for terrestrial insects. This assessment will use the ratio of 0.05 as a cut-off value for making effects determinations.

Toxicity values used in RQ calculations:

[1] LD_{50} and estimated NOAEL, respectively.

[2] LD_{50} and NOAEL, respectively.

[3] EC_{50} for non-listed species and NOAEC for listed species.

[4] LC/EC_{50} and estimated and reproductive NOAEC, respectively (the acute designation is not applicable for plants).

[5] EC_{05}/EEC or NOAEC/EEC for the listed LOC and EC_{25}/EEC for non-listed LOC.

[6] LD_{50}

4.1.1 Toxicity to Freshwater Fish and Aquatic-Phase Amphibians

4.1.1.1 Freshwater Fish and Aquatic-Phase Amphibians: Acute Exposure (Mortality) Studies

There are three registrant submitted freshwater fish acute toxicity studies (MRID 157315, MRID 400980-01, and MRID 400980-01). There are no acceptable fish acute or amphibian toxicity studies available in the open literature. The 96-h LC_{50} values for freshwater fish among the available registrant submitted studies range from 0.72 ppm a.i. to 1.1 ppm a.i. Based on this data, bensulide is categorized as moderately to highly toxic to freshwater fish. The most sensitive endpoint value among all the studies was a 96-h LC_{50} of 0.72 ppm a.i. for rainbow trout, *Oncorhynchus mykiss*, (MRID 400980-01). This endpoint is selected as the measurement endpoint for characterizing: 1) the acute direct effects of bensulide to the aquatic phase of the CRLF and 2) acute effects of bensulide to the aquatic phase CLRF prey including other frogs and fish.

4.1.1.2 Freshwater Fish and Aquatic-Phase Amphibians: Chronic Exposure (Early Life Stage and Reproduction) Studies

Similar to the acute data, chronic freshwater fish toxicity studies are used to assess potential direct effects to the CRLF because direct chronic toxicity bensulide data for frogs do not exist. There is one acceptable fish chronic toxicity study available to access the potential risk to the CRLF (Table 4.1; Acc. No. 447204). This study is an "Early Life-Stage Toxicity Test of the Fathead, *Pimephales promelas*, Under Flow-through Conditions". The results of the study demonstrate a NOEAC of 0.374 ppm a.i. based on larval growth and survival. The NOAEC produced in this study is used as the measurement endpoint for characterizing: 1) the chronic direct effects of bensulide to the aquatic phase of the CRLF and 2) chronic effects of bensulide to the aquatic phase CLRF prey including other frogs and fish.

4.1.1.3 Freshwater Fish and Aquatic-Phase Amphibians: Sublethal Effects and Additional Open Literature Information

There are no reported sublethal effects in any of the registrant submitted fish acute toxicity studies. There are no acceptable fish or aquatic-phase amphibian acute toxicity studies testing bensulide available in the open literature. The registrant submitted chronic toxicity study reported a significant decrease in larval growth at a NOAEC of 0.374 a.i ppm as a sublethal effect to the fish. No other sublethal effects were noted at concentrations at or below this NOAEC.

4.1.2 Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data are used to assess potential effects of bensulide to freshwater invertebrate prey of the CRLF. Effects to freshwater invertebrates resulting from exposure to bensulide may affect the CRLF via reduction in available food. Aquatic-phase is presumed to be algae grazers but there is some uncertainty in that assumption. Therefore, aquatic invertebrates are also assumed to be a food source for CRLF aquatic-phase.

A summary of acute and chronic freshwater invertebrate data is provided below in Sections 4.1.2.1 through 4.1.2.2.

4.1.2.1 Freshwater Invertebrates: Acute Exposure (Mortality) Studies

There are two supplemental registrant submitted freshwater invertebrate acute toxicity studies. One study tested the acute toxicity of bensulide on the water flea, *Daphnia magna*, (Acc. No.159322) and the other study tested the acute toxicity of bensulide on the amphipod, *Gammarus fasciatus* (MRID 400980-01). The study testing *Daphnia magna* demonstrated the most sensitive EC_{50} value of the two studies.

The toxicity endpoint values were a 48-hr. LC_{50} of 0.58 and 3.3 ppm a.i. for the water flea and the amphipod, respectively. These studies indicate that bensulide is moderately to highly toxic to freshwater invertebrates. There are no acceptable freshwater invertebrate acute toxicity studies testing bensulide available in the public literature.

The 48 hr LC_{50} value of 0.58 ppm a.i. is used to evaluate whether bensulide will pose an acute risk to CRLF freshwater invertebrate dietary sources. This value is used because it is the most sensitive acute invertebrate toxicity endpoint available. The study was deemed supplemental because the dissolved oxygen at the four highest test concentrations was unacceptably low (27.2%-48.9%).

Further details regarding the available acute freshwater invertebrate toxicity data are provided in Appendix A.

4.1.2.2 Freshwater Invertebrates: Chronic Exposure (Reproduction) Studies

Currently there are no valid registrant submitted freshwater invertebrate chronic toxicity studies available. Additionally according to the ECOTOX database there are no acceptable aquatic invertebrate chronic toxicity data available in the public literature.

4.1.2.3 Freshwater Invertebrates: Sublethal Effects and Open Literature Data

None of the registrant submitted freshwater acute invertebrate studies reported any sublethal effects.

4.1.3 Toxicity to Aquatic Plants

The registrant has submitted two acceptable freshwater plant studies testing the technical grade active ingredient of bensulide. The species tested in these studies include the cyanobacteria (formerly classified as blue-green algae), *Anabaena floss-aquae*, and the freshwater green algae, *Pseudokirchneriella subcapitata (formerly Selenastrum capriconutum)* (MRID 447204-03 and 447204-02 respectively). The endpoint values for the cyanobacteria study are a 120 hr. EC_{50} > 3.58 ppm a.i. and a 120 hr NOEAC of 3.58 ppm. The endpoint values for the green algae study are a 120 hr. EC_{50} of 1.8 ppm a.i. and an EC_{05} of 0.93 ppm a.i.. Appendix A provides further details regarding these studies. The ECOTOX database lists 10 open literature aquatic plant studies testing bensulide toxicity to the green algae species, *Pseudokirchneriella subcapitata*. Only one of endpoints produced by the ECOTOX data demonstrate an EC_{50} value that is more sensitive more than the EC_{50} values produced in the registrant submitted study. This value is a 72 hr EC_{50} value of 1.5 ppm for *Pseudokirchneriella subcapitata*. Appendix A provides further details regarding these studies listed in ECOTOX. The green algae EC_{50} of 1.5 ppm a.i. (ECOTOX Reference no. 2748) and an EC_{05} of 0.93 ppm a.i for green algae study (447204-02) will be used to assess the risk of indirect of effects of bensulide to the aquatic phase of the CRLF. This endpoint is selected because it is the most sensitive endpoint among all the available aquatic plant toxicity data.

4.1.4 Freshwater Field Studies

No freshwater field studies with bensulide are available..

4.2 Evaluation of Terrestrial Ecotoxicity

4.2.1 Toxicity to Terrestrial-Phase Amphibians

No information on bensulide toxicity to terrestrial-phase amphibians was found in the open literature. Therefore, birds will be used as a surrogate species for effects to terrestrial-phase amphibians (U.S. EPA, 2004). Avian toxicity acute and chronic endpoint values for bensulide from open literature are generally less sensitive than the registrant submitted avian studies with bensulide. A summary of acute and chronic avian data, including sublethal effects, is provided below.

4.2.1.1 Birds (Terrestrial-Phase Amphibian Surrogate): Acute Exposure (Mortality) Studies

Avian acute toxicity studies are used to assess potential direct effects to the CRLF because direct acute toxicity data on amphibians are unavailable (See Section 6.2.5 for an explanation of the extrapolation between birds and amphibians). Bensulide acute oral and acute dietary toxicity has been evaluated by two registrant submitted studies. The registrant submitted avian acute oral toxicity study demonstrated a LD_{50} of 1386 mg a.i./kg-bw for bobwhite quail (MRID 158455). This study classifies bensulide as slightly toxic to birds on an acute oral basis. Both registrant submitted avian dietary toxicity studies demonstrated no mortality or overt signs of toxicity at the highest test concentration of 5620 ppm (MRID 158456 and MRID 158457). Since the LC_{50}, is greater than 5000 ppm as demonstrated by avian dietary studies, bensulide is practically nontoxic to birds on a subacute dietary basis. There are no bensulide avian acute toxicity data available in the public literature. The endpoints produced in these studies will be used to assess the acute effects of bensulide to the terrestrial phase of the CRLF.

4.2.1.2 Birds (Terrestrial-Phase Amphibian Surrogate): Chronic Exposure (Reproduction) Studies

There are three registrant submitted avian reproduction studies. The submitted studies test the chronic toxicity of bensulide to the Mallard duck, and the Northern bobwhite quail. The reproduction NOAEL values were produced in two of the studies. They include a NOAEL of 2.5 ppm a.i. for the Mallard duck study (MRID 4486901) and a NOAEL of 250 ppm a.i. for the Northern bobwhite quail study (MRID 43616001). Affected endpoints in the studies include eggshell thickness, hatching success, and survival of chicks. The other study did not determine a NOAEL. Further details of these studies are provided in Appendix A. The NOAEL value of 2.5 ppm will be used to assess the chronic risk of bensulide to the terrestrial phase of the CRLF. This endpoint is used because it is the most sensitive endpoint among all the registrant submitted bird reproduction studies.

4.2.1.3 Avians: Sublethal Effects and Additional Open Literature Information

None of the bird acute or chronic toxicity studies reported any sublethal effects lower than any concentrations lower than those selected as measurement endpoints.

4.2.2 Toxicity to Mammals

Rat or mouse toxicity values are obtained from the Agency's Health Effects Division (HED) as substitute for wild mammal testing. Toxicity data on small mammals are used in this assessment to assess the effect of bensulide exposure on their availability as food items for the CRLF. Additional information regarding the available data can be found in Appendix A.

4.2.2.1 Mammals: Acute Exposure (Mortality) Studies

There is one acute oral rat toxicity available to the Agency (MRID 00097921). The results of this study indicate that bensulide is characterized as moderately toxic to small mammals on an acute oral basis. The most sensitive endpoint value obtained in this study was an LD_{50} of 270 mg/kg-bw (MRID 920050-11). Further details regarding this study are presented in Appendix A.

4.2.2.2 Mammals: Chronic Exposure (Reproduction) Studies

A single rat multigenerational reproductive toxicity study was performed with bensulide. The endpoints for reproductive toxicity were a NOAEL of 150 ppm a.i. (15.4 mg/kg/day) and a LOAEL of 900 ppm a.i. (93.2 mg/kg/day) based on pup survival. Plasma cholinesterase activity was significantly reduced compared to control at dietary concentrations as low as 25 ppm a.i.(2.3 mg/kg/day). Further details regarding this study are presented in Appendix A.

a) Mammals: Sublethal Effects and Additional Open Literature Information

The mammal acute oral toxicity study (MRID 00097921) demonstrated treatment related sublethal effects inclulding: convulsions or ataxia at higher doses (1500, 389, 322, or 320 mg/kg/day), exophthalmus, diarrhea, yellow stains in ano-genital region, red stains about face, and depression. All survivors appeared normal by day 6.

As previously mentioned the rat multigenerational reproductive toxicity study (MRID 43948701) demonstrated sublethal effects which entailed reduced plasma cholinesterase activity compared to control at dietary concentrations as low as 25 ppm a.i. (2.3 mg/kg/day).

4.2.3. Terrestrial Plants: Vegetative Vigor and Seedling Emergence Toxicity

There are two acceptable registrant submitted terrestrial plant toxicity studies. These include a vegetative vigor study (MRID 447463) and seedling emergence study (MRID 447463-01). The most sensitive endpoints produced in the vegetative vigor study was an EC_{25} of 1.3 lbs a.i. /A and a NOEAC of 0.38 lbs a.i./A. Appendix A provides a detailed account of the vegetative vigor toxic effects exhibited to the other less sensitive plant species tested in this study. The most sensitive endpoints produced in the seedling emergence study was an EC_{25} of 1.9 lb a.i./A and a NOEAC of 0.38 lb a.i./A. Appendix A provides a detailed account of the seedling emergence toxic effects exhibited to the other less sensitive plant species tested in this study. In addition to the registrant submitted terrestrial plant toxicity studies, there are several terrestrial plant studies listed in ECOTOX. However, none of these studies produced endpoints that were any more sensitive than the endpoints produced in the registrant submitted studies. Thus, the most sensitive endpoints produced in the registrant submitted studies will be utilized to determine the risk of indirect effects posed to the CRLF.

4.3 Use of Probit Slope Response Relationship to Provide Information on the Listed 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 bensulide 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. The upper and lower bounds of the effects probability are based on available information on the 95% confidence interval of the slope. A statement regarding the confidence in the estimated event probabilities is also included. Studies with good probit fit characteristics (*i.e.*, statistically appropriate for the data set) are associated with a high degree of confidence. Conversely, a low degree of confidence is associated with data from studies that do not statistically support a probit dose response relationship. In addition, confidence in the data set may be reduced by high variance in the slope (*i.e.*, large 95% confidence intervals), despite good probit fit characteristics. In the event that dose response information is not available to estimate a slope, a default slope assumption of 4.5 (lower and upper bounds of 2 to 9) (Urban and Cook, 1986) is used.

Individual effect probabilities are calculated using 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. Results of the probit slope analyses are described in Section 5.2.

4.4 Incident Database Review

According to the Agency's Ecological Incident Information System (EIIS) currently there are no reported ecological incidents for bensulide.

5.0 Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations to determine the ecological risk from bensulide labeled uses (Sections 3 and 24(c) on the CRLF and its critical habitat. The risk characterization provides an estimation of risks (RQ method) relative to established LOCs and the results are then interpreted through a risk description and synthesized into an overall conclusion regarding the effects determination (*i.e.*, "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect") for the CRLF. The risk characterization includes a description of the assumptions, limitations and uncertainties associated with the risk estimates and the impact to the effect determination.

A "may effect" will be concluded when at least one LOC is exceeded. In cases where the RQ exceeds one or more LOCs (*i.e.*, "may affect"), additional factors including the biology and life history characteristics of the assessed species are considered and used to characterize the potential of Bensulide to adversely affect the CRLF and its designated critical habitat.

5.1 Risk Estimation

Risk was estimated by calculating the ratio of estimated environmental concentrations (EECs) and the appropriate toxicity endpoint. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs). Risk quotients used to evaluate potential direct and indirect effects to the CRLF and to designate critical habitat are in Sections 5.1.1. and 5.1.2. RQs are described and interpreted in Section 5.2 (risk description).

5.1.1 Direct Effects

Direct effects to the CRLF associated with acute and chronic exposure to Bensulide residues in surface water (table in 3.2.3.2) are based on the most sensitive toxicity data available for fish (surrogate for aquatic phase amphibians). RQs for assessing these direct effects for all labeled uses of bensulide exceeded the agency's level of concern for acute exposure for all uses. These results are presented in Table 11. Direct effects to CRLF associated with acute and chronic exposure to Bensulide residues on dietary items and the most sensitive toxicity data available for birds (surrogate for terrestrial phase amphibians). Detailed T-REX V. 1.3.1 determination of dietary item RQs for all uses are included in Appendix B.

The dietary item assessment in the T-REX V. 1.3.1 model uses avian intake rates, because amphibian dietary intake rates are lower than avian rates this model will overestimate risks to amphibians. Because acute and chronic RQ values exceeded LOC values, risk estimates for the dietary exposure pathway were refined by using amphibian dietary intake rates using the T-HERPS V. 1.0 model. Acute and chronic RQ values calculated using T-HERPS V. 1.0 exceeded the agency's level of concern for acute exposure for all uses. These results are presented in Table 12.

Table 11. Summary of Acute and Chronic RQs for CRLF Exposed to Bensulide Surface Water Residues*

Scenario	Acute RQ[a]	Chronic RQ[b]
Golf course turf (gran)	**0.12**	0.18
Golf course turf (ec)	**0.07**	0.13
Residential lawns (gran)	**0.12**	0.18
Residential lawns (ec)	**0.27**	0.48
Ornamental	**0.07**	0.13
Ornamental (gran)	**0.32**	0.43
Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables	**0.16**	0.24
Broccoli raab, broccoli, Chinese,	**0.10**	0.14
Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	**0.19**	0.26
Chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula),	**0.12**	0.18
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili)	**0.12**	0.18
Celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili)	**0.08**	0.12
Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash)	**0.12**	0.18
Eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear)	**0.08**	0.12
Garlic	**0.12**	0.17
Tomatillo	**0.08**	0.11
Okra (Chinese)	**0.06**	0.07
Onion, orach (mountain spinach), shallot	**0.12**	0.18
Radish/daikon Chinese	**0.18**	0.27

* Bolded acute RQ values exceed the listed species LOC (0.05) for acute exposure and LOC (1.0) for chronic exposure.
[a] Based on Rainbow trout (*Oncorhynchus mykiss*) 96-h LC_{50} = 720 ppb a.i. (Table 6).
[b] Based on Fathead minnow (*Pimephales promelas)* early life stage NOAEC = 374 ppb a.i. (Table 6).

Table 12. Summary of Acute and Chronic RQs for the CRLF Terrestrial Phase Exposed to Dietary Residues of Bensulide (based on T-REX V. 1.3.1 model)*[†]

Scenario	Acute Dose RQ[a] (Emulsifiable Concentrations) and LD_{50}/ft^2 (Granular Applications)		Chronic Dietary RQ[b]
	20g Bird	100g Bird	
Golf course, residential lawn, turf (gran)	**16.69**	**2.62**	___
Golf course, residential lawn, turf (EC)	**2.27**	**1.02**	**796.71**
Ornamental (gran)	**6.52**	**1.02**	___
Ornamental, broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables, Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	**1.39**	**0.62**	**486**
Broccoli raab, broccoli, Chinese, chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic,	**0.92**	**0.41**	**324**
Celery, pepper, cardoon, dock (sorrel), melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash), tomatillo	**1.51**	**0.68**	**531.14**

Scenario	Acute Dose RQ[a] (Emulsifiable Concentrations) and LD_{50}/ft^2 (Granular Applications)		Chronic Dietary RQ[b]
	20g Bird	100g Bird	
Celtuce, chervil, chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese)	**1.01**	**0.45**	**354.09**
Onion, orach (mountain spinach), shallot	**1.02**	**0.46**	**357.15**
Radish/daikon Chinese	**1.53**	**0.68**	**535.33**

***** Bolded acute RQ values exceed the acute listed species LOC (0.1) and bolded chronic RQ values exceed the chronic LOC (1)
[a] Based on Northern Bobwhite quail *(Colinus virginianus* Avian (single dose) acute oral LD_{50} = 1386 mg/kg-bw *)* as amphibian surrogate.
[b] Based on Mallard duck (*Anas platyrhynchos)* Reproductive study Toxicity Value NOAEL = 2.50 ppm ppb a.i. *)* as amphibian surrogate.
[c] Chronic dietary RQ's for granular applications are not typically assessed.
† Unable to calculate acute dietary RQ's as avian 5-day LC50 = >5620 ppm a.i. (Table 6). However, application highest application rates yielded EEC's less than 5620 ppm a.i..

5.1.2 Indirect Effects

Pesticides have the potential to exert indirect effects upon listed species by inducing changes in structural or functional characteristics of affected communities. Perturbation of forage or prey availability and alteration of the extent and nature of habitat are examples of indirect effects.

In conducting a screen for indirect effects, direct effects LOCs for each taxonomic group (freshwater and terrestrial vertebrates, freshwater and terrestrial invertebrates, terrestrial plants) are employed to make inferences concerning the potential for indirect effects upon listed species that rely upon non-listed organisms in these taxonomic groups as resources critical to their life cycle (U.S. EPA, 2004). This approach used to evaluate indirect effects to listed species is endorsed by the Services (USFWS/NMFS, 2004b). If no direct effect listed species LOCs are exceeded for non-listed organisms that are critical to the California Red Legged Frog's life cycle, the concern for indirect effects to the CRLF is expected to be minimal. As an herbicide, bensulide has a potential to negatively impact vegetation in CRLF habitat areas.

5.1.2.1 Evaluation of Potential Indirect Effects via Reduction in Food Items

Potential indirect effects from direct effects on animal food items were evaluated by considering the diet of the California Red Legged frog and the sensitivity distribution of aquatic prey organisms. Aquatic phase CRLF larvae consume algae, diatoms, and detritus. The green alga *Selenastrum capriconutum* data was used to assess potential indirect effects on the larval stage of the CRLF; no other aquatic plant data are available for an indirect effects analysis of the aquatic phase of the CRLF. Terrestrial phase CRLFs feed on a wide range of freshwater and terrestrial invertebrates, and freshwater and terrestrial vertebrates, including water striders, sow bugs, fish, other frogs, salamanders, and small mice. While aquatic and terrestrial invertebrates comprise the most numerous food items, 50% of the prey mass in larger adult CRLFs consists of vertebrates such as mice, frogs, and fish. The RQs used to characterize potential indirect effects to the terrestrial and aquatic phase of the CRLF from direct acute and chronic effects on freshwater vertebrate and invertebrate as well as terrestrial vertebrate and invertebrate food sources are provided in Table 13, Table 14,

Table 15 and Table 16.

Based on these RQ calculations, there are acute LOC exceedances for fish and aquatic invertebrate prey of the CRLF for all the modeled uses of bensulide (Table 13). There are acute and chronic LOC exceedances for mammalian prey of the CRLF for all the modeled uses (Table 14). The RQ calculations for terrestrial amphibian prey of the CRLF indicate the LOC is exceeded for chronic risk for all the modeled uses (Table 15). There are acute LOC exceedances for terrestrial invertebrate prey of the CRLF for all the proposed uses.

Table 13. Summary of Bensulide Indirect Effects RQs for the CRLF Aquatic Phase, Aquatic Animal Food Items*

	Fish		Invertebrates
Scenario	Acute RQ[a]	Chronic RQ[b]	Acute RQ[c]

Scenario	Fish		Invertebrates
	Acute RQ[a]	Chronic RQ[b]	Acute RQ[c]
Golf course turf (gran)	**0.12**	0.18	**0.15**
Golf course turf (ec)	**0.07**	0.13	**0.09**
Residential lawns (gran)	**0.12**	0.18	**0.15**
Residential lawns (ec)	**0.27**	0.48	**0.33**
Ornamental	**0.07**	0.13	**0.09**
Ornamental (gran)	**0.32**	0.43	**0.40**
Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables	**0.16**	0.24	**0.19**
Broccoli raab, broccoli, Chinese,	**0.10**	0.14	**0.12**
Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	**0.19**	0.26	**0.23**
Chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula),	**0.12**	0.18	**0.15**
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili)	**0.12**	0.18	**0.15**
Celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili)	**0.08**	0.12	**0.10**
Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash)	**0.12**	0.18	**0.15**
Eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear)	**0.08**	0.12	**0.10**
Garlic	**0.12**	0.17	**0.15**
Tomatillo	**0.08**	0.11	**0.10**
Okra (Chinese)	**0.06**	0.07	**0.07**
Onion, orach (mountain spinach), shallot	**0.12**	0.18	**0.14**
Radish/daikon Chinese	**0.18**	0.27	**0.22**

* Bolded values exceed LOC of ≥ 0.05 for acute exposure. No values exceeded the LOC of ≥1.00 for chronic exposure.
[a] Based on Rainbow trout (*Oncorrhynchus mykiss*) Toxicity Value LC_{50} 720 ppb a.i.
[b] Based on Fathead minnow (*Pimephales promelas)* Toxicity Value NOAEC = 374 ppb a.i.
[c] Based on Water Flea (*Daphnia magna*) Toxicity Value LC_{50} 580 ppb a.i.

Table 14. Summary of Bensulide Indirect Effects RQs for the CRLF, Mammalian Food Items*

Mammal RQ					
Scenario	**Acute Dose RQ[a] (Emulsifiable Concentrations) and LD_{50}/ft^2 (Granular Applications)**		**Chronic Dose RQ[b]**		**Chronic Dietary RQ[b]**
	15g Mammal	**35g Mammal**	**15g Mammal**	**35g Mammal**	
Golf course, residential lawn, turf (gran) [c]	**37.43**	**19.83**	___	___	____
Golf course, residential lawn, turf (EC)	**5.69**	**4.86**	**204.81**	**174.95**	**23.61**
Ornamental (gran) [c]	**14.62**	**7.75**	___	___	____
Ornamental, Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables, Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	**3.47**	**2.96**	**124.93**	**106.72**	**14.4**
Broccoli raab, broccoli, Chinese, chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic	**2.31**	**1.98**	**83.29**	**71.15**	**9.6**

Mammal RQ					
Scenario	Acute Dose RQ[a] (Emulsifiable Concentrations) and LD_{50}/ft^2 (Granular Applications)		Chronic Dose RQ[b]		Chronic Dietary RQ[b]
	15g Mammal	35g Mammal	15g Mammal	35g Mammal	
Celery, pepper, cardoon, dock (sorrel), Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash), Tomatillo	**3.47**	**2.96**	**124.93**	**106.72**	**14.4**
celtuce, chervil, chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese)	**2.55**	**2.18**	**91.81**	**78.42**	**10.58**
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili)	**3.79**	**3.24**	**136.54**	**116.63**	**15.74**
Onion, orach (mountain spinach), shallot	**2.55**	**2.18**	**91.81**	**78.42**	**10.58**
Radish/daikon Chinese	**3.82**	**3.27**	**137.62**	**117.55**	**15.86**

* Bolded RQ values exceed LOC values

[a] Based on Rat (*Rattus norvegicus*) Toxicity Value LC_{50} 270 mg/kg-bw.

[b] Based on Rat (*Rattus norvegicus*) Toxicity Value NOAL 150 ppm

[c] Chronic dietary RQ's for granular applications are not typically assessed.

Table 15. Summary of Acute and Chronic RQs for the CRLF Terrestrial Amphibian Prey Exposed to Dietary Residues of Bensulide (based on T-HERPS V. 1.0 Model).* † ‡

Scenario	Acute Dose RQ[a]		Chronic Dietary RQ[b]
	1.4 g Frog	37 g Frog	
Golf Course Turf (EC)	0.06	0.05	**796.91**
Ornamental Crops, Lettuce (head, leaf), Brussels sprout, chard (), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (Arugula), spinach	0.03	0.03	**864.00**
Broccoli raab, broccoli, Chinese, chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic, celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese), Onion, orach (mountain spinach), shallot	0.02	0.02	**324.00**
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili)	0.04	0.04	**531.14**
Melon, cucumber, chayote, eggplant, gherkin, gourds, gourd cherry, melon (bitter) cantaloupe, citron, honeydew, musk, water, pineapple), pear, pumpkin, squash	0.03	0.03	**486.00**
Garlic	0.02	0.02	**324.00**
Tomatillo	0.02	0.02	**324.00**
Okra (Chinese)	0.03	0.03	**486.00**
Onion, orach (mountain spinach)	0.02	0.02	**324.00**

***** Bolded RQ values meet or exceed LOC values for listed aquatic animals

[a] Based on Northern Bobwhite quail *(Colinus virginianus)* Avian (single dose) acute oral Toxicity Value LD_{50} = 1386 mg/kg –bw.

[b] Based on Mallard duck (*Anas platyrhynchos)* Reproductive study Toxicity Value NOAEL = 2500 ppm ppb a.i..

† Unable to calculate acute dietary RQ's as avian 5-day LC50 = >5620 ppm a.i.. However, application highest application rates yielded EEC's less than 5620 ppm a.i..

‡ Granular applications could not be refined via T-HERPS V. 1.0 model.

Table 16. Summary of Bensulide Indirect Effects RQs for the CRLF Invertebrate Food Items.*

Invertebrate Acute RQ			
Scenario	Aquatic[a]	Terrestrial[b]	
		Large	Small
golf course, residential lawn, turf (gran) [c]	**0.06**	**41.97**	**377.70**
golf course, residential lawn, turf (EC)	0.03	**0.16**	**17.70**
Ornamental (gran) [c]	**0.06**	**0.38**	**41.97**
Ornamental, Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables, Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	**0.13**	**0.16**	**17.70**
Broccoli raab, broccoli, Chinese, chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic	0.03	**0.10**	**10.80**
Celery, pepper, cardoon, dock (sorrel), Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash), Tomatillo celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese)	**0.15**	**0.06**	**7.20**
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili) Onion, orach (mountain spinach), shallot	**0.07**	**0.10**	**10.80**
Radish/daikon Chinese	**0.05**	**0.06**	**7.20**
golf course, residential lawn, turf (gran) [c]	**0.09**	**0.10**	**10.80**
golf course, residential lawn, turf (EC)	**0.06**	**0.06**	**7.20**
Ornamental (gran) [c]	**0.06**	**0.11**	**11.80**

Invertebrate Acute RQ			
		Terrestrial[b]	
Ornamental, Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables, Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	0.04	**0.07**	**7.87**
Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash)	**0.06**	**0.11**	**11.80**
Broccoli raab, broccoli, Chinese, chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic	0.04	**0.07**	**7.87**
Garlic	0.06	**0.06**	**7.20**
Celery, pepper, cardoon, dock (sorrel), Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash), Tomatillo	0.04	**0.11**	**11.80**
celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese)	0.03	**0.07**	**7.87**
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili)	**0.06**	**0.07**	**7.94**
Onion, orach (mountain spinach), shallot	**0.06**	**0.11**	**11.90**

* Bolded RQ values exceed LOC values

[a] Based on Water Flea (*Daphnia magna*) Toxicity Value LC_{50} 580 ppb a.i. and 21 day peak EEC.

[b] Based on Honey Bee (*Apis sp.*) Toxicity Value 1.6 ug/individual, assuming an average fresh weight per honey bee of 128 milligrams. The LD_{50} of honey bees was multiplied by 7.8 to determine the ppm toxicity.

[c] Chronic dietary RQ's for granular applications are not typically assessed.

5.1.2.2 Evaluation of Potential Indirect Effects via Reduction in Habitat and/or Primary Productivity (Freshwater Aquatic Plants)

Potential indirect effects on habitat and/or primary productivity were assessed using the RQs from a green alga (*Selenastrum capriconutum*). This species will only provide insight into a small part of the sensitivity spectrum of freshwater plants. Risk quotients used to estimate potential indirect effects to the CRLF from effects on aquatic and terrestrial plants primary productivity are summarized in Table 17.

None of the use scenarios led to LOC exceedances for freshwater aquatic plants and terrestrial plants, or for terrestrial plants growing in semi-aquatic areas. Both aquatic plant and terrestrial plant RQs were <1.0 and do not exceed the LOC.

Table 17. Summary of Bensulide Indirect Effects RQs for the CRLF Aquatic Plant Food items and Habitat.*

Scenario	Non-Listed[a]	Listed[b]
Golf course turf (gran)	0.06	0.07
Golf course turf (ec)	0.03	0.05
Residential lawns (gran)	0.06	0.07
Residential lawns (ec)	0.13	0.19
Ornamental	0.03	0.05
Ornamental (gran)	0.15	0.17
Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables	0.07	0.09
Broccoli raab, broccoli, Chinese,	0.05	0.06
Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach	0.09	0.11
chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula),	0.06	0.07
Celery, pepper, cardoon, pepper (chili)	0.06	0.07
Celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili)	0.04	0.05
Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash)	0.06	0.07
Eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear)	0.04	0.05
Garlic	0.06	0.07
Tomatillo	0.04	0.05
Okra (Chinese)	0.03	0.03
Onion, orach (mountain spinach), shallot	0.06	0.07
Radish/daikon Chinese	0.06	0.06

* Bolded RQ values exceed LOC values

[a] Based on Green Algae (*Selenastrum capriconutum*) Toxicity Value 72h LC_{50} 1.5 ppm.

[b] Based on Green Algae (*Selenastrum capriconutum*) Toxicity Value 96h EC_{05} = 0.93 ppm a.i.

5.1.2.3 Evaluation of Potential Indirect Effects via Reduction in Terrestrial Plant Community (Riparian Habitat)

Bensulide is an herbicide, therefore it may pose indirect risks to the CRLF by impacting the terrestrial plant communities in which it depends. Bensulide RQs exceed the Agency's LOC's for all monocot plants in turf and lawn applications for both granular and EC formulations. Listed monocot RQs are exceeded for all other application scenarios. No data exist for dicotyledonous plants. These risks are summarized in Table 18.

Table 18. Summary of Bensulide Indirect Effects RQs for the CRLF Terrestrial and Semi-aquatic Plant Habitat.*†

Scenario	Plant Type	Listed Status	Dry	Semi-Aquatic	Spray Drift
Turf and Lawn Granular	Monocot	non-listed	0.30	**3.05**	<0.1
		listed	**1.68**	**16.84**	<0.1
	Dicot	non-listed	0.11	**1.07**	<0.1
		listed	0.43	**4.27**	<0.1
Turf and Lawn EC	Monocot	non-listed	0.19	**1.35**	<0.1
		listed	**1.07**	**7.46**	0.36
	Dicot	non-listed	<0.1	0.47	0.10
		listed	0.27	**1.89**	0.36
Ornamental (gran)	Monocot	non-listed	<0.1	0.57	<0.1
		listed	0.32	**3.16**	<0.1
	Dicot	non-listed	<0.1	0.20	<0.1
		listed	<0.1	0.80	<0.1
Broccoli raab, broccoli, Chinese, chard (), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic, celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese), Onion, orach (mountain spinach), shallot	Monocot	non-listed	<0.1	0.60	<0.1
		listed	0.47	**3.32**	0.16
	Dicot	non-listed	<0.1	0.21	<0.1
		listed	0.12	0.84	0.16
Ornamental, Broccoli, cabbage, cauliflower, collards, cress (garden), kale, kohlrabi, leafy vegetables, Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (arugula), spinach, celery, pepper, cardoon, dock (sorrel), Melon, cucumber, chayote, gherkin, gourds, gourd (wax) Chinese, bitter melons (balsam pear), melons (cantaloupe, mango, musk, water, pineapple), winter melons (casaba, Crenshaw, honeydew, Persian), pumpkin, cucuzzi (spaghetti squash), Tomatillo, Radish/daikon Chinese	Monocot	non-listed	0.13	0.90	<0.1
		listed	0.71	**4.97**	0.24
	Dicot	non-listed	<0.1	0.32	<0.1
		listed	0.18	**1.26**	0.24

* Bolded RQ values exceed LOC values

† Monocot seedling emergence values based on Ryegrass (EC_{25} = 2.1 ppm, NOEAC = 0.38ppm). Monocot vegetative vigor values based on Ryegrass (EC_{25} = >6.00 ppm, NOEAC = 0.75 ppm). Dicot seedling emergence values based on Cucumber (EC_{25} = >6.00ppm, NOEAC = 1.50 ppm). Dicot vegetative vigor values based on Cucumber (EC_{25} = 1.30 ppm, NOEAC = 0.38 ppm).

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 California Red Legged frog.

If the RQs presented in the Risk Estimation (Section 5.1.2) show no indirect effects, and LOCs for the CRLF are not exceeded for direct effects (Section 5.1.1), a "no effect" determination is made based on bensulide's use within the action area. If, however, indirect effects are anticipated and/or exposure exceeds the LOCs for direct effects, the Agency concludes a preliminary "may affect" determination for 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 and potential community-level effects to aquatic plants and terrestrial plants growing in semi-aquatic areas. 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.

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

- <u>Significance of Effect</u>: 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. For example, use of dose-response information to estimate the likelihood of effects can inform the evaluation of some discountable effects.

- <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 is provided in Sections 5.2.1 through 5.2.3.

5.2.1 Direct Effects to the CRLF

The federal action is all labeled uses. In order to compare the location of the labeled uses with the areas important to the frog, the potential use areas in California were over laid with the core areas, critical habitat and known occurrence areas of the CRLF. The result of this layering is the ability to discern areas of overlap between potential use and the CRLF life-cycle.

5.2.1.1 Aquatic Phase

The fish (surrogate species to the CRLF) acute RQ calculations indicate that the Agency level of concern (LOC = 0.05) is exceeded for acute effects to the aquatic phase of the CRLF for all modeled bensulide uses. The primary driver of these acute LOC exceedances is bensulide's EC formulation use on residential lawns. These acute LOC exceedances indicate that the aquatic phase of the CRLF is LAA by all the modeled uses of bensulide. The chronic RQ calculations indicate that the LOC is not exceeded for risk of chronic effects of bensulide to the aquatic phase of the CRLF.

Because of the fish acute LOC exceedances, mortality effects to the CRLF are anticipated based on all modeled uses of bensulide. To provide additional information, the probability of an individual mortality to the CRLF was calculated using the probit slope analysis described in Section 4.3. A probit slope value for the acute fish toxicity test is not available; therefore, the effect probability was calculated using a default slope assumption of 4.5. Based on the default dose response curve slope of 4.5, the corresponding estimated chance of an individual acute mortality to the aquatic-phase CRLF is 1 in 4.18×10^8.

5.2.1.2 Terrestrial Phase (Direct Effects)

Based on the T-REX V. 1.3.1 model, acute dose RQs and chronic RQs for terrestrial phase CRLF exceed for all modeled bensulide uses (Table 2). The acute dose LOC exceedances range from 0.41-16.69 for small and large terrestrial phase CRLF, and the chronic RQs ranged from 324 – 797. The LOCs for the chronic dietary RQs exceed the Agency level of concern for risk to the terrestrial phase of the CRLF for all the modeled uses.

The T-HERPS V.1.0 model was conducted to refine the assessment of bensulide's risk to the terrestrial phase of the CRLF (Table 19). Based on this refinement, there are no acute LOC exceedances for bensulide. There are chronic LOC exceedances for all the proposed uses of bensulide. The chronic dietary RQs range from 354.09- 535.33. Based on these LOC exceedances the terrestrial phase of the CRLF is LAA by all the modeled uses of bensulide.

Table 19. Summary of Acute and Chronic RQs for the CRLF Terrestrial Phase Exposed to Dietary Residues of Bensulide (based on T-HERPS V. 1.0 Model).* † ‡

Scenario	Acute Dose RQ[a]		Chronic Dietary RQ[b]
	1.4 g Frog	37 g Frog	
Golf Course Turf (EC)	0.06	0.05	**796.91**
Ornamental Crops, Lettuce (head, leaf), Brussels sprout, chard (Swiss), chicory, corn salad, dandelion, endive, fennel, parsley, roquette (Arugula), spinach	0.03	0.03	**864.00**
Broccoli raab, broccoli, Chinese, chard (Swiss), chicory, corn salad, dandelion, fennel, roquette (arugula), Garlic, celtuce, chervil, , chrysanthemum (garland), pimento, orach, pepper (chili), eggplant, gourd cherry (strawberry tomato/tomatillo), pepino (melon pear), okra (Chinese), Onion, orach (mountain spinach), shallot	0.02	0.02	**324.00**
Celery, pepper, cardoon, celtuce, chervil, , chrysanthemum (garland), dock (sorrel), pimento, orach, pepper (chili)	0.04	0.04	**531.14**
Melon, cucumber, chayote, eggplant, gherkin, gourds, gourd cherry, melon (bitter) cantaloupe, citron, honeydew, musk, water, pineapple), pear, pumpkin, squash	0.03	0.03	**486.00**
Garlic	0.02	0.02	**324.00**
Tomatillo,	0.02	0.02	**324.00**
Okra (Chinese)	0.03	0.03	**486.00**
Onion, orach (mountain spinach)	0.02	0.02	**324.00**

***** Bolded RQ values meet or exceed LOC values for listed aquatic animals
[a] Based on Northern Bobwhite quail *(Colinus virginianus)* Avian (single dose) acute oral Toxicity Value LD_{50} = 1386 mg/kg –bw.
[b] Based on Mallard duck (*Anas platyrhynchos)* Reproductive study Toxicity Value NOAEL = 2500 ppm ppb a.i.
† Unable to calculate acute dietary RQs as avian 5-day LC50 = >5620 ppm a.i. However, application highest application rates yielded EEC's less than 5620 ppm a.i.
‡ Granular applications could not be refined via T-HERPS V. 1.0 model.

5.2.2 Indirect Effects via Reduction in Food Items

Indirect effects on the CRLF in the terrestrial phase or aquatic phase of its life cycle might be due to loss of prey (terrestrial or aquatic invertebrates, small mammals, small frogs, and fish) or effects on terrestrial or aquatic plants that provide habitat.

5.2.2.1 Aquatic Phase

Aquatic invertebrates and fish are the animal prey of the CRLF. Based on the RQ calculations, the LOC is exceeded for all the modeled uses for risk of acute effects to fish, and aquatic invertebrate prey of the CRLF. The acute RQs range from 0.07-0.40 for freshwater invertebrate prey and from 0.07 to 0.32 for fish prey. . These acute LOC exceedances indicate that bensulide "May Affect" fish and aquatic invertebrate prey of the CRLF. The primary driver for these LOC exceedances is bensulide's use on residential lawn. The acute freshwater invertebrate LOC exceedances were based upon a supplemental water flea acute toxicity study (MRID 159322). The study is supplemental because the dissolved oxygen at the four highest test concentrations was unacceptably low. Thus, the low dissolved oxygen may have contributed to the lethality effects demonstrated in this study. Therefore, there is some uncertainty regarding the validity of the endpoints produced in this study.

There are no chronic LOC exceedances for fish prey of the CRLF. Currently, no valid aquatic invertebrate data is available to access the chronic risk of aquatic invertebrate prey of the CRLF. Thus, the Agency cannot calculate chronic RQs for CRLF aquatic invertebrate prey items. Although there are no aquatic invertebrate chronic toxicity data available, EFED assumes that bensulide will Likely Adversely Affect (LAA) aquatic invertebrate prey of the CRLF. This assumption is a based on the presumption of chronic risk in the absence of corresponding data.

The probability of an individual mortality to fish prey and aquatic invertebrate prey of the CRLF was calculated using the probit slope analysis described in Section 4.3. Based on the probit slope for the most sensitive fish acute toxicity test (rainbow trout acute LC_{50} = 0.72 ppm MRID 40098001) with a default slope of 4.5, the corresponding estimated chance of an individual acute mortality to the fish prey of the CRLF at the highest LOC exceedance of 0.32 is 1 in 77. Based on the probit slope for the most sensitive freshwater invertebrate acute toxicity test (Waterflea acute LC_{50} = 0.58 ppm MRID 159322) with a slope of 3.8, the corresponding estimated chance of an individual acute mortality to the aquatic invertebrate of the CRLF at the highest LOC exceedance of 0.40 is 1 in 15 (Appendix F). Based on this probit analysis, these effects are considered insignificant, therefore acute effects to the CRLF via aquatic prey are considered NLAA.

5.2.2.2 Terrestrial Phase

a) <u>5.2.2.3.1 Terrestrial Vertebrate Food Items</u>

The RQ calculations indicate that the LOC (0.1 for acute and 1 for chronic) is exceeded for all modeled uses of bensulide for acute and chronic risk of effect to small mammal food items of the CRLF. The RQ values ranged from 1.98 to 37.43 for acute dose based RQs for 15 gram mammals and 35 gram mammals, from 83.29 to 204.81 for chronic dose RQs for 15 gram mammals and 35 gram mammals and from 9.6 to 15.86 for chronic dietary based RQs. The primary driver of all these RQ exceedances is bensulide's liquid application to golf course turf, residential lawn, and turf. Table 19 gives a detailed explanation of the LOC exceedances.

Additionally, the probability of an individual mortality to mammal prey of the CRLF was calculated using the probit slope analysis described in Section 4.3. Based on the probit slope analysis for the most sensitive acute rat toxicity test (LD_{50} = 1386 mg/kg) with a slope of 2.92, the corresponding estimated chance of an individual acute mortality to the 15 gm and 35 gm mammal prey of the CRLF at the highest LOC exceedance of 37 and 19.83 respectively approaches 100%. Thus, effects to the CRLF via reduction in terrestrial prey are considered LAA.

The terrestrial-phase CRLF uses small mammal burrows for shelter. If populations of small mammals are reduced, as is anticipated from the acute and chronic RQs, then there may be fewer burrows for the CRLF to exploit. This effect is considered to be LAA to the CRLF.

Based on the T-HERPS V. 1.0 model, acute dose RQs for of terrestrial amphibian prey (surrogate species bird) of the terrestrial phase CRLF are not exceeded for any of the modeled uses (Table 6). The LOCs for the chronic dietary RQs exceed the Agency level of concern for risk to the amphibian prey of the CRLF for all the modeled uses. The chronic dietary RQs range from 324 - 864.

Based on these LOC exceedances, EFED expects all the modeled uses of bensulide to be LAA terrestrial amphibian prey of CRLF.

b) <u>5.2.3.2 Terrestrial Invertebrate Food Items</u>

The LOC for risk to terrestrial invertebrate food items of the CRLF is exceeded for all modeled bensulide uses. The LOC exceedances for large terrestrial invertebrate range from 7.87- 41.97. The LOC exceedances for small terrestrial invertebrates range from 0.1 – 377.70. The primary driver of these LOC exceedances is bensulide's use on golf course turf. Table 16 provides a detailed list the LOC exceedances for risk to terrestrial invertebrate food items of the CRLF for all modeled bensulide uses. Because of these LOC exceedances all the modeled uses are LAA the terrestrial invertebrate food items of the CRLF.

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

The RQ calculations for freshwater aquatic plants indicate that there are no LOC exceedances for risk to fresh aquatic plants that may support the habitat of the CRLF.
Table 17 demonstrates the RQ calculations for freshwater aquatic plants.

5.2.4 Indirect Effects via Alteration in Terrestrial Plant Community (Riparian Habitat)

5.2.4.1 Importance of Riparian Habitat to the CRLF

As discussed in section 2.5.4, the habitat of the CRLF varies during its life cycle, with the CRLF surviving in aquatic, riparian and upland areas. Adults rely on riparian vegetation for resting, feeding, and dispersal. 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).

5.2.4.2 Sensitivity of Riparian Zones to Bensulide

The only RQ exceedances that indicate a risk to riparian habitats are bensulide's granular and formulation product uses on turf and lawns. The RQs for these uses (range 1.07- 16.84; LOC $\geq$ 1) demonstrate an LOC exceedance that plants inhabiting semi-aquatic habitat are at risk of being adversely affected from bensulide's use on turf. Riparian habitats are largely composed of semiaquatic plants. Because of these LOC exceedances EFED expects bensulide's turf and lawn uses to be LAA to riparian habitats of the CRLF.

6.0 Uncertainties

6.1 Exposure Assessment Uncertainties

Overall, the uncertainties inherent in the exposure assessment tend to result in overestimation of exposures. Factors influencing the over-estimation of exposure include the assumption of no degradation, dilution, or mixing in the subsurface transport from edge of field. The modeling exercise conservatively assumes that the surface water and bensulide application site are adjacent. In reality, there are likely to be processes at work which cannot be accounted for in the modeling that will reduce the predicted exposures. In addition, the impact of setbacks on runoff estimates has not been quantified, although these buffers, especially those that are well-vegetated, are likely to result in significant reduction in runoff loading of bensulide.

Landscape maintenance is known to be a major use of bensulide. This exposure is described for the aquatic environment using the PRZM turf scenario. All exposure estimates were done with maximum application rates, minimum intervals, and maximum number of applications, to define the Action Area for the Federal action. Actual exposures will depend on actual use rates, which may be lower. Spray drift estimates were set at 1% for ground application, per EFED policy.

6.1.1 Modeling Assumptions

Overall, the uncertainties addressed in this assessment cannot be quantitatively characterized. However, given the available data and the tendency to rely on conservative modeling assumptions, it is expected that the modeling results in an over-prediction in exposure. In general, the simplifying assumptions used in this assessment appear to be reasonable especially in light of the analysis completed and the absence of monitoring data. There are also a number of assumptions that tend to result in exposure over-estimation that cannot be quantified, but can be qualitatively described. For instance, modeling for each use site assumes that the entire 10-hectare watershed is taken up by the respective use pattern. The assessment assumes that all applications have occurred concurrently on the same day at the exact same application rate. This is unlikely to occur in reality, but is a reasonable conservative assumption in lieu of actual data.

6.1.2 Impact of Vegetative Setbacks on Runoff

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 of various conditions on pesticide loadings becomes available, the aquatic exposure predictions are likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

6.1.3 PRZM Modeling Inputs and Predicted Aquatic Concentrations

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 (PRZM) 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 simulates 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.
Uncertainty associated with each of these individual components adds 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 open environment 90 percent of the time. Mobility input values are chosen to be representative of conditions in the open 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.

Additionally, the rate at which bensulide is applied, the percent of a watershed that is cropped, and the percent of crops in that watershed that are actually treated with bensulide may be lower than the Agency’s default assumptions including use of the maximum allowable application rate, treatment of the entire crop, and the estimated area within a watershed planted with agricultural crops. The geometry of a watershed and limited meteorological data sets also add to the uncertainty of estimated aquatic concentrations.

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, such as bensulide, 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 California Red Legged Frog.

6.2.2 Extrapolation of Long-term Environmental Effects from Short-term Laboratory Tests

The influence of length of exposure and concurrent environmental stressors to the California Red Legged Frog (*i.e.*, urban expansion, habitat modification, decreased quantity and quality of water in CRLF habitat, predators, etc.) will likely affect the species' response to bensulide. Additional environmental stressors may decrease the CRLF's sensitivity to the insecticide, although there is the possibility of additive/synergistic reactions. Timing, peak concentration, and duration of exposure are critical in terms of evaluating effects, and these factors will vary both temporally and spatially within the action area. Overall, the effect of this variability may result in either an overestimation or underestimation of risk. However, as previously discussed, 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.

6.2.4 Location of Wildlife Species

For this baseline 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.

6.2.5 Use of avian data as surrogate for amphibian data

Toxicity data for terrestrial phase amphibians was not available for use in this assessment. Therefore, avian toxicity data were used as a surrogate for risk estimation. There is uncertainty regarding the relative sensitivity of reptiles and birds to bensulide. If birds are substantially more or less sensitive than the California red legged frog, then risk would be over or under estimated, respectively.

6.2.6 Assumptions Associated with the Acute LOCs

The risk characterization section of this listed species assessment includes an evaluation of the potential for individual effects. 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 for the effects study corresponding to the taxonomic group for which the LOCs are exceeded.

Additionally the acute freshwater invertebrate LOC exceedances were based upon a supplemental water flea acute toxicity study (MRID 159322). The study is supplemental because the dissolve oxygen at the four highest test concentrations was unacceptably low. Thus, the low dissolved oxygen may have contributed to the lethality effects demonstrated in this study. Thus, there is some uncertainty regarding the use of the endpoints produced in this study. However, in order to ensure adequate protection to the CRLF, the data produced in the study was used as a conservative approach to assessing the risk of bensulide to freshwater aquatic invertebrate.

Table 20 Summary of Direct and Indirect Effects to the CRLF

Table 1.1 Summary of effects determinations for direct/indirect effects to the CRLF and its critical habitat.		
Assessment Endpoint	Effects determination	Basis for Determination
Aquatic Phase (Eggs, larvae, tadpoles, juveniles, and adults)		
Direct Effects		
Survival, growth, and reproduction of CRLF	LAA	All acute RQs are above the listed LOC for surrogate species (rainbow trout) for all the modeled bensulide uses.
Indirect Effects and Critical Habitat Effects		
Reduction or modification of invertebrate aquatic prey base	LAA	The Agency presumed risk of chronic effects to the CRLF aquatic invertebrate prey for all modeled uses (See Risk Description Sec. 5.2.2.1 for explanation of presumption).
Reduction or modification of aquatic vertebrate prey base	NLAA	No LOC exceedance for acute or chronic risks to fish or amphibian prey base.
Reduction or modification of aquatic plant community	No Effect	No LOC Exceedances for any aquatic plant species
Degradation of riparian vegetation	LAA	The levels of concern for risk to nonlisted plants in semiaquatic areas (which may include plants inhabiting riparian areas) are exceeded for bensulide granular and EC formulation uses on turf and lawn.
Terrestrial Phase (Juveniles and Adults)		
Direct Effects		
Survival, growth, and reproduction of CRLF	LAA	The dietary based RQs calculated by TREX and THERPS (as a refinement) exceed the acute and chronic LOC for all modeled bensulide uses.
Indirect Effects and Critical Habitat Effects		
Reduction or modification of terrestrial prey base	LAA	The level of concern is exceeded for risk to invertebrate, mammalian and amphibian prey of the CRLF.
Degradation of riparian vegetation	LAA	The levels of concern for risk to nonlisted plants in semiaquatic areas (which may include plants inhabiting riparian areas) are exceeded for bensulide granular and EC formulation uses on turf and lawn.

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.

7.0 References

Altig, R. and R.W. McDiarmid. 1999. Body Plan: Development and Morphology. In R.W. McDiarmid and R. Altig (Eds.), Tadpoles: The Biology of Anuran Larvae.University of Chicago Press, Chicago. pp. 24-51.

Alvarez, J. 2000. Letter to the U.S. Fish and Wildlife Service providing comments on the Draft California Red-legged Frog Recovery Plan.

Chambers JE, Carr RL. 1995. Biochemical mechanisms contributing to species differences in insecticidal toxicity. Toxicology. 105(2-3):291-304.

Crawshaw, G.J. 2000. Diseases and Pathology of Amphibians and Reptiles *in:* Ecotoxicology of Amphibians and Reptiles; ed: Sparling, D.W., G. Linder, and C.A. Bishop. SETAC Publication Series, Columbia, MO.

Fellers, G. M., *et al*. 2001. Overwintering tadpoles in the California red-legged frog (*Rana aurora draytonii*). Herpetological Review, 32(3): 156-157.

Fellers, G.M, L.L. McConnell, D. Pratt, S. Datta. 2004. Pesticides in Mountain Yellow-Legged Frogs (Rana Mucosa) from the Sierra Nevada Mountains of California, USA. Environmental Toxicology & Chemistry 23 (9):2170-2177.

Fellers, Gary M. 2005a. *Rana draytonii* Baird and Girard 1852. California Red-legged Frog. Pages 552-554. *In*: M. Lannoo (ed.) Amphibian Declines: The Conservation Status of United States Species, Vol. 2: Species Accounts. University of California Press, Berkeley, California. xxi+1094 pp. (http://www.werc.usgs.gov/pt-reyes/pdfs/Rana%20draytonii.PDF)

Fellers, Gary M. 2005b. California red-legged frog, *Rana draytonii* Baird and Girard. Pages 198-201. *In*: L.L.C. Jones, *et al* (eds.) Amphibians of the Pacific Northwest. xxi+227.

Hayes, M.P. and M.M. Miyamoto. 1984. Biochemical, behavioral and body size differences between *Rana aurora aurora* and *R. a. draytonii*. Copeia 1984(4): 1018-22.

Hayes and Tennant. 1985. Diet and feeding behavior of the California red-legged frog. The Southwestern Naturalist 30(4): 601-605.

Jennings, M.R. and M.P. Hayes. 1985. Pre-1900 over harvest of California red-legged frogs (*Rana aurora draytonii*): The inducement for bullfrog (*Rana catesbeiana*) introduction. Herpetological Review 31(1): 94-103.

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Report prepared for the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. 255 pp.

Jennings, M.R., S. Townsend, and R.R. Duke. 1997. Santa Clara Valley Water District California red-legged frog distribution and status – 1997. Final Report prepared by H.T. Harvey & Associates, Alviso, California. 22 pp.

Kupferberg, S. 1997. Facilitation of periphyton production by tadpole grazing: Functional differences between species. Freshwater Biology 37:427-439.

Kupferberg, S.J., J.C. Marks and M.E. Power. 1994. Effects of variation in natural algal and detrital diets on larval anuran (*Hyla regilla*) life-history traits. Copeia 1994:446-457.

LeNoir, J.S., L.L. McConnell, G.M. Fellers, T.M. Cahill, J.N. Seiber. 1999. Summertime Transport of Current-use pesticides from California's Central Valley to the Sierra Nevada Mountain Range,USA. Environmental Toxicology & Chemistry 18(12): 2715-2722.

McConnell, L.L., J.S. LeNoir, S. Datta, J.N. Seiber. 1998. Wet deposition of current-use pesticides in the Sierra Nevada mountain range, California, USA. Environmental Toxicology & Chemistry 17(10):1908-1916.

Rathburn, G.B. 1998. *Rana aurora draytonii* egg predation. Herpetological Review, 29(3): 165.

Reis, D.K. Habitat characteristics of California red-legged frogs (*Rana aurora draytonii*): Ecological differences between eggs, tadpoles, and adults in a coastal brackish and freshwater system. M.S. Thesis. San Jose State University. 58 pp.

Seale, D.B. and N. Beckvar. 1980. The comparative ability of anuran larvae (genera: *Hyla*, *Bufo* and *Rana*) to ingest suspended blue-green algae. Copeia 1980:495-503.

Sparling, D.W., Fellers, G.M. . McConnell, L.L. 2001. Pesticides and amphibian population declines in California, USA. Environmental Toxicology & Chemistry 20(7): 1591-1595.

U.S. Environmental Protection Agency (U.S. EPA). 1998. Guidance for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-95/002F, April 1998.

U.S. EPA. 2004. Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs. Office of Prevention, Pesticides, and Toxic Substances. Office of Pesticide Programs. Washington, D.C. January 23, 2004.

U.S. Fish and Wildlife Service (USFWS). 1996. Endangered and threatened wildlife and plants: determination of threatened status for the California red-legged frog. Federal Register 61(101):25813-25833.

USFWS. 2002. Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*). Region 1, USFWS, Portland, Oregon. (http://ecos.fws.gov/docs/recovery_plan/020528.pdf)

USFWS. 2006. Endangered and threatened wildlife and plants: determination of critical habitat for the California red-legged frog. 71 FR 19244-19346.

USFWS. Website accessed: 30 December 2006. http://www.fws.gov/endangered/features/rl_frog/rlfrog.html#where

U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 1998. Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. Final Draft. March 1998.

USFWS/NMFS. 2004. 50 CFR Part 402. Joint Counterpart Endangered Species Act Section 7 Consultation Regulations; Final Rule. FR 47732-47762.

Wassersug, R. 1984. Why tadpoles love fast food. Natural History 4/84.