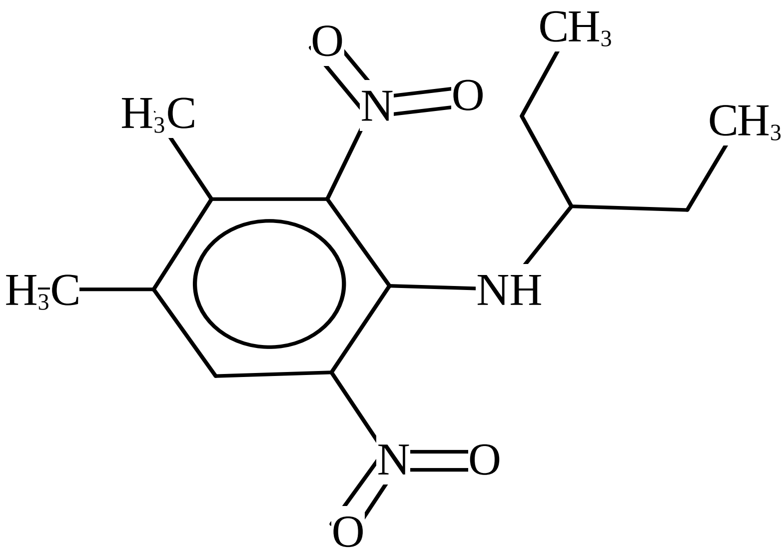
Risks of Pendimethalin Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*)



Pesticide Effects Determination

Environmental Fate and Effects Division
Office of Pesticide Programs
Washington, D.C. 20460

June 16, 2009

Primary Authors:

Michael Davy, Agronomist

William P. Eckel, Ph.D., Physical Scientist

Secondary Review:

Jean Holmes, DVM,MPH
Risk Assessment Process Leader

Final Review:

Tom Bailey, Ph.D., Branch Chief
Environmental Risk Assessment Branch 2

Table of Contents

List of Tables

List of Figures

Appendices

1.0 Executive Summary

The purpose of this assessment is to evaluate potential direct and indirect effects on the California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of pendimethalin on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in effects to the species' designated critical habitat. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998 and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

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

The following uses are considered as part of the federal action evaluated in this assessment: alfalfa, lupine for seed, almond, beech nut, brazil nut, butternut, cashew, chestnut, chinquapin, filbert (hazelnut), hickory nut, macadamia nut (bushnut), mayhaw (hawthorn), pecan, pistachio, walnut (English/black), calamondin, citron (citrus), citrus, citrus hybrids other than tangelo, grapefruit, kumquat, lemon, lime, orange, pummelo (shaddock), tangelo, tangerines, *Brassica* (head and stem) vegetables, broccoli, broccoli (Chinese), brussels sprouts, cabbage, cabbage (Chinese), cauliflower, kohlrabi, mustard cabbage (gai choy - pak-choi), corn (field, pop, sweet), sunflower, cotton, forest trees (all species), Christmas tree plantations, apple, apricot, cherry, crabapple, fig, loquat, nectarine, peach, pear, pepino (melon pear), plum, plum (Japanese), pomegranate, prune, quince, small fruits, garlic, leek, grapes, eggplant, olive, onion (green, scallions, spring), shallot, potato (white/Irish), nonagricultural rights-of-way/fencerows/hedgerows, artichoke, asparagus, beans (dry, succulent/lima/snap), carrot (including tops), garbanzos (including chick peas), legume vegetables, lentils, peanuts, peas (dry, early dwarf, pigeon, southern/cowpea), pepper, strawberry, tomato, groundcherry (strawberry tomato, tomatillo), airports/landing fields, commercial/industrial lawns, golf course turf, industrial areas (outdoor), ornamental and/or shade trees, ornamental ground cover, ornamental herbaceous plants, ornamental lawns and turf, ornamental nonflowering plants, ornamental sod farm (turf), ornamental woody shrubs and vines, recreation area lawns, residential lawns, shelterbelt plantings, sorghum, wheat, and rice.

Ground and aerial spray applications of pendimethalin (including some forms of chemigation) will potentially result in spray drift onto non-target plants, soil, and water adjacent to a treated field. Pendimethalin is expected to be persistent in the terrestrial environment and under the right conditions, may accumulate in the soil with repeated applications resulting in the potential for pendimethalin to reach the aquatic environment on suspended soil in runoff water. Laboratory dissipation studies in soil under aerobic conditions, demonstrate a half-life of approximately 72-172 days, and field dissipation studies in the Midwest similarly had half-lives that ranged from 84-147 days. However, field dissipation studies in Louisiana and Mississippi had half-lives of <20 days, demonstrating that pendimethalin can be relatively short-lived under some environmental conditions. Field half-lives less than 20 days may be due to volatilization, which has a measured half-life of 12.5 days in moist soil. In laboratory studies, pendimethalin can photodegrade in water with a half-life of approximately 42 days. However, in the environment, pendimethalin will not be available for photodegradation because the pendimethalin in water will tend to sorb to soil or sediment particles as indicated by K_{oc}'s which range from 13000-29400 ml/g. Thus, pendimethalin is considered hardly mobile according to FAO classification.

Pendimethalin may accumulate in fish based on submitted data. Pendimethalin residues accumulated in bluegill sunfish exposed to 3 ppb of pendimethalin, with BCFs of 1400X for edible, 5800X for nonedible, and 5100X for whole fish. Depuration was rapid, with 87- 91% of the ^{14}C-residues eliminated from the fish tissues by 14 days of depuration. The major terminal degradates in terrestrial environments include several compounds formed at insignificant levels (<10 % of applied). Therefore, no degradates are included in the definition of the chemical stressor.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF and its prey to pendimethalin are assessed separately for the two habitats. Tier-II aquatic exposure models are used to estimate high-end exposures of pendimethalin in aquatic habitats resulting from runoff and spray drift from different uses. Peak model-estimated environmental concentrations resulting from different pendimethalin uses range from 1.74 ppb (rights-of-way/impervious) to 16.6 µg/L (forestry) and 48 ppb (rice paddies). These estimates are supplemented with analysis of available California surface water monitoring data from U. S. Geological Survey's National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation. The maximum concentration of pendimethalin reported by NAWQA for California surface waters with agricultural watersheds is 0.68 µg/L. This value is approximately 71 times less than the maximum model-estimated environmental concentration. The maximum concentration of pendimethalin reported by the California Department of Pesticide Regulation surface water database (3.5 µg/L) is roughly 14 times lower than the highest peak model-estimated environmental concentration.

To estimate pendimethalin exposures to the terrestrial-phase CRLF, and its potential prey resulting from uses involving pendimethalin applications, the T-REX model is used for foliar uses. AgDRIFT and AGDISP models are also used to estimate deposition of pendimethalin on terrestrial and aquatic habitats from aerial and ground spray drift. The TerrPlant model is used to estimate pendimethalin exposures to terrestrial-phase CRLF habitat, including plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar pendimethalin applications. The T-HERPS model is used to allow for further characterization of dietary exposures of terrestrial-phase CRLFs relative to birds.

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

Pendimethalin is stable to most of the environmental degradation processes measured, meaning there is little production of degradates. Thus, no degradates were considered in the assessment, which was based on parent pendimethalin alone. There was monitoring data for one possible degradate, 4-hydroxypendamethalin, in the NAWQA data. It was not detected (less than 0.143 ppb) in 61 ground water samples, and 8 surface water samples, all taken from the San Joaquin-Tulare Basin.

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

Based on the best available information, the Agency makes a May Affect and Likely to Adversely Affect determination for the CRLF from the use of pendimethalin. Additionally, the Agency has determined that there is the potential for effects to CRLF designated critical habitat from the use of the chemical. There is potential for direct and indirect effects to the aquatic-phase and terrestrial-phase CRLF from the use of pendimethalin. Potential effects to the habitat of the aquatic and terrestrial phase CRLF has been determined due to effects to terrestrial and aquatic non-target plants. A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat is presented in Table 1-1 and Table 1-2. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2. Given the LAA determination for the CRLF and potential effects to designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment 2**.

Table 1-1 Effects Determination Summary for Pendimethalin Use and the CRLF

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Survival, growth, and/or reproduction of CRLF individuals	LAA[1]	**Potential for Direct Effects** ***Aquatic-phase (Eggs, Larvae, and Adults)***: Acute LOCs were exceeded for fish or aquatic-phase amphibians ***Terrestrial-phase (Juveniles and Adults)***: Acute and chronic LOCs were exceeded for birds. The available toxicity data suggest that amphibians are less sensitive than birds to pendimethalin, and considering factors such as lower food intake of terrestrial phase amphibians relative to birds reduces EECs and RQs, but does not reduce RQs to levels that are below LOCs. Likely to adversely affect CRLF. **Potential for Indirect Effects** ***Aquatic prey items, aquatic habitat, cover and/or primary productivity:*** LOC is exceeded only for non-vascular aquatic plants. RQs are below LOC for freshwater invertebrates (chronic and acute effects) and fish or frogs (chronic and acute effects). Pendimethalin could potentially impact terrestrial and aquatic plants to an extent that could result in indirect effects to the CRLF or effects to critical habitat. ***Terrestrial prey items, riparian habitat:*** Chronic LOC is exceeded for mammal and birds (surrogate for frog). Pendimethalin is practically non-toxic to honeybees with no mortalities observed in testing. LOC is exceeded for terrestrial invertebrates. Uncertainty in toxicity to insects from EEC that is above highest bee concentration tested does not preclude potential risk. Pendimethalin may adversely affect insects. Acute LOCs were not exceeded for insectivorous amphibians using the T-HERPS model at the highest rate of application. LOC is exceeded for non-target terrestrial plants and thereby critical habitat could be affected as a result of these potential impacts.

[1] No effect (NE); May affect, but not likely to adversely affect (NLAA); May affect, likely to adversely affect (LAA)

Table 1-2 Effects Determination Summary for Pendimethalin Use and CRLF Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination	Basis for Determination
Modification of aquatic-phase PCE	**Habitat effects**	Effects to riparian vegetation (terrestrial plants) and aquatic non-vascular and vascular plants result in LOC exceedances. These effects may indirectly affect the CRLF via reduction in food supply, changes in available cover, physical parameters of the waterbody *(e.g.* increase temperature or turbidity) LOC is exceeded for effects to non-vascular aquatic plants, freshwater invertebrates (chronic and acute effects) and fish or frogs (chronic and acute effects).

Modification of terrestrial-phase PCE		Effects to riparian vegetation (terrestrial plants) result in LOC exceedances. Effects may result in changes in community composition or relative abundance of riparian plant species, possibly altering terrestrial – phase CRLF habitat. Chronic LOC is exceeded for mammal. Although there are NLAA determinations for other prey items, small mammals constitute up to half of the food intake for CRLF and reduction in small mammalian populations may be significant.

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

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat 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 endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog (Rana aurora draytonii) (CRLF) arising from FIFRA regulatory actions regarding use of pendimethalin on alfalfa, lupine for seed, almond, beech nut, brazil nut, butternut, cashew, chestnut, chinquapin, filbert (hazelnut), hickory nut, macadamia nut (bushnut), mayhaw (hawthorn), pecan, pistachio, walnut (English/black), calamondin, citron (citrus), citrus, citrus hybrids other than tangelo, grapefruit, kumquat, lemon, lime, orange, pummelo (shaddock), tangelo, tangerines, *Brassica* (head and stem) vegetables, broccoli, broccoli (Chinese), brussels sprouts, cabbage, cabbage (Chinese), cauliflower, kohlrabi, mustard cabbage (gai choy - pak-choi), corn (field, pop, sweet), sunflower, cotton, forest trees (all species), Christmas tree plantations, apple, apricot, cherry, crabapple, fig, loquat, nectarine, peach, pear, pepino (melon pear), plum, plum (Japanese), pomegranate, prune, quince, small fruits, garlic, leek, grapes, eggplant, olive, onion (green, scallions, spring), shallot, potato (white/Irish), nonagricultural rights-of-way/fencerows/hedgerows, artichoke, asparagus, beans (dry, succulent/lima/snap), carrot (including tops), garbanzos (including chick peas), legume vegetables, lentils, peanuts, peas (dry, early dwarf, pigeon, southern/cowpea), pepper, strawberry, tomato, groundcherry (strawberry tomato, tomatillo), airports/landing fields, commercial/industrial lawns, golf course turf, industrial areas (outdoor), ornamental and/or shade trees, ornamental ground cover, ornamental herbaceous plants, ornamental lawns and turf, ornamental nonflowering plants, ornamental sod farm (turf), ornamental woody shrubs and vines, recreation area lawns, residential lawns, shelterbelt plantings, sorghum, wheat, and rice. In addition, this assessment evaluates whether use on these sites is expected to result in effects to the species' designated critical habitat. This ecological risk assessment has been prepared consistent with a settlement agreement in the case Center for Biological Diversity (CBD) vs. EPA et al. (Case No. 02-1580-JSW(JL)) entered in Federal District Court for the Northern District of California on October 20, 2006.

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

In accordance with the Overview Document, provisions of the ESA, and the Services' Endangered Species Consultation Handbook, the assessment of effects associated with registrations of pendimethalin is based on an action area. The action area is the area directly or indirectly affected by the federal action. It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of pendimethalin may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the CRLF and its designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached regarding the potential use of pendimethalin in accordance with current labels:

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

Designated 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 are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat.

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

If a determination is made that use of pendimethalin within the action area(s) associated with the CRLF "may affect" this species or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to the CRLF and other taxonomic groups upon which these species depend (e.g., aquatic and terrestrial vertebrates and invertebrates, aquatic plants, riparian vegetation, etc.). Additional information, including spatial analysis (to determine the geographical proximity of CRLF habitat and pendimethalin use sites) and further evaluation of the potential impact of pendimethalin on the PCEs is also used to determine whether effects 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 or affect 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 pendimethalin is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for pendimethalin is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes (i.e., the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of pendimethalin 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

As described above, the herbicide pendimethalin has a wide variety of outdoor uses, including both in agricultural and non-agricultural settings.

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

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

Degradates were not considered, as pendimethalin is relatively stable to all degradation processes measured. The half-lives used as model inputs reflect this stability and lack of degradate production. Sixty-nine measurements of one potential degradate (4-hydroxypendamthalin) in California waters produced no detections.

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).

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

2.3 Previous Assessments

A Reregistration Eligibility Decision (RED) ecological risk chapter was completed in 1997. The RED concluded that pendimethalin would not represent a high acute risk to birds or a high acute or chronic risk to mammals. The chronic risk to birds could not be determined because avian reproduction studies had not been submitted. Chronic risk Levels of Concern (LOCs) for fish were exceeded by a small margin. But it was presumed that overall, pendimethalin did not represent a high risk to aquatic animals and plants, including estuarine organisms. The use of pendimethalin may adversely affect endangered species of terrestrial and semi-aquatic plants, aquatic plants and invertebrates including mollusks, fish, and birds (specifically grazers). The risk to nontarget terrestrial and semi-aquatic plants was expected to be moderate.

On December 1, 2004, EPA initiated consultation with the National Marine Fisheries Service (NMFS) requesting concurrence in a determination relative to potential effects from pendimethalin uses to Pacific salmon and steelhead. In the assessment supporting that consultation, EPA concluded that pendimethalin has moderate to high laboratory toxicity to fish and aquatic invertebrates and somewhat less toxicity on aquatic plants. OPP determined that any effects of concern would be directly on listed salmon and steelhead and would vary for different uses and species. It was further determined that pendimethalin would not affect salmon and steelhead food or cover, nor adversely modify their Critical Habitat from any of the registered uses except a single aerial use - aerial application to corn. OPP's conclusions relative to 26 listed Pacific salmon and steelhead was that uses of pendimethalin were not likely to adversely affect four species and would have no effect on twenty-two species reviewed. A response to this request is anticipated from NMFS in 2012.

2.4 Stressor Source and Distribution

2.4.1 Environmental Fate Assessment

The environmental fate properties of pendimethalin indicate that it is persistent, with half-lives in relevant compartments of 172 days (soil) and 208 to 330 days (anaerobic and aerobic aquatic systems). Only the aqueous photolysis half-life is relatively short (42 days) but photolysis may not occur because of the strong tendency of pendimethalin to sorb to sediment (log Kow = 5.18, average Koc = 17,040 mL/g O.C.). Pendimethalin may be bioaccumulative in aquatic organisms. A whole-body bioconcentration factor (BCF) of 5100 from a 35-day exposure was measured in bluegill sunfish. BCFs were lower in catfish (about 1600) and negligible in guppy. The most rapid dissipation process for pendimethalin appears to be volatilization from moist soil (half-life about 12.5 days). Thus, pendimethalin may be transported away from the site of application before it degrades, making atmospheric transport a potentially important exposure mechanism. However, EPISuite v4.0 (http://www.epa.gov/oppt/exposure/pubs/episuite.htm), an EPA-sponsored environmental fate estimation program, estimates of atmospheric half-life (4.2 hours due to reaction with hydroxyl radical, AOPWin program) and sorption to airborne particles (1 to 7%, AEROWin program) indicate that long-range transport may not be a concern. The tendency of pendimethalin to partition to sediment, and its long half-life there, make transport by movement of sediment in flowing water systems a concern.

Table 2.1 lists the environmental fate properties of pendimethalin, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

Table 2-1 Summary of Pendimethalin Environmental Fate Properties

Study	Value (units)	Major Degradates *Minor Degradates*	MRID #	Study Status
Hydrolysis	Stable	None	00106777	acceptable
Direct Aqueous Photolysis	Dark corrected, continuous irradiation half-life 21 days; 12-hour light/dark half-life 42 days. 16.5-day half-life	37 minor, unidentified degradates *2,6-dinitro-3,4-dimethylaniline* (9.3% of applied)	00153763 43808201	acceptable
Soil Photolysis	Stable	None	00153764	acceptable
Aerobic Soil Metabolism	172 day (Deviation from IPG, as explained in 1997 RED) Range 42-1322 days	*2,6-dinitro3,4-xylidine* *4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitrobenzyl alcohol* *4-[(1-ethylpropyl)amino]-2-methyl3,5-dinitro-o-toluic acid*	40185104	acceptable
Anaerobic Soil Metabolism	Stable 98% parent at 60 days	*2,6-dinitro3,4-xylidine* *4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitrobenzyl alcohol* *4-[(1-ethylpropyl)amino]-2-methyl3,5-dinitro-o-toluic acid*	40185105	acceptable
Anaerobic Aquatic Metabolism	208-day half-life (upper 90^{th} %ile confidence bound on mean)	None	40813501 43154702	acceptable
Aerobic Aquatic Metabolism	330 days (single value)	None	47385201	acceptable
$K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g) $K_{oc\text{-}ads}$ / $K_{oc\text{-}des}$ (mL/g)	30 – 854 (U.S. soils) 61 – 285 (Japanese soils) 17,040 mL/g O.C. (U.S. soils) (avg of 5 values, 13000 – 29400) 7011- 43863 mL/g o.c. (Japanese soils)	n.a.	00153765 43041901	acceptable
Laboratory Volatility	Volatilization half-life 12.5 days from moist loam soil	None measured	00153766	
Fish Bioaccumulation	Bioconcentration factor BCF = 5100, 35-day exposure	*4-[(1-ethylpropyl)amino]-2-methyl-3,5-dinitrobenzyl alcohol (3.1%)*	00156726 00158235	acceptable

Study	Value (units)	Major Degradates *Minor Degradates*	MRID #	Study Status
Terrestrial Field Dissipation	34-day half-life in California almond orchard, sandy loam soil. No leaching below 6 inches.		41722504	acceptable
Aquatic Field Dissipation	No data			

2.4.2 Environmental Transport Assessment

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

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

In general, deposition of drifting or volatilized pesticides is expected to be greatest close to the site of application. Computer models of spray drift (AgDRIFT and/or AGDISP) are used to determine potential exposures to aquatic and terrestrial organisms via spray drift.

2.4.2 Mechanism of Action

Pendimethalin is a selective herbicide registered for control of broadleaf weeds and grassy weed species on a variety of agricultural crops, turf, and ornamentals. Pendimethalin disrupts the process of mitosis in the growth of shoots and roots. It acts as a microtubule disruptor by inhibiting cell division and cell elongation in plants, and is generally applied early in the growing season. Absorption of the herbicide takes place at the roots and the shoots. Very little translocation occurs from the site of intake.

2.4.3 Use Characterization

Pendimethalin is applied as a liquid spray formulation. Pendimethalin can be applied either by aerial equipment or using ground equipment to a variety of row crops, orchard crops, vineyards, sod, seed, and to rice. It can be broadcasted by air or ground, and be banded as a directed spray or applied by irrigation equipment in various crops. It can also be left on the soil surface or incorporated.

Approximately 27 million pounds of pendimethalin were applied in 2002 according to the National Center for Food and Agriculture, and the majority was applied to soybeans (39.6%), cotton (20.22 %), and corn (19.4 %) (Fig. 2.1). Together, soybeans, cotton, and corn account for 79 % of the applied pendimethalin nationwide. This existing use information is provided as a basis for considering background exposures from existing use.

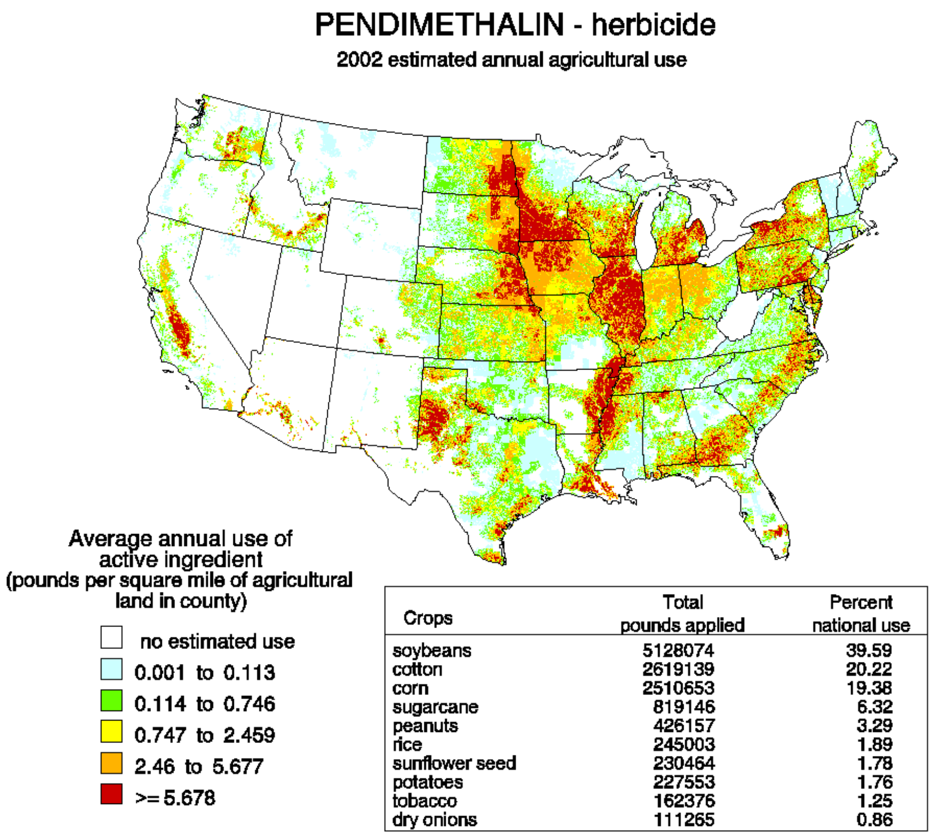
Table 2.2 presents the uses and corresponding application rates and methods of application considered in this assessment.

Table 2-2 Pendimethalin Uses Assessed for the CRLF

Use	Max. Single Appl. Rate (lb ai/A)	Max. Number of Application per Year	Application Method
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes.	6.0	1	ground
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa	4.0	1	ground, aerial
Asparagus, artichoke	3.9	1	ground, aerial
golf course turf, airports/landing fields	3.5	1	ground, aerial
residential lawns	3.0	1	ground, aerial
Shallot, onion, corn (sweet, pop, field)	2.0	1	ground, aerial
Carrot	1.9	1	ground, aerial
Sunflower	1.73	1	ground, aerial
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean),	1.485	1	ground, aerial

Use	Max. Single Appl. Rate (lb ai/A)	Max. Number of Application per Year	Application Method
Wheat, pepper, pepino (melon pear), groundcherry, eggplant	1.425	1	ground, aerial
Strawberry	1.485	2	ground, aerial
Legume vegetables	1.24	1	ground, aerial
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables	1.0	1	ground, aerial

The figure below summarizes pendimethalin use nationwide in 2002. Pendimethalin is used primarily on soybeans, cotton, corn, sugarcane, peanuts, rice, sunflower, potatoes, tobacco, and onions. Most use is apparently outside of California. Non-agricultural uses, which predominate in California, are not represented on this map. The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website.



Crops	Total pounds applied	Percent national use
soybeans	5128074	39.59
cotton	2619139	20.22
corn	2510653	19.38
sugarcane	819146	6.32
peanuts	426157	3.29
rice	245003	1.89
sunflower seed	230464	1.78
potatoes	227553	1.76
tobacco	162376	1.25
dry onions	111265	0.86

http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1629

Figure 2.1 Pendimethalin Use in Total Pounds per County

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for pendimethalin 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 Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[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 pendimethalin by county in this California-specific assessment were generated using CDPR PUR data. Eight years (1999-2006) of usage data were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all five years. The units of area treated are also provided where available.

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

Table 2.3 below gives the total number of pounds of pendimethalin used in California counties from 1994 to 1998 and 1999 to 2006. The figures represent the sum of the average number of pounds used in each year of the two periods, as reported in the Pesticide use Reporting database (PUR). Summaries of the data were provided by OPP's Biological and Economic Analysis Division (BEAD). The data indicate that the largest amounts were used in Kings, Fresno, and Kern counties, all of which exceeded 150,000 pounds. Thirteen counties (Santa Barbara through Glenn) showed use of between 10,000 and 100,000 pounds during the period. Twenty-two counties (Contra Costa through El Dorado) had usage of between 1,000 and 10,000 pounds. Overall, 54 of 58 California counties had reported usage of pendimethalin, indicating that use of the compound is geographically widespread. This is a strong line of evidence that the CRLF is potentially exposed to pendimethalin.

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

Table 2-3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1994 to 2006 for Currently Registered Pendimethalin Uses: By County

County	1994 – 1998	1999- 2006	Total
KINGS	99690	95429	195119
FRESNO	74212	77816	152028
KERN	90122	59505	149627
SANTA BARBARA	820	83486	84306
TULARE	16738	33549	50287
LOS ANGELES	4671	41639	46310
IMPERIAL	15584	24149	39733
STANISLAUS	9128	24623	33751
RIVERSIDE	15279	14997	30276
MERCED	10480	9747	20227
SAN JOAQUIN	6801	11203	18004
MADERA	7660	10086	17746
BUTTE	5758	5974	11732
SANTA CLARA	5717	5838	11555
GLENN	4865	6202	11067
CONTRA COSTA	3222	6083	9305
ORANGE	5272	3634	8906
SACRAMENTO	5571	3030	8601
SAN DIEGO	6588	1854	8442
SOLANO	2211	4261	6472
SONOMA	2897	3546	6443
ALAMEDA	1810	3288	5098
YOLO	1322	3640	4962
PLACER	1309	3167	4476
SAN BERNARDINO	2339	2073	4412
MONTEREY	2328	2052	4380
COLUSA	1149	2985	4134
SAN LUIS OBISPO	1761	1610	3371
SUTTER	1109	1857	2966
TEHAMA	1148	1212	2360
YUBA	371	1368	1739
SAN MATEO	798	854	1652
VENTURA	824	809	1633
SAN BENITO	809	753	1562
CALAVERAS	609	665	1274
SHASTA	593	642	1235
EL DORADO	466	611	1077
NAPA	418	411	829
LAKE	367	261	628
MARIN	563	46	609
TUOLUMNE	239	361	600
LASSEN	169	309	478
MODOC	84	389	473

MENDOCINO	158	293	451
AMADOR	272	145	417
SISKIYOU	138	250	388
NEVADA	307	74	381
SANTA CRUZ	148	131	279
SAN FRANCISCO	85	116	201
MONO	149	39	188
HUMBOLDT	53	19	72
INYO	49	11	60
MARIPOSA	24	4	28
TRINITY	0	1	1

Table 2.3b below shows the number of pounds of pendimethalin applied by crop and use site, during the periods 1994 to 1998, and 1999 to 2006. The figures are aggregated across counties, and are ranked by total numbers of pounds applied in the entire period. Only crops or use sites with at least 1,000 pounds usage are shown in the table.

Cotton is the major use, with nearly two million pounds applied from 1994 to 2006. Six use sites (landscape, almond, rights-of-way, garlic, onions, pistachio, and alfalfa) each totaled over 100,000 pounds applied. A further 18 uses (nursery through nectarine) each had from 10,000 to 100,000 pounds of usage.

It is notable that non-agricultural uses (landscape and rights-of-way) are among the highest uses of pendimethalin. Based on the county rankings, it is concluded that these uses represent the greatest part of the usage in urban counties.

Table 2.3b. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1994 to 2006 for Currently Registered Pendimethalin Uses: By Crop/Use Site

CROP/USE SITE	1994-1998 lbs	1999-2006 lbs	TOTAL lbs
COTTON	1198354	787909	1986263
LANDSCAPE MAINTENANCE	213421	224903	438324
ALMOND	124150	88858	213008
RIGHTS OF WAY	40510	146505	187015
GARLIC	100657	70532	171189
ONION, DRY & GREEN	49023	93909	142932
PISTACHIO	28480	93363	121843
ALFALFA	3327	99865	103192
NURSERY - ALL	43897	44167	88064
GRAPE, WINE	39711	45880	85591
POTATO	41086	35707	76793
GRAPE	34005	25160	59165
CORN, HUMAN CONSUMPTION	29757	28782	58539
BEAN, DRIED	14529	38200	52729
UNCULTIVATED AG / nonag	8370	42817	51187
WALNUT	17340	29352	46692

CORN (FORAGE - FODDER)	13629	22894	36523
SUNFLOWER	8257	12354	20611
ORANGE	2317	17988	20305
PEACH	3572	13534	17106
RICE	1237	15149	16386
BEAN, UNSPECIFIED	11229	4922	16151
SOIL FUMIGATION/PREPLANT	6852	8718	15570
PRUNE	12351	3213	15564
BEAN, SUCCULENT	2817	7853	10670
NECTARINE	2529	8053	10582
WHEAT	7703	1143	8846
PLUM	594	6954	7548
CHERRY	0	6913	6913
SAFFLOWER	180	3853	4033
STRUCTURAL PEST CONTROL	2204	1685	3889
TOMATO	796	2863	3659
CELERY	3354	15	3369
LEMON	817	2288	3105
APPLE	2369	594	2963
TURF/SOD	1624	1013	2637
WATER(INDUSTRIAL)	0	1429	1429
SUGARCANE	72	1307	1379
TANGERINE	174	1178	1352
SORGHUM/MILO	892	281	1173

2.5 Assessed Species

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

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

2.5.1 Distribution

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

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

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

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 CRLFs outside of the currently occupied core areas and designated critical habitat is considered in defining the current range of the CRLF. See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.

Recovery Units

1. Sierra Nevada Foothills and Central Valley
2. North Coast Range Foothills nd Western Sacramento River Valley
3. North Coast and North San Francisco Bay
4. South and East San Francisc Bay
5. Central Coast
6. Diablo Range and Salinas Valley
7. Northern Transverse Rang nd 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

Figure 2.2 Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

2.5.2 Reproduction

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers 2005a). According to the Recovery Plan (USFWS 2002), CRLFs breed from November through late April. Peaks in spawning activity vary geographically; Fellers (2005b) reports peak spawning as early as January in parts of coastal central California. Eggs are fertilized as they are being laid. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto 1984). Egg masses contain approximately 2000 to 6000 eggs ranging in size between 2 and 2.8 mm (Jennings and Hayes 1994). Embryos hatch 10 to 14 days after fertilization (Fellers 2005a) depending on water temperature. Egg predation is reported to be infrequent and most mortality is associated with the larval stage (particularly through predation by fish); however, predation on eggs by newts has also been reported (Rathburn 1998). Tadpoles require 11 to 28 weeks to metamorphose into juveniles (terrestrial-phase), typically between May and September (Jennings and Hayes 1994, USFWS 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers 2005b, USFWS 2002). Males reach sexual maturity at 2 years, and females reach sexual maturity at 3 years of age; adults have been reported to live 8 to 10 years (USFWS 2002). Figure 2.3 depicts CRLF annual reproductive timing.

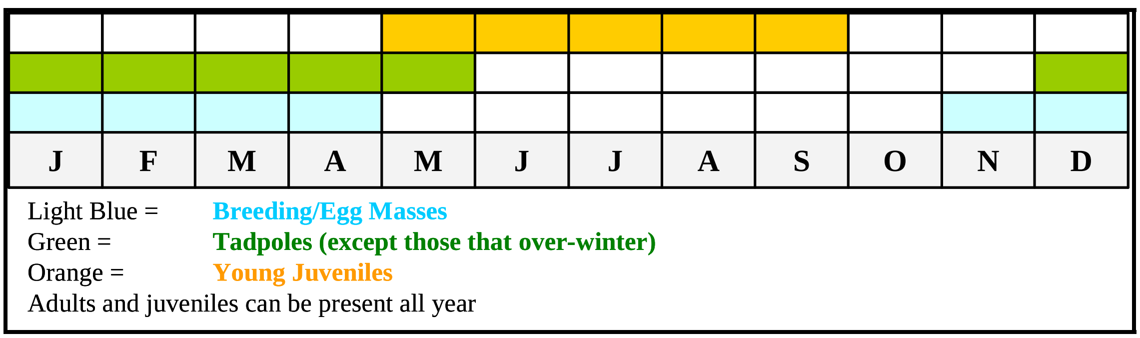


Figure 2.3 CRLF Reproductive Events by Month

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 CRLFs forage in aquatic and terrestrial habitats, and their diet differs greatly from that of larvae. The main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic and terrestrial invertebrates found along the shoreline and on the water surface. Hayes and Tennant (1985) report, based on a study examining the gut content of 35 juvenile and adult CRLFs, that the species feeds on as many as 42 different invertebrate taxa, including Arachnida, Amphipoda, Isopoda, Insecta, and Mollusca. The most commonly observed prey species were larval alderflies

(*Sialis* cf. *californica*), pillbugs (*Armadilliadrium vulgare*), and water striders (*Gerris* sp). The preferred prey species, however, was the sowbug (Hayes and Tennant, 1985). This study suggests that CRLFs forage primarily above water, although the authors note other data reporting that adults also feed under water, are cannibalistic, and consume fish. For larger CRLFs, over 50% of the prey mass may consists of vertebrates such as mice, frogs, and fish, although aquatic and terrestrial invertebrates were the most numerous food items (Hayes and Tennant 1985). For adults, feeding activity takes place primarily at night; for juveniles feeding occurs during the day and at night (Hayes and Tennant 1985).

2.5.4 Habitat

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

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

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

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

2.6 Designated Critical Habitat

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

'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 (Section 7) through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be 'essential to the conservation of the species.' Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

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

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

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

USFWS has established adverse modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of pendimethalin 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) Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.
(3) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat 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.
(4) 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.
(5) Elimination of upland foraging and/or aestivating habitat or 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 (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 pendimethalin is expected to directly impact living organisms within the action area, critical habitat analysis for pendimethalin 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 pendimethalin is likely to encompass considerable portions of the United States based on the large array of agricultural and its 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. The Agency's approach to defining the action area under the provisions of the Overview Document (USEPA 2004) considers the results of the risk assessment process to establish boundaries for that action area with the understanding that exposures below the Agency's defined Levels of Concern (LOCs) constitute a no-effect threshold. For the purposes of this assessment, attention will be focused on the footprint of the action (i.e., the area where pesticide application occurs), plus all areas where offsite transport (i.e., spray drift, downstream dilution, etc.) may result in potential exposure within the state of California that exceeds the Agency's LOCs.

Deriving the geographical extent of this portion of the action area is based on consideration of the types of effects that pendimethalin may be expected to have on the environment, the exposure levels to pendimethalin that are associated with those effects, and the best available information concerning the use of pendimethalin and its fate and transport within the state of California. Specific measures of ecological effect that define the action area include any direct and indirect toxic effect and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature. Therefore, the action area extends to a point where environmental exposures are below any measured lethal or sublethal effect threshold for any biological entity at the whole organism, organ, tissue, and cellular level of organization. In situations where it is not possible to determine the threshold for an observed effect, the action area is not spatially limited and is assumed to be the entire 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 pendimethalin. An analysis of labeled uses and review of available product labels was completed. Several of the current labels are special local needs (SLN) labels for other states and some uses on other labels are restricted to specific states other than California and are, therefore, excluded from this assessment. The agricultural and nonagricultural uses that are considered as part of the federal action evaluated in this assessment can be found in Table 2.2.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of pendimethalin use patterns (i.e., the area where pesticide application occurs) is determined. This "footprint" represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. A map representing all the land cover types that make up the initial area of concern for pendimethalin is presented in

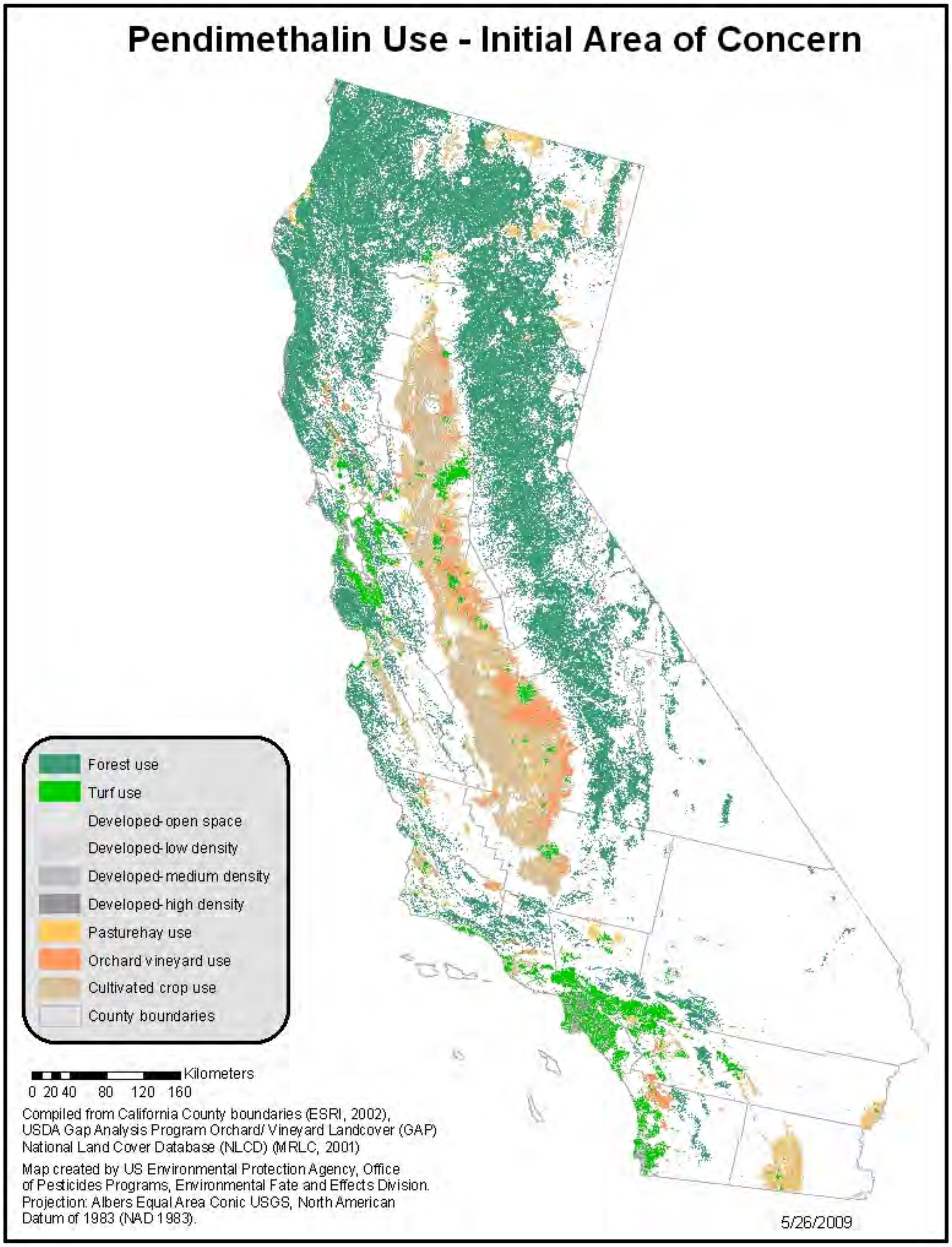


Figure 2.4.

More information regarding which specific uses are represented for each land cover types can be found in Appendix D.

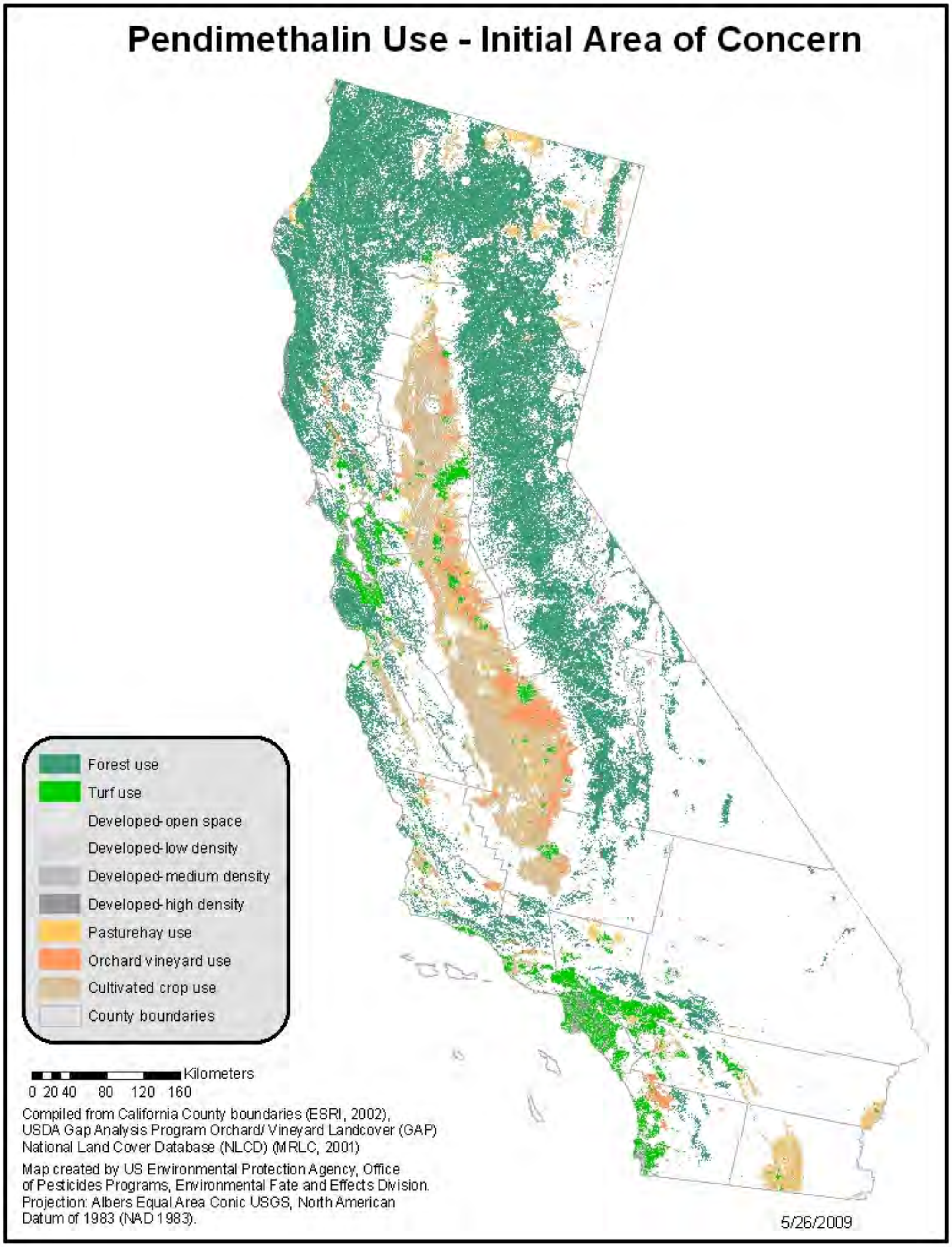


Figure 2.4. Initial area of concern, or "footprint" of potential use, for Pendimethalin

Once the initial area of concern is defined, the next step is to define the potential boundaries of the action area by determining the extent of offsite transport via spray drift and runoff where exposure of one or more taxonomic groups to the pesticide exceeds the listed species LOCs.

As previously discussed, the action area is defined by the most sensitive measure of direct and indirect ecological toxic effects including reduction in survival, growth, reproduction, and the entire suite of sublethal effects from valid, peer-reviewed studies.

The action area is determined by the footprint of the action plus all offsite areas where exposure of one or more taxonomic groups to pendimethalin exceeds the Agency's LOCs. The spatial extent at which the Agency's LOCs are not exceeded is based on the potential exposure level and the most sensitive effects endpoints The most sensitive for terrestrial environments was the plant EC25 of 0.01 lb/acre for ryegrass seedling emergence, Table 4.5). The most sensitive endpoints for aquatic environments were the duckweed EC50 of 12.5 ppb and the diatom EC50 of 5.2 ppb (section 4.1.3.1).

The routes of exposure that determine the extent of the action area are run-off in stormwater or irrigation water (mostly in the sorbed phase) and spray drift. Volatilization and redeposition (eg., via rainwater) may also contribute to the extent of the action area, bur this could not be quantified. A paper by Vogel et al. (2008) found pendimethalin in rainwater in Merced County at a concentration of 0.143 ppb maximum. This is an additional line of evidence that pendimethalin may be transported by air outside the immediate use site.

The AgDRIFT model (Version 2.01) is used to define how far from the initial area of concern an effect to a given species may be expected via spray drift. The spray drift analysis for pendimethalin using the most sensitive endpoint (ryegrass seedling emergence EC25 of 0.01 lb/acre) suggests that effects are expected beyond 1,000 feet from the edge of pendimethalin treated areas

In addition to the buffered area from the spray drift analysis, the final action area also considers the downstream extent of pendimethalin that exceeds the LOC. Based on this analysis, the action area includes streams as far as 272 kilometers downstream from forestry use areas.

An evaluation of usage information was conducted to determine the area where use of pendimethalin may impact the CRLF. This analysis is used to characterize where predicted exposures are most likely to occur, but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed. These data suggest that pendimethalin is widely used both in agricultural and non-agricultural settings in 54 of 58 California counties. Thus, it is likely that pendimethalin use sites and CRLF habitat areas intersect.

Based on these considerations, the action area is considered to be the entire state of California.

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 pendimethalin (e.g., runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to pendimethalin (e.g., direct contact, etc.).

2.8.1 Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base 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. It should be noted that assessment endpoints are limited to direct and indirect effects associated with survival, growth, and fecundity, and do not include the full suite of sublethal effects used to define the action area. According the Overview Document (USEPA 2004), the Agency relies on acute and chronic effects endpoints that are either direct measures of impairment of survival, growth, or fecundity or endpoints for which there is a scientifically robust, peer reviewed relationship that can quantify the impact of the measured effect endpoint on the assessment endpoints of survival, growth, and fecundity.

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 4.0 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 pendimethalin is provided in table 2-4 below.

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

Table 2-4 Assessment Endpoints and Measures of Ecological Effects

Assessment Endpoint	**Measures of Ecological Effects**[4]
Aquatic-Phase CRLF (Eggs, larvae, juveniles, and adults)[a]	
Direct Effects	
1. Survival, growth, and reproduction of CRLF	1a. Most sensitive fish acute LC_{50} (guideline or ECOTOX) if no suitable amphibian data are available 1b. Most sensitive fish chronic NOAEC (guideline or ECOTOX) if no suitable amphibian data are available
Indirect Effects and Critical Habitat Effects	
2. Survival, growth, and reproduction of CRLF individuals via indirect effects on aquatic prey food supply (*i.e.*, fish, freshwater invertebrates, non-vascular plants)	2a. Most sensitive fish, aquatic invertebrate, and aquatic plant EC_{50} or LC_{50} (guideline or ECOTOX) 2b. Most sensitive aquatic invertebrate and fish chronic NOAEC (guideline or ECOTOX)
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Vascular plant acute EC_{50} (duckweed guideline test or ECOTOX vascular plant) 3b. Non-vascular plant acute EC_{50} (freshwater algae or diatom, or ECOTOX non-vascular)
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation	4a. Distribution of EC_{25} values for monocots (seedling emergence, vegetative vigor, or ECOTOX) 4b. Distribution of EC_{25} values for dicots (seedling emergence, vegetative vigor, or ECOTOX)
Terrestrial-Phase CRLF (Juveniles and adults)	
Direct Effects	
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Most sensitive bird[b] or terrestrial-phase amphibian acute LC_{50} or LD_{50} (guideline or ECOTOX) 5b. Most sensitive bird[b] or terrestrial-phase amphibian chronic NOAEC (guideline or ECOTOX)
Indirect Effects and Critical Habitat Effects	
6. Survival, growth, and reproduction of CRLF individuals via effects on terrestrial prey (*i.e.,*terrestrial invertebrates, small mammals , and frogs)	6a. Most sensitive terrestrial invertebrate and vertebrate acute EC_{50} or LC_{50} (guideline or ECOTOX)[c] 6b. Most sensitive terrestrial invertebrate and vertebrate chronic NOAEC (guideline or ECOTOX)
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian and upland vegetation)	7a. Distribution of EC_{25} for monocots (seedling emergence, vegetative vigor, or ECOTOX 7b. Distribution of EC_{25} for dicots (seedling emergence, vegetative vigor, or ECOTOX)

[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.

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

2.8.2 Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of pendimethalin that may alter the PCEs of the CRLF's critical habitat. PCEs for the CRLF were previously described in Section 2.6. Actions that may modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the CRLF. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (i.e., the biological resource requirements for the listed species associated with the critical habitat) and those for which pendimethalin effects data are available. Adverse modification to the critical habitat of the CRLF includes, but is not limited to, those listed in Section 2.6.

Measures of such possible effects by labeled use of pendimethalin on critical habitat of the CRLF are described in Table 2-55. Some components of these PCEs are associated with physical abiotic features (e.g., presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 2-5 Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat[a]

Assessment Endpoint	Measures of Ecological Effect
Aquatic-Phase CRLF PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	a. Most sensitive aquatic plant EC_{50} (guideline or ECOTOX) b. Distribution of EC_{25} values for terrestrial monocots (seedling emergence, vegetative vigor, or ECOTOX) c. Distribution of EC_{25} values for terrestrial dicots (seedling emergence, vegetative vigor, or ECOTOX)
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	a. Most sensitive EC_{50} values for aquatic plants (guideline or ECOTOX) b. Distribution of EC_{25} values for terrestrial monocots (seedling emergence or vegetative vigor, or ECOTOX) c. Distribution of EC_{25} values for terrestrial dicots (seedling emergence, vegetative vigor, or ECOTOX)
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	a. Most sensitive EC_{50} or LC_{50} values for fish or aquatic-phase amphibians and aquatic invertebrates (guideline or ECOTOX) b. Most sensitive NOAEC values for fish or aquatic-phase amphibians and aquatic invertebrates (guideline or ECOTOX)
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	a. Most sensitive aquatic plant EC_{50} (guideline or ECOTOX)
Terrestrial-Phase CRLF PCEs (Upland Habitat and Dispersal Habitat)	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	a. Distribution of EC_{25} values for monocots (seedling emergence, vegetative vigor, or ECOTOX) b. Distribution of EC_{25} values for dicots (seedling emergence, vegetative vigor, or ECOTOX) c. Most sensitive food source acute EC_{50}/LC_{50} and NOAEC values for terrestrial vertebrates (mammals) and invertebrates, birds or terrestrial-phase amphibians, and freshwater fish.
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	

[a] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

2.9 Conceptual Model

2.9.1 Risk Hypotheses

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

The labeled use of pendimethalin within the action area may:

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

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the pendimethalin release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for terrestrial and aquatic exposures are shown in Figure 2.5 and Figure 2.6, respectively, which include the conceptual models for the aquatic and terrestrial PCE components of critical habitat.

Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the CRLF and modification to designated critical habitat is expected to be negligible.

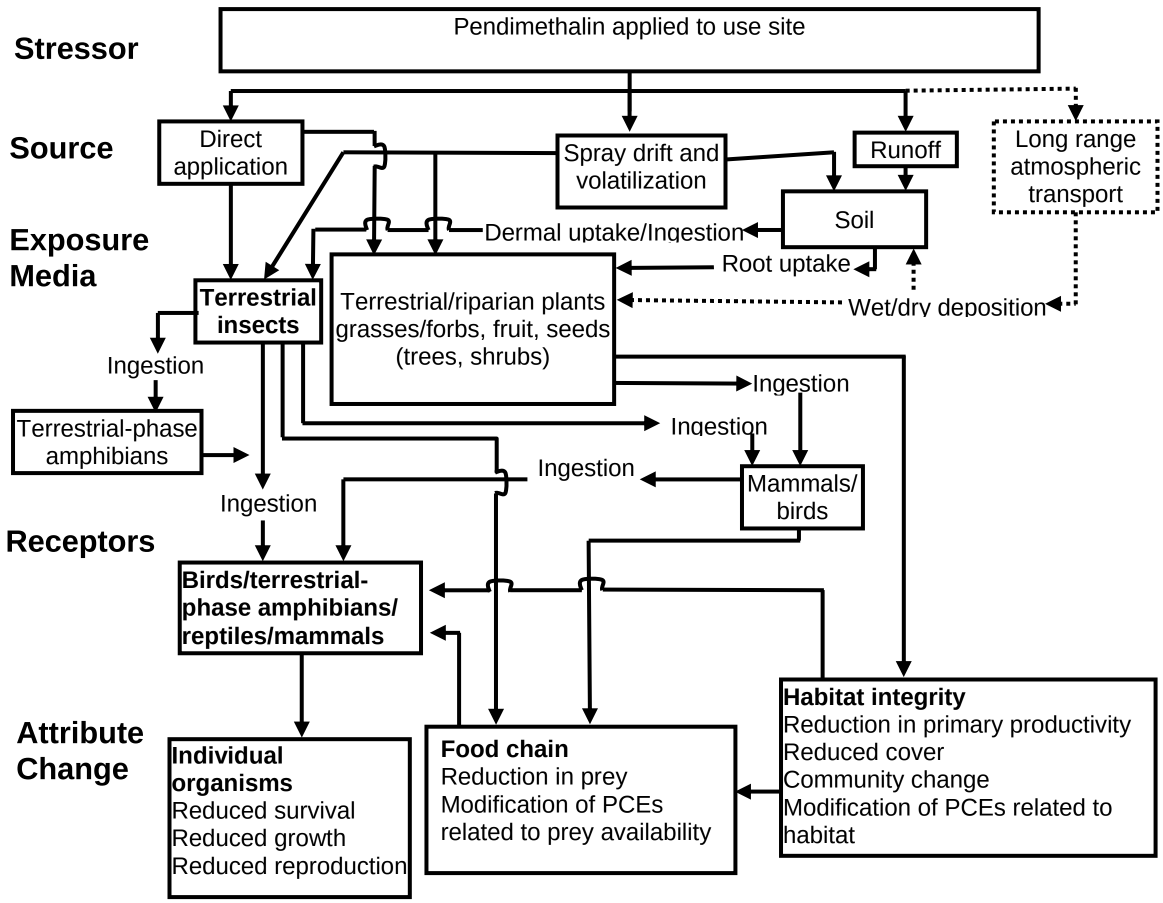


Figure 2.5 Conceptual Model for Pesticide Effects on Terrestrial Phase of the CRLF

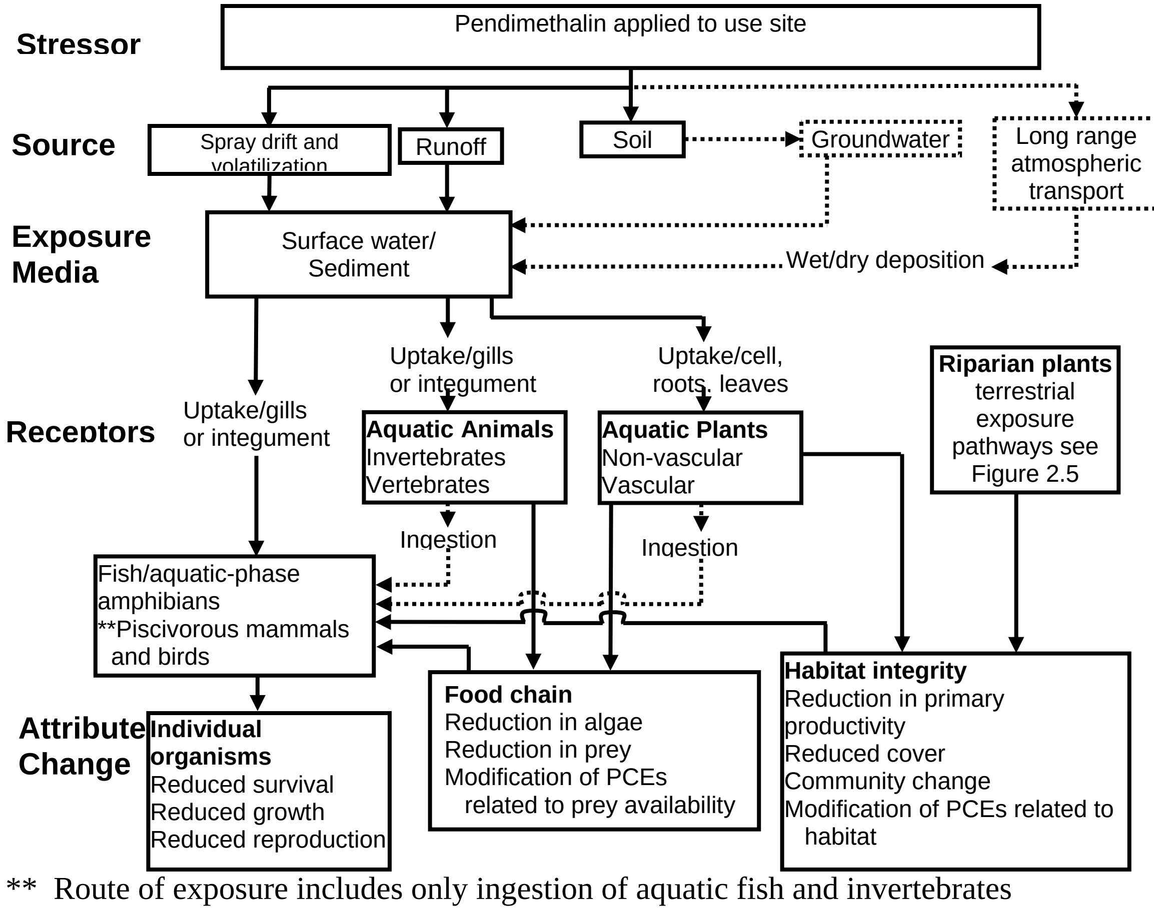


Figure 2.6 Conceptual Model for Pesticide Effects on Aquatic Phase of the CRLF

2.10 Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the CRLF, its prey, and its habitat is estimated. In the following sections, the use, environmental fate, and ecological effects of pendimethalin are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (U.S. EPA, 2004), the likelihood of effects to individual organisms from particular uses of pendimethalin is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

2.10.1 Measures to Evaluate the Risk Hypothesis and Conceptual Model

2.10.1.1 Measures of Exposure

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

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of pendimethalin using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The Tier 1 Rice model is used to estimate pendimethalin concentrations in rice paddy water on the day of application. The model used to predict terrestrial EECs on food items is T-REX. The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data.

PRZM (v3.12.2, May 2005) and EXAMS (v2.98.4.6, April 2005) are screening simulation models coupled with the input shell pe5.pl (Aug 2007) to generate daily exposures and 1-in-10 year EECs of pendimethalin that may occur in surface water bodies adjacent to application sites receiving pendimethalin through runoff and spray drift. PRZM simulates pesticide application, movement and transformation on an agricultural field and the resultant pesticide loadings to a receiving water body via runoff, erosion and spray drift. EXAMS simulates the fate of the pesticide and resulting concentrations in the water body. The standard scenario used for ecological pesticide assessments assumes application to a 10-hectare agricultural field that drains into an adjacent 1-hectare water body, 2-meters deep (20,000 m^3 volume) with no outlet. PRZM/EXAMS was used to estimate screening-level exposure of aquatic organisms to pendimethalin. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10 year peak is used for estimating acute exposures of direct effects to the CRLF, as well as indirect effects to the CRLF through effects to potential prey items, including: algae, aquatic invertebrates, fish and frogs. The 1-in-10-year 60-day mean is used for assessing chronic exposure to the CRLF and fish and frogs serving as prey items; the 1-in-10-year 21-day mean is used for assessing chronic exposure for aquatic invertebrates, which are also potential prey items.

Exposure in aquatic environments via bioaccumulation and foodchain exposure was quantified with the KABAM (Kow-based bioaccumulation) model (documented at http://www.epa.gov/oppefed1/models/water/kabam/kabam_user_guide.html).

Exposure estimates for the terrestrial-phase CRLF and terrestrial invertebrates and mammals (serving as potential prey) assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.3.1, 12/07/2006). This model incorporates the Kenega nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenega, 1972). For modeling purposes, direct exposures of the CRLF to pendimethalin through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey (small mammals) are assessed using the small mammal (15 g) which consumes short grass. The small bird (20g) consuming small insects and the small mammal (15g) consuming short grass are used because these categories represent the largest RQs of the size and dietary categories in T-REX that are appropriate surrogates for the CRLF and one of its prey items. Estimated exposures of terrestrial insects to pendimethalin are bound by using the dietary based EECs for small insects and large insects.

Birds are currently used as surrogates for terrestrial-phase CRLF. However, amphibians are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds or mammals. As a consequence, birds are likely to consume more food than amphibians on a daily dietary intake basis, assuming similar caloric content of the food items. Therefore, the use of avian food intake allometric equation as a surrogate to amphibians is likely to result in an over-estimation of exposure and risk for reptiles and terrestrial-phase amphibians. Therefore, T-REX (version 1.3.1) has been refined to the T-HERPS model (v. 1.0), which allows for an estimation of food intake for poikilotherms using the same basic procedure as T-REX to estimate avian food intake.

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

Spray drift models, AGDISP and/or AgDRIFT are used to assess exposures of terrestrial phase CRLF and its prey to pendimethalin deposited on terrestrial habitats by spray drift. AGDISP (version 8.13; dated 12/14/2004) (Teske and Curbishley, 2003) is used to simulate aerial and ground applications. In addition to the buffered area from the spray drift analysis, the downstream extent of pendimethalin that exceeds the LOC for the effects determination is also considered.

Although volatility is a potential route of exposure, volatility and subsequent deposition will not be quantified because there are currently no valid models that would be useful to quantify this potential route of exposure to terrestrial environments. Pendimethalin is a semi-volatile compound that may be lost from moist soil. The volatilization half-life from moist soil was found to be 12.5 days (MRID 00153766). Pendimethalin has been observed at low concentrations (0.143 ppb maximum) in rainwater in California (Vogel et al., 2008). This effect was accounted for in the PRZM-EXAMS modeling by invoking the PRZM volatilization routine, thus allowing volatilization to compete with runoff and metabolism as a dissipation route. Comparison of the highest EEC scenario (forestry) shows that the effect is small (16.6 ppb with volatility invoked and 18.1 ppb without). The relatively slow volatilization rate from even moist soil is not believed to result in as large or immediate an aquatic exposure as spray drift at the time of application. Thus, airborne exposure is adequately quantified by the spray drift analysis. Terrestrial exposure of plants and animals is accounted for by the AgDrift and AgDISP effect area analysis.

2.10.1.2 Measures of Effect

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

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

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

It is important to note that the measures of effect for direct and indirect effects to the CRLF and its designated critical habitat are associated with impacts to survival, growth, and fecundity, and do not include the full suite of sublethal effects used to define the action area. According the Overview Document (USEPA 2004), the Agency relies on effects endpoints that are either direct measures of impairment of survival, growth, or fecundity or endpoints for which there is a scientifically robust, peer reviewed relationship that can quantify the impact of the measured effect endpoint on the assessment endpoints of survival, growth, and fecundity.

2.10.1.3 Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from agricultural and non-agricultural uses of pendimethalin, and the likelihood of direct and indirect effects to CRLF in aquatic and terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. For the assessment of pendimethalin risks, the risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see Appendix C).

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

3.0 Exposure Assessment

Pendimethalin is formulated as granules and emulsifiable concentrate. Application equipment includes ground application, and aerial application. Risks from ground boom and aerial applications are expected to result in the highest off-target levels of pendimethalin due to generally higher spray drift levels. Ground boom and aerial modes of application tend to use lower volumes of application applied in finer sprays than applications coincident with sprayers and spreaders and thus have a higher potential for off-target movement via spray drift.

3.1 Label Application Rates and Intervals

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

There are no known pending mitigations that would influence the exposure assessment.

Currently registered agricultural and non-agricultural uses of pendimethalin within California are summarized in Table 3-1.

Table 3-1 Pendimethalin Uses, Scenarios, and Application Information for the CRLF risk assessment[1]

Scenario	Uses Represented by Scenario	Application Rate	Application Method
Scenario	**Uses Represented**	**Application rate (lb/acre)**	**Application method**
CAalfalfa_WirrigOP	alfalfa	3.98	air
CAalmond_WirrigSTD	nut trees	5.985	ground
CAalmond_WirrigSTD	nut trees	3.96	air
Cacitrus_WirrigSTD	citrus crops	5.985	ground
Cacitrus_WirrigSTD	citrus crops	3.96	air
CAcolecropRLF	cole crops	0.99	air
CAcornOP	field corn, sweet corn, popcorn	1.98	air
Cacotton_WirrigSTD	cotton	1.98	air
CAForestryRLF	forestry	3.96	air
Cafruit_WirrigSTD	fruit trees	3.96	air
CAgarlicRLF	garlic	1.485	air
Cagrapes_WirrigSTD	grapes	5.845	ground
Cagrapes_WirrigSTD	grapes	3.96	air
CAmelonsRLF	eggplant	1.485	air
CAOliveRLF	olives	3.96	air
CAOnion_WirrigSTD	onion	1.98	air
CApotatoRLF	potato, white/Irish	1.485	air
CArowcropRLF	artichoke/asparagus	3.895	air
CAStrawberry-noplasticRLF	strawberry	1.485	air

Scenario	Uses Represented by Scenario	Application Rate	Application Method
Catomato_WirrigSTD	tomato, tomatillo	1.485	ground
CAtomatoSTD	groundcherry	1.485	air
CARightofWayfRLF, CAImperviousRLF	rights-of-way	3.96	air
CAwheatRLF	wheat	1.485	air
Tier 1 Rice Model	rice	0.99	air

1 Uses assessed based on memorandum from SRRD (Verification Memorandum for Pendimethalin for Red Legged Frog Assessment) dated 2/17/2009.

3.2 Aquatic Exposure Assessment

3.2.1 Modeling Approach

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

Crop-specific management practices for all of the assessed uses of pendimethalin were used for modeling, including application rates, number of applications per year, application intervals, and the first application date for each crop.

The Tier 1 Rice Model calculates the water column concentration in a flooded rice paddy on the day of application, accounting only for sorption to sediment as a dissipation mechanism.

KABAM is used to estimate potential bioaccumulation of hydrophobic organic pesticides in freshwater aquatic ecosystems and risks to mammals and birds consuming aquatic organisms which have bioaccumulated these pesticides. This tool can also be used to estimate pesticide concentrations in fish tissues consumed by humans (i.e., filets). The bioaccumulation portion of KABAM is based upon work by Arnot and Gobas (2004) who parameterized a bioaccumulation model based on PCBs and some pesticides (e.g., lindane, DDT) in freshwater aquatic ecosystems. KABAM relies on a chemical's octanol-water partition coefficient (KOW) to estimate uptake and elimination constants through respiration and diet of organisms in different trophic levels. Pesticide tissue residues are calculated for different levels of an aquatic food web. The model then uses pesticide tissue concentrations in aquatic animals to estimate dose- and dietary-based exposures and associated risks to mammals and birds consuming aquatic organisms, using an approach that is similar to the TREX model (USEPA 2008). Input parameters for KABAM are given in Appendix K.

3.2.2 Model Inputs

Pendimethalin is a herbicide used on a wide variety of food, non-food crops, and non-agricultural sites. Pendimethalin environmental fate data used for generating model parameters is listed in Table 2.1 in Section 2.4.1. The input parameters for PRZM and EXAMS are in Table 3-2. Application dates were generally one to two weeks before the crop emergence date in the PRZM scenario, as pendimethalin is a pre-emergence/pre-plant herbicide.

Table 3-2 Summary of PRZM/EZAMS Environmental Fate Data Used for Aquatic Exposure Inputs for Pendimethalin Endangered Species Assessment for the CRLF [1]

Fate Property	Value (unit)	MRID (or source)
Molecular Weight	281.31	
Henry’s constant	8.6E-7 atm-m3/mol	VP/solubility
Vapor Pressure	3.0E-5 mmHg	00153766
Solubility in Water	3.0 mg/L at 25ºC	00153762; 10x actual value as per Input Parameter Guidance (IPG)
Photolysis in Water	42 day half-life (12 hours light/dark)	00153763
Aerobic Soil Metabolism Half-lives	172 days	40185104; deviation from IPG as explained in 1997 RED
Hydrolysis	Stable	00106777
Aerobic Aquatic Metabolism (water column)	330 day half-life (total system) 3x factor not used due to long half-life from single study	47385201
Anaerobic Aquatic Metabolism (benthic)	208 day half-life	40813501; upper 90th %ile confidence bound
Koc	17040 mL/g o.c.	43041901 (average of 5 values)
Application rate and frequency	See table 3.1	
Application intervals		
Chemical Application Method (CAM)	Soil appl;ied	

Fate Property	Value (unit)	MRID (or source)
Application Efficiency	0.99 ground 0.95 aerial	IPG
Spray Drift Fraction	0.01 ground 0.05 aerial	IPG
Air Diffusion coefficient	3427 cm2/day	= 1.55/(MW)^0.65
Enthalpy of Vaporization	20 kcal/mol	PRZM default

1 – Inputs determined in accordance with EFED "Guidance for Chemistry and Management Practice Input Parameters for Use in Modeling the Environmental Fate and Transport of Pesticides" dated February 28, 2002

3.2.3 Results

The aquatic EECs for the various scenarios and application practices are listed in Table 3-3**.** Most peak exposures were 16 ppb or below. Most exposures were dominated by spray drift.

Table 3-3 Aquatic EECs (µg/L) for Pendimethalin Uses in California

PRZM Scenario	Application Rate (lb/A)	Aerial/ Ground	Specific Crop	Peak EEC (ppb)	21-day EEC (ppb)	60-day EEC (ppb)
CAcolecropRLF	0.99	A	Several cole crops	3.16	1.29	0.98
Cacitrus_WirrigSTD [a]	5.985	G	Several citrus crops	3.42	0.94	0.58
Cagrapes_WirrigSTD, CAwinegrapesRLF	5.845	G	grapes	4.06	1.31	0.95
CApotatoRLF	1.485	A	potato, white/Irish	4.14	0.99	0.57
CAtomatoSTD	1.485	A	groundcherry	4.21	1.10	0.66
CAmelonsRLF	1.485	A	eggplant	4.22	1.04	0.62
CAgarlicRLF	1.485	A	garlic	4.31	1.15	0.73
CAStrawberry-noplasticRLF	1.485	A	strawberry	4.74	1.92	1.36
CAOnion_WirrigSTD	1.98	A	onion	5.55	1.35	0.80
Cacotton_WirrigSTD	1.98	A	cotton	5.75	1.54	0.99
CAwheatRLF	1.485	A	wheat	6.10	2.81	2.13
CAalmond_WirrigSTD	5.985	G	several	6.56	2.38	1.61
CAcornOP	1.98	A	several	6.84	2.00	1.54
Cacitrus_WirrigSTD [a]	3.96	A	several	11.06	2.65	1.52
CAOliveRLF	3.96	A	olives	11.16	2.78	1.70
Cafruit_WirrigSTD [b]	3.96	A	several	11.18	3.03	1.85
CAalfalfa_WirrigOP	3.98	A	alfalfa	11.28	3.11	1.95
Cagrapes_WirrigSTD, CAwinegrapesRLF	3.96	A	grapes	11.44	2.94	1.83
CAalmond_WirrigSTD [c]	3.96	A	several	11.71	3.68	2.30
CArowcropRLF [d]	3.895	A	artichoke/asparagus	11.92	4.04	2.86

CAForestryRLF [e]	3.96	A	several	16.60	6.41	4.93
Tier 1 Rice Model	0.99	A	rice	48	---	---
CARightofWayfRLF, CAImperviousRLF [f]	3.96	A	several	1.74	0.55	0.36

[a] This scenario represents calamondin, citron (citrus), citrus hybrids other than tangelo, grapefruit, kumquat, lemon, lime, orange, pummelo (shaddock), and tangelo.
[b] This scenario represents apple, apricot, cherry, crabapple, fig, loquat, nectarine, peach, pear, pepino (melon pear), plum, pomegranate, prune, quince, and small fruits.
[c] This scenario represents almond, beech nut, brazil nut, butternut, cashew, chestnut, chinquapin, filbert (hazelnut), hickory nut, macadamia nut (bushnut), mayhaw (hawthorn), pecan, pistachio, walnut (English or black) .
d This scenario represents artichoke, asparagus, beans, carrot (including tops), garbanzos (including chick peas), legume vegetables, peanuts (unspecified), peas, and pepper.
[e] This scenario represents forestry and Christmas tree plantations.
[f] These combined scenarios represents airports/landing fields, commercial/industrial lawns, golf course turf, industrial areas (outdoor), mulch, ornamental and/or shade trees, ornamental ground cover, ornamental herbaceous plants, ornamental lawns and turf, ornamental non-flowering plants, ornamental sod farm (turf), ornamental woody shrubs and vines, paved areas (private roads/sidewalks), Rights-of-way, fencerows, hedges recreation area lawns, residential lawns, and shelterbelt plantings. Combined EEC is 50% Impervious scenario with 1% of application rate and no drift, and 50% Rights-of-way scenario.

3.2.4 Existing Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. Included in this assessment are pendimethalin data from the USGS NAWQA program (http://water.usgs.gov/nawqa) and data from the California Department of Pesticide Regulation (CDPR).

3.2.4.1 USGS NAWQA Surface Water Data

Data for pendimethalin and its degradate hydroxypendamethalin were downloaded from the NAWQA Data Warehouse site on March 30, 2009. The data was restricted to California sampling stations. There were 604 measurements of pendimethalin in the Sacramento River and San Joaquin-Tulare River basins. There was measureable pendimethalin in 319 of the 604 samples (53% positive).

The highest concentration recorded (0.679 ppb) was at a station called "Highline Cn Spill Nr Hilmar Ca" in the San Joaquin-Tulare River Basin. All 9 measurements at this site were positive for pendimethalin, with a range of 0.262 to 0.679 ppb.

All 8 measurements of hydroxypendimethalin in surface water were in the San Joaquin-Tulare basin. All were non-detect (<0.143 ppb).

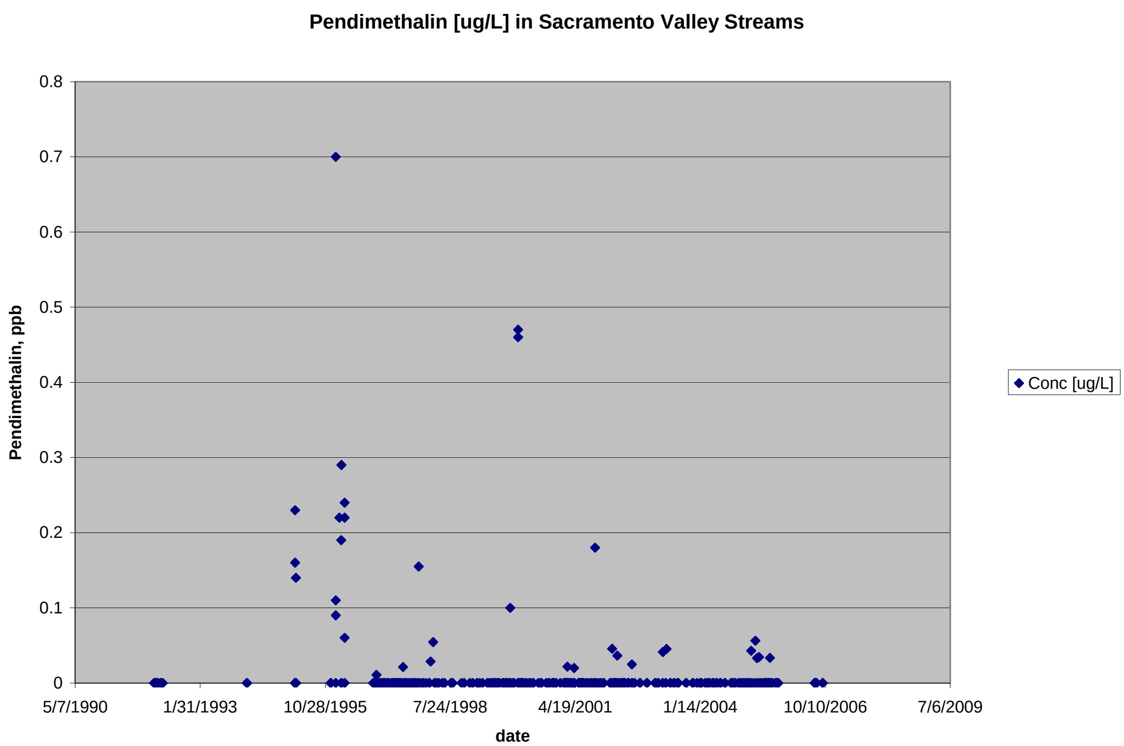
3.2.4.2 USGS NAWQA Groundwater Data

There were 589 measurements of pendimethalin in the NAWQA data for the Sacramento River and San Joaquin-Tulare River Basins. There was only one positive result (0.0138 ppb) in Stanislaus County (San Joaquin-Tulare basin).

All 61 measurements of pendimethalin in ground water were in the San Joaquin-Tulare basin. All were non-detect (<0.143 ppb).

3.2.4.3 California Department of Pesticide Regulation (CPR) Data

Data for pendimethalin were downloaded from the California surface water monitoring database on March 19, 2009. There were 565 measurements of pendimethalin in the Sacramento River valley (33 were positive), and 1802 measurements (326 were positive) in the San Joaquin River valley. The maximum concentration in the Sacramento River valley was 0.7 ppb, and it was 3.5 ppb in the San Joaquin valley. The data for all stations in the two valleys are given in Figure 3.1 below.



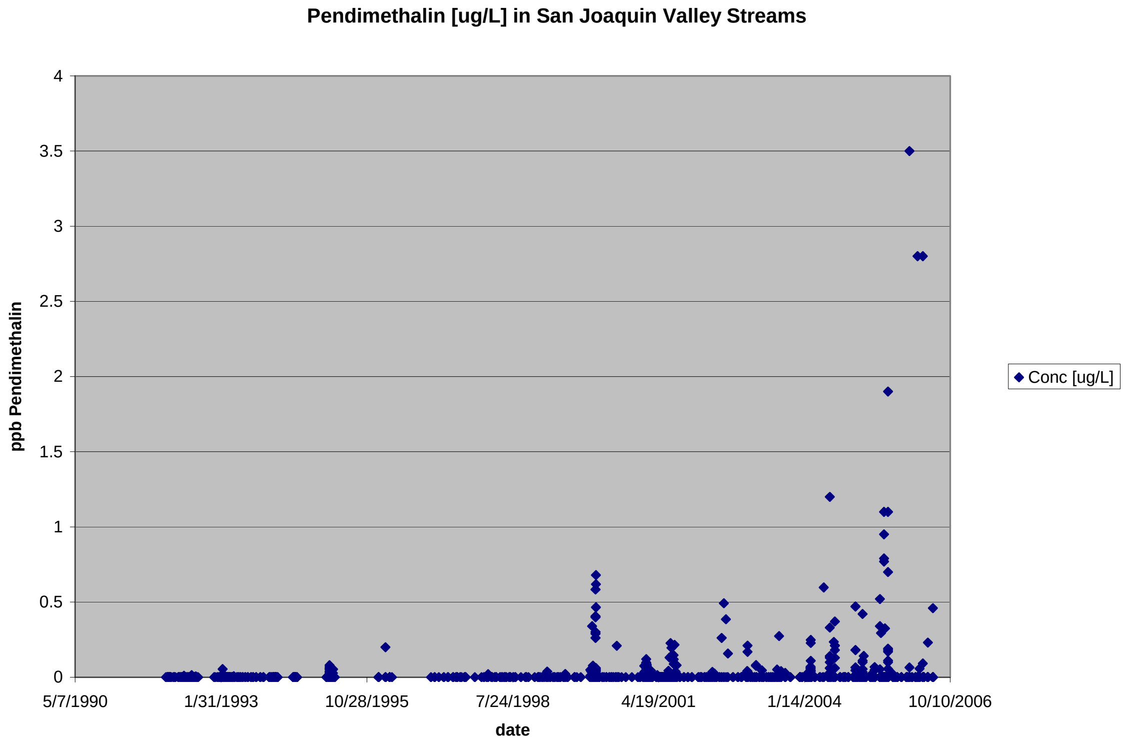


Figure 3.1 California DPR surface water monitoring data

3.2.4.4 Atmospheric Monitoring Data

Pendimethalin has been detected in air in an agricultural setting (Merced River basin downstream from McSwain dam) in California (Vogel et al. 2008). Of 23 rainwater samples taken, 78% were positive, with a maximum concentration of 0.143 µg/L, and a median of 0.021 µg/L. Sampling was conducted in 2003 and 2004.

As explained above in section 2.10.1.1, volatilization and redeposition is not quantifiable with currently approved models. However, analysis of water modeling results with and with soil volatilization routines invoked indicate that the volatilization effect is small for pendimethalin, and airborne exposure is dominated by spray drift at the time of application.

3.2.4.5 Spray Drift Buffer and Downstream Dilution Analysis for Action Area

Because pendimethalin use is documented in 54 of 58 California counties, and because it is semi-volatile and has been detected in rainwater, the Action Area is considered to be the entire state. Spray drift and downstream dilution analysis for the Action Area were therefore not conducted.

3.3 Terrestrial Animal Exposure Assessment

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

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

Table 3-4 Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Pendimethalin with T-REX

Use Sites	Application rate (lbs ai/A)	Number of Applications
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes.	6.0	1
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa	4.0	1
Asparagus, artichoke	3.9	1
golf course turf, airports/landing fields	3.5	1
residential lawns	3.0	1
Shallot, onion, corn (sweet, pop, field)	2.0	1
Carrot	1.9	1
Sunflower	1.73	1
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean),	1.485	1
Wheat, pepper, pepino (melon pear), groundcherry, eggplant	1.425	1
Strawberry	1.485	2 (30 day interval)
Legume vegetables	1.24	1
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables	1.0	1

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

For modeling purposes, exposures of the CRLF to pendimethalin through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey are assessed using the small mammal (15 g) which consumes short grass. Upper-bound Kenega nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential prey (**Table 3.5**). Dietary-based EECs for small and large insects reported by T-REX as well as the resulting adjusted EECs are available in **Table 3.6**. An example output from T-REX v. 1.3.1 is available in **Appendix E**.

Table 3-5 Upper-bound Kenega Nomogram EECs for Dietary- and Dose-based Exposures of the CRLF and its Prey to Pendimethalin

Application rate	EECs for CRLF (including other frog prey)		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
6.0	810	922	1,440	1374
4.0	540	615	960	915
3.9	526	600	936	892
3.5	472	538	840	801
3.0	405	461	720	686
2.0	270	307	480	458
1.9	256	292	456	435
1.73	234	267	415	396
1.485	200	228	356	340
1.425	192	219	242	326
1.485 (2 applications)	301	342	535	510
1.24	167	191	298	284
1.0	135	154	240	229

Table 3-6 EECs (ppm) for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items

Application Rate	Small Insect	Large Insect
6.0	810	90
4.0	540	60
3.9	527	59
3.5	473	53
3.0	405	45
2.0	270	30
1.9	257	29
1.73	234	26

1.485	200	22
1.425	192	21
1.485 (2 applications)	342	38
1.24	167	19
1.0	135	15

3.4 Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.1.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate and drift assumption are based upon the use and related application method (**Table 3.7**). A runoff value of 0.01 is utilized based on pendimethalin's solubility, which is 0.28 mg/L. For aerial and ground application methods, drift is assumed to be 5% and 1%, respectively. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 3.7**. An example output from TerrPlant v.1.2.2 is available in **Appendix F.**

Table 3-7 TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Pendimethalin via Runoff and Drift

Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift EEC (lbs a.i./A)	Dry area EEC (lbs a.i./A)	Semi-aquatic area EEC (lbs a.i./A)
6.0	Foliar - ground	1	0.060	0.120	0.660
4.0	Foliar - ground	1	0.040	0.080	0.440
4.0	Foliar - aerial	5	0.200	0.24	0.600
3.9	Foliar - ground	1	0.039	0.078	0.429
3.9	Foliar - aerial	5	0.195	0.234	0.585
3.5	Foliar - ground	1	0.035	0.070	0.385
3.5	Foliar - aerial	5	0.175	0.210	0.525
3.0	Foliar - ground	1	0.030	0.060	0.330
3.0	Foliar - aerial	5	0.150	0.180	0.450
2.0	Foliar - ground	1	0.020	0.040	0.220
2.0	Foliar - aerial	5	0.100	0.120	0.300
1.9	Foliar - ground	1	0.019	0.038	0.209
1.9	Foliar - aerial	5	0.095	0.114	0.285
1.73	Foliar - ground	1	0.017	0.035	0.190
1.73	Foliar - aerial	5	0.087	0.104	0.260
1.485	Foliar - ground	1	0.015	0.030	0.163
1.485	Foliar - aerial	5	0.074	0.089	0.223
1.24	Foliar - ground	1	0.012	0.025	0.136
1.24	Foliar - aerial	5	0.062	0.074	0.186
1.0	Foliar - ground	1	0.010	0.020	0.110
1.0	Foliar - aerial	5	0.050	0.060	0.150

4.0 Effects Assessment

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

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

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (U.S. EPA, 2004). Open literature data presented in this assessment were obtained from ECOTOX on 10/31/2008. In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

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

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

Citations of all open literature not considered as part of this assessment because they were either rejected by the ECOTOX screen or accepted by ECOTOX but not used (e.g., the endpoint is less sensitive) are included in Appendix G. Appendix G also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment.
A detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sublethal endpoints is presented in Appendix G. Appendix I also includes a summary of the human health effects data for pendimethalin.

In addition to registrant-submitted and open literature toxicity information, other sources of information, including use of the acute probit dose response relationship to establish the probability of an individual effect and reviews of the Ecological Incident Information System (EIIS), are conducted to further refine the characterization of potential ecological effects associated with exposure to pendimethalin. A summary of the available aquatic and terrestrial ecotoxicity information, use of the probit dose response relationship, and the incident information for pendimethalin are provided in Sections 4.1 through 4.4, respectively.

There are no available toxicity information on the degradates of pendimethalin.

A detailed summary of the available ecotoxicity information for all pendimethalin formulated products are presented in Appendix A.

In regards to mixtures of other products containing pendimethalin, only three products (EPA Reg. Nos. 241-331, 241-376 and 5905-495) have definitive product LD_{50} values with associated confidence intervals. Although there are no 95% confidence intervals associated with the pendimethalin technical, an evaluation of the three products listed above show that for EPA Reg. Nos. 241-331 and 241-376, the product LD_{50} values can be attributed solely to the toxicity of pendimethalin. When these product LD_{50}s (3506 and 2500 mg/kg, respectively) and associated confidence intervals (892-1223 and 504-800 mg/kg, respectively) are adjusted for the percent pendimethalin (30.24% and 25.4%, respectively), the adjusted LD50 values for EPA Reg. No. 241-331 (1060 mg/kg, CI: 892-1223) and EPA Reg. No. 241-376 (635 mg/kg, CI: 504-800) are not toxicologically distinct from the LD_{50} of pendimethalin (1050 mg/kg). Similarly, for EPA Reg. No. 5905-495, the toxicity can be attributed to propanil. When the LD50 for this product (1110 mg/kg) and its confidence interval (913-1360 mg/kg) are adjusted for the percent propanil (33.7%), the adjusted LD_{50} value of 374 mg/kg (CI: 308-458 mg/kg) is within a factor of two of the confidence interval for propanil (1080 mg/kg; CI: 868-1343 mg/kg) and the difference is not considered to be toxicologically significant.

Because the active ingredients are not expected to have similar mechanisms of action, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would be inappropriate. Consequently, an assessment based on the toxicity of pendimethalin is the only reasonable approach that employs the available data to address the potential acute risks of the formulated products. Additional information can be found in Appendix B.

4.1 Evaluation of Aquatic Ecotoxicity Studies

Table 4-1 summarizes the most sensitive aquatic toxicity endpoints for the CRLF, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the CRLF is presented below. Additional information is provided in **Appendix A.**

Table 4-1 Freshwater Aquatic Toxicity Profile for Pendimethalin

Assessment Endpoint	**Species**	**Toxicity Value Used in Risk Assessment**	**Describe effect (i.e. mortality, growth, reproduction)**	**Citation MRID # (Author & Date)**	**Study Classification**
Acute Direct Toxicity to Aquatic-Phase CRLF	Rainbow trout	LC_{50} = 138 ppb	mortality	00046291 Sleight, 1972	Acceptable
Chronic Direct Toxicity to Aquatic-Phase CRLF	Fathead minnow	NOAEC = 6.3 ppb	reduction of egg production	00037940 EG&G Bionomics, 1975	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Freshwater Invertebrates (i.e. prey items)	*Daphnia magna*	EC_{50} = 280 ppb	mortality	00059738 LeBlanc, 1976	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Chronic Toxicity to Freshwater Invertebrates (i.e. prey items)	Waterflea *(Daphnia magna)*	NOAEC = 14.5 ppb	reduced production of *Daphnia* young	00100504 Graney, 1981	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Non-vascular Aquatic Plants	Marine diatom *Skeletonema costatum*	EC_{50} = 5.2 ppb	growth	42372205 Hughes, 1992	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Vascular Aquatic	Duckweed (*Lemna gibba*)	EC_{50} = 12..5 ppb	growth	42137101 Hughes, 1992	Acceptable

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Describe effect (i.e. mortality, growth, reproduction)	Citation MRID # (Author & Date)	Study Classification
Plants					

Toxicity to aquatic fish and invertebrates is categorized using the system shown in Table 4-2 (U.S. EPA, 2004). Toxicity categories for aquatic plants have not been defined.

Table 4-2 Categories of Acute Toxicity for Fish and Aquatic Invertebrates

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

4.1.1 Toxicity to Freshwater Fish

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

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

4.1.1.1 Freshwater Fish: Acute Exposure (Mortality) Studies

Three acute freshwater studies using the technical pendimethalin and seven using formulations were submitted to the Agency. For the technical pendimethalin studies, the LC_{50} for the three species of fish range from 138 ppb to 418 ppb. For the formulated product studies, three species of fish range from 520 ppb formulation to 86,600 ppb formulation.

The species for the three technical pendimethalin studies are bluegill sunfish, rainbow trout, and channel catfish. The LC_{50} for the species are 199 ppb, 138 ppb, and 418 ppb, respectively.

The species for the seven formulated product studies are bluegill sunfish, rainbow trout, and channel catfish. The LC50 for the formulation studies are listed below:

AI [1]	LC_{50} (ppm formulation)	LC_{50} (ppm a.i. calculated)	MRID

Bluegill sunfish *Lepomis macrochirus*	Prowl 3E 34.4%	1.04 ppm	0.358 ppm	00037927
Rainbow trout *Oncorhynchus mykiss*	Prowl 3E 34.4%	1.0 ppm	0.344 ppm	00037927
Bluegill sunfish *Lepomis macrochirus*	Prowl 4E 42.3%	0.92 ppm	0.389 ppm	00037927
Rainbow trout *Oncorhynchus mykiss*	Prowl 4E 42.3%	0.52 ppm	0.220 ppm	00037927
Bluegill sunfish *Lepomis macrochirus*	Avenge 2AS 31.8%	90.4 ppm	28.747 ppm	00037927
Rainbow trout *Oncorhynchus mykiss*	Avenge 2AS 31.8%	86.6 ppm	27.539 ppm	00037927
Channel catfish *Ictalurus punctatus*	Prowl 4E 42.3%	1.9 ppm	0.804 ppm	00131773

1 AI refers to active ingredient percentage. The formulated product is also displayed.

The endpoint selected for the assessment is the rainbow trout study using technical grade pendimethalin and it had an LC_{50} of 138 ppb (C.I. 110-170) since it is the most sensitive of the freshwater fish. The MRID number is 00046291.

4.1.1.2 Freshwater Fish: Chronic Exposure (Early Life Stage and Reproduction) Studies

One chronic freshwater fish study (MRID00037940) was submitted to the Agency. This study is a Fathead minnow (*Pimephales promelas*) full life cycle study using a technical grade pendimethalin. The 288-day NOAEC is 6.3 ppb (0.0063 ppm). The NOAEC is based on reduction of egg production. The LOAEC = 9.8 ppb (0.0098 ppm) based on reduction of egg production. Reduced hatchability was also observed at 22 and 43 ppb.

4.1.1.3 Freshwater Fish: Sublethal Effects and Additional Open Literature Information

The ecotoxicity studies from the ECOTOX database provided endpoints that are less sensitive than the submitted rainbow trout study (MRID 00046291) which had an LC_{50} of 138 ppb. No useful chronic freshwater invertebrate studies were found in the ECOTOX database with NOAEC more sensitive than the submitted fathead minnow study (MRID 00037940).

4.1.1.4 Aquatic-phase Amphibian: Acute and Chronic Studies

No studies are available.

4.1.2 Toxicity to Freshwater Invertebrates

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

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

4.1.2.1 Freshwater Invertebrates: Acute Exposure (Mortality) Studies

Three acute freshwater invertebrate studies were submitted to the Agency: two studies using the waterflea *Daphnia magna* and one using crayfish, *Procambarus simulans*.

A *Daphnia magna* study using technical grade pendimethalin had an EC_{50} of 280 ppb (C.I. 230-330) and is considered to be an acceptable study. The other *Daphnia magna* study used the formulation containing 45.6% active ingredient with the EC50 = 5.1 ppm (5100 ppb) formulation. This study is considered to be acceptable for formulated study.

The crayfish study is categorized as supplemental due to the precipitate being observed in concentrations of 1.0 ppm and more; the dissolved O_2 concentration is less than 40% of saturation; and DMSO was used as a solvent which tends to increase mortalities rather than decrease them. This EC_{50} for this study is greater than 1.0 ppm (1000 ppb).

Acute toxicity of pendimethalin technical to freshwater invertebrates is categorized as highly toxic and moderately toxic. Pendimethalin formulation is categorized as moderately toxic.

The most sensitive freshwater invertebrate species tested is *Daphnia magna*, with a 48-hour EC_{50} value of 280 µg/L (MRID: 00059738), is used for deriving risk quotients for the CRLF prey.

4.1.2.2 Freshwater Invertebrates: Chronic Exposure (Reproduction) Studies

One chronic freshwater invertebrate study (MRID 00100504) was submitted to the Agency. This study is a *Daphnia magna* life cycle study using a technical grade pendimethalin. The 21-day NOAEC is 14.5 ppb (0.0145 ppm). The NOAEC is based on reduced production of Daphnia. LOAEC = 0.0172 ppm (17.2 ppb). Mortality was observed in the study with 100% mortality at the 2 highest dose levels of 35.8 and 74.2 ppb. No appreciable mortality observed at 3 lowest concentration levels of 4.3, 8.2, and 14.5 ppb. Reduction of productivity of 50% occurred at 22.1 and 17.5 ppb concentration levels.

4.1.2.3 Freshwater Invertebrates: Sublethal Effects and Open Literature Data

The ecotoxicity studies from the ECOTOX database provided endpoints that are less sensitive than the submitted *Daphnia magna* study (MRID 00059738) which had an EC_{50} of 280 ppb. No useful chronic freshwater invertebrate studies were found in the ECOTOX database with NOAEC more sensitive than the submitted *Daphnia magna* study (MRID 00100504).

4.1.3 Toxicity to Aquatic Plants

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

Only laboratory studies were used to determine whether pendimethalin may cause direct effects to aquatic plants since there are no available field studies to evaluate the effects of pendimethalin to aquatic plants. A summary of the laboratory data for aquatic plants is provided in Sections 4.1.3.1 and 4.1.3.2 .

4.1.3.1 Aquatic Plants: Laboratory Data

Aquatic plant toxicity data submitted to the Agency show a range of EC_{50} values from 5.2 ppb to >174 ppb. The most sensitive species tested are the green algae and marine diatom and the least sensitive species is the cyanobacteria (blue-green algae). Below is a listing of the species tested and their toxicity value:

	EC_{50} (ppb)	NOAEL	MRID
Green algae (*Selenastrum capricornutum*)	5.4 ppb	3.0	42372204
Marine diatom (*Skeletonema costatum*)	5.2 ppb	0.7	42372205
Freshwater diatom (*Navicula pelliculosa*)	6.7 ppb	3.2	42372206
Blue-green algae (*Anabaena flos-aquae*)	>174 ppb	98	42372207
Duckweed (*Lemna gibba*)	12.5 ppb	5.6	42137101

The endpoint selected for the assessment is the marine diatom study using technical grade pendimethalin had an EC_{50} of 5.2 ppb since it is most sensitive of the aquatic plants tested. In addition, the duckweed is the only vascular aquatic plant tested and will be used for assessing aquatic habitat. The EC_{50} for the duckweed is 12.5 ppb.

4.1.3.2 Freshwater Field Studies

No studies are available.

4.2 Toxicity of Pendimethalin to Terrestrial Organisms

Table 4.3 below summarizes the most sensitive terrestrial toxicity endpoints for the CRLF, based on an evaluation of both the submitted studies and the open literature. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the CRLF is presented below.

Table 4-3. Terrestrial Toxicity Profile for Pendimethalin

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Describe effect (i.e. mortality, growth, reproduction)	Citation MRID # (Author & Date)	Study Classification
Acute Dose-based Direct Toxicity to Terrestrial-Phase CRLF	Mallard duck	LD_{50} = 1421 mg/kg-bw	mortality	00059739 Fink, 1976	Acceptable
Acute Dietary-based Direct Toxicity to Terrestrial-Phase CRLF	Bobwhite quail	LC_{50} = 4187 ppm	mortality	00026675 Fink, 1973	Acceptable
Chronic Direct Toxicity to Terrestrial-Phase CRLF	Mallard duck	NOAEC = 141 ppm	14-day survivor bodyweight	44907601 Beavers, 1996	Acceptable
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to mammalian prey items)	Rat	LD_{50} = 1050 mg/kg-bw	mortality	00026657	Acceptable
Indirect Toxicity to Terrestrial-Phase CRLF (via chronic toxicity to mammalian prey items)	Rat	NOAEL = 25 mg/kg-bw (500 ppm)	decreases in the number of pups born and pup weights	41725203	Acceptable
Indirect Toxicity to Terrestrial-	Honey bee	LD_{50} = >49.8 µgm/bee	mortality	00099890 Atkins,	Acceptable

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Describe effect (i.e. mortality, growth, reproduction)	Citation MRID # (Author & Date)	Study Classification
Phase CRLF (via acute toxicity to terrestrial invertebrate prey items)					
Indirect Toxicity to Terrestrial- and Aquatic-Phase CRLF (via toxicity to terrestrial plants)	Seedling Emergence Monocots	Ryegrass EC_{25} = 0.01 lb ai/A	Dry weight	42372201 Chetram, 1992	Acceptable
	Seedling Emergence Dicots	Lettuce EC_{25} = 0.09 lb ai/A	Dry weight	42372201 Chetram, 1992	Acceptable
	Vegetative Vigor Monocots	Ryegrass EC_{25} = 0.034 lb ai/A	Dry weight	42372203 Chetram, 1992	Acceptable
	Vegetative Vigor Dicots	Lettuce EC_{25} = 0.10 lb ai/A	Dry weight	42372203 Chetram, 1992	Acceptable

Acute toxicity to terrestrial animals is categorized using the classification system shown in Table 4-44 (U.S. EPA, 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4-4 Categories of Acute Toxicity for Avian and Mammalian Studies

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

4.2.1 Toxicity to Birds

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

4.2.1.1 Birds: Acute Exposure (Mortality) Studies

Two subacute LC_{50} dietary avian studies and one acute LD_{50} oral acute avian study using the technical pendimethalin were submitted to the Agency. For the LC_{50} dietary studies, the LC_{50} for the bobwhite quail is 4187 ppm and the mallard duck is >4640 ppm. For the acute LD_{50} for the mallard, the LD_{50} is 1421 mg/kg-bw.

The endpoint selected for the assessment is the bobwhite quail's LC_{50} of 4187 ppm (MRID 00026674) and the mallard's LD_{50} of 1421 mg/kg-bw (00059739).

Pendimethalin technical is categorized as slightly toxic on subacute dietary and acute oral basis to birds. No avian studies using pendimethalin formulated product have been submitted to the Agency.

4.2.1.2 Birds: Chronic Exposure (Growth, Reproduction) Studies

Two avian reproduction studies were submitted to the Agency. No treatment related effects were observed in the bobwhite quail and the LOAEL is greater than 1410 ppm. The mallard duck study (MRID 44907601) showed the parameter of 14-day survivor bodyweight was reduced at 1410 ppm. The NOAEL for the mallard study is 410 ppm. No other treatment related effects were observed. This study is classified as acceptable.

4.2.1.3 Birds: Open Literature Studies

No studies more sensitive than the submitted avian studies were found in the ECOTOX database.

4.2.2 Toxicity to Mammals

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

Most recent data and information on mammalian toxicity comes from Registration Division document entitled "Pendimethalin. Human Health Risk Assessment for the Proposed Food Uses of the Herbicide on Artichoke, Globe; Asparagus; *Brassica* Head and Stem Vegetables, Subgroup 5A; and Grape (PP#6E7129)", dated August 22, 2007. The document was authored by Debra Rate, Ph.D., Biologist, Alternative Risk Integration and Assessment (ARIA), Risk Integration, Minor Use, and Emergency Response Branch (RIMUERB), Registration Division (RD) (7505P) to Barbara Madden/ Susan Stanton RIMUERB/RD (7505P). This is found in Appendix I.

4.2.2.1 Mammals: Acute Exposure (Mortality) Studies

The Agency's rat acute oral assessment endpoint for risk assessment purpose shows the LD_{50} to be 1250 mg/kg (male) and 1050 mg/kg (female) (MRID 00026657). Pendimethalin is considered to be slightly toxic to mammals on an acute oral basis.

4.2.2.2 Mammals: Chronic Exposure (Growth, Reproduction) Studies

A 2-generation reproduction study (MRID 41725203) with pendimethalin was reviewed by HED. The parental systemic NOAEL was 25 mg/kg/day (**500 ppm**), based on decreased body weight gain and food consumption at the LOAEL of 125 mg/kg/day (**2500 ppm**). The reproductive/offspring NOAEL is 25 mg/kg/day (**500 ppm**), based on decreases in the number of pups born and pup weight at the LOAEL of 125 mg/kg/day (**2500 ppm**). Parental and reproductive NOAELs and LOAELs were based on a generic ratio (1:20) of dietary intake of chemical.

The HED Cancer Peer Review Committee classified pendimethalin as a "Group C" (possible human) carcinogen, based on thyroid follicular cell adenomas in rats. The committee recommended a non-quantitative approach (non-linear, RfD approach) since mode of action studies are available that demonstrate that the thyroid tumors are due to a thyroid-pituitary imbalance, and also since pendimethalin was shown to be non-mutagenic in mammalian somatic cells and germ cells.

4.2.2.3 Mammals: Open Literature Studies

No studies more sensitive than the submitted mammalian studies were found in the ECOTOX database.

4.2.3 Toxicity to Terrestrial Invertebrates

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

4.2.3.1 Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

Only one acute oral bee toxicity study (MRID) was submitted to the Agency. This study was authored by Dr. Atkins in 1974. The species tested is the honey bee, *Apis mellifera*. The LD50 acute oral is greater than 49.8 µg/bee with no mortality observed at the highest tested dose. Pendimethalin is classified as practically non-toxic to the honey bee.

4.2.3.2 Terrestrial Invertebrates: Open Literature Studies

No studies more sensitive than the submitted bee study were found in the ECOTOX database.

4.2.4 Toxicity to Terrestrial Plants

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

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

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

The results of the Tier II seedling emergence and vegetative vigor toxicity tests on non-target plants are summarized below in Table 4-55**.**

Table 4-5 Non-target Terrestrial Plant Seedling Emergence and Vegetative Vigor Toxicity (Tier II) Data

Crop	Species	NOAEC (lb ai/A)	EC_{25} (lb ai/A)	Most sensitive parameter
Seedling Emergence				
Monocots	Oat, *Avena sativa*	0.25	1.0	Plant height

Crop	Species	NOAEC (lb ai/A)	EC_{25} (lb ai/A)	Most sensitive parameter
	Ryegrass, *Lolium perenne*	0.065 [1]	0.01	Dry weight
	Corn, *Zea mays*	0.5	0.68	Plant height
	Onion, *Allium cepa*	0.06	0.08	Dry weight
Dicots	Soybean, *Glycine max*	2.0	4.7	Dry weight
	Lettuce, *Lactuca sativa*	0.063	0.09	Dry weight
	Radish, *Rhaphanus sativus*	0.13	0.86	Plant height
	Tomato, *Lycopersicon esculentum*	0.13	0.2	Dry weight
	Cucumber, *Cucumis sativus*	0.25	2.4	Plant height
	Cabbage, *Brassica oleracea*	0.25	0.44	Plant height
Vegetative Vigor				
Monocots	Oat, *Avena sativa*	0.5	0.78	Dry weight
	Ryegrass, *Lolium perenne*	0.0008	0.034	Dry weight
	Corn, *Zea mays*	2.0	2.8	Plant height
	Onion, *Allium cepa*	0.50	0.56	Plant height
Dicots	Soybean, *Glycine max*	0.13	0.27	Dry weight
	Lettuce, *Lactuca sativa*	0.003	0.10	Dry weight
	Radish, *Rhaphanus sativus*	>4.0	>4.0	n/a
	Tomato, *Lycopersicon esculentum*	0.13	0.5	Dry weight
	Cucumber, *Cucumis sativus*	>4.0	>4.0	n/a
	Cabbage, *Brassica oleracea*	2.0	4.8	Dry weight

1 EC05 was used in lieu of NOEAC since study was unable to determine NOAEC value

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

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

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

4.4 Incident Database Review

EPA maintains an incident database system (Ecological Incident Information System or EIIS) to track and evaluate accidental kills associated with pesticide use. The likelihood that a particular pesticide caused the incident is classified as “highly probable”, “probable”, “possible”, or “unlikely”, based on the information contained in the incident report.

A review of the EIIS database for ecological incidents involving pendimethalin was completed on April 16, 2009. The results of this review for terrestrial, plant, and aquatic incidents are discussed below in Sections 4.4.1 through 4.4.3, respectively. A complete list of the incidents involving pendimethalin including associated uncertainties is included as **Appendix H**.

In the years since EPA has maintained the database, a total of 69 incidents were reported, of which 65 related to terrestrial plants.

4.4.1 Terrestrial Incidents

There were two incidents involving pendimethalin with alleged adverse effects to terrestrial animals (American Robin, Rock dove, Ground squirrel, and an “unknown” bird.)

In a 1998 Kansas incident (I007495-001) twelve robins and rock doves were killed. It is not known as to what site the pendimethalin was applied but was applied nearby. No toxicological analysis was reportedly taken; therefore no confirmation was made as to whether pendimethalin was responsible for the deaths of the 12 birds. Pendimethalin is slightly toxic on an acute oral and subacute dietary basis to birds. It is uncertain that pendimethalin was responsible for the bird deaths.

There was also an incomplete incident report (I002343-001) involving surface application of pendimethalin and fertilizer granules to turf with mortality of unknown numbers of ground squirrel and an “unknown” bird. The corpses were analyzed for organophosphates (OP) but not for pendimethalin. No OPs were found. Pendimethalin is slightly toxic on an acute oral and subacute dietary basis to birds and small mammals.   It is uncertain and not likely that pendimethalin is responsible for the deaths of the squirrels and the bird.

4.4.2 Plant Incidents

Most of these plant incidents related to the treated crop itself, including corn, soybean, potatoes, lawns, azalea bushes, and peanuts. Some of the incidents occur from spray drift and runoff. Of the 65 reported alleged incidents involving pendimethalin, four of the incidents were from spray drift to nearby non-target plants. The severity of these plant incidents ranged from plant damage (most incidents) to mortality. The following reported alleged incidents are from spray drift or runoff from treated sites to non-target plants:

I014702-053 - In Wisconsin, pendimethalin was applied with clomazone to soybean. The two herbicides drifted over to raspberry plants and trees causing some damage to these plants. The damage symptoms observed were more consistent with clomazone damage than pendimethalin. Pendimethalin may have contributed to plant damage but the symptoms of plant damage to non-target plants are more consistent with clomazone. It is probable that pendimethalin may be involved with non-target plant damage.

B000621-001 – In 1986 in Illinois, pendimethalin was applied with clomazone to soybean field. The two herbicides drifted over to damage nearby lawns, fruit trees, and vegetable gardens. The damage symptoms observed were more consistent with clomazone damage than pendimethalin. Pendimethalin may have contributed to plant damage but the symptoms of plant damage to non-target plants are more consistent with clomazone. It is probable that pendimethalin may be involved with non-target plant damage.

I0009262-054 – In 1996 in California, a greenhouse floor was sprayed with pendimethalin. Vapor from the spray drifted onto potted azaleas plants sitting on the benches above the floor. 172,636 potted azaleas were unmarketable. It is likely that pendimethalin contributed to damage to azaleas from volatility.

I013587-052 – In 1999 in Washington State, pendimethalin was applied to residential ornamentals. Large tree limbs were observed dying. Pendimethalin was analyzed and found present in the foliage of the trees.

4.4.3 Aquatic Incidents

There are two aquatic incidents reported involving mortality of 300 and 996 fish, respectively. The fish involved were bass and bluegill (300 fish) and minnow (996 fish), but the incident reports considered pendimethalin involvement “unlikely.”

In 1998 in Ohio, (incident I007677-001) pendimethalin and Lorsban were applied to a corn field. One inch of rain fell shortly afterwards and runoff from the corn field ran into a pond. The distance from the field to the pond is from 14-70 feet. Approximately 300 bass and bluegills were later found dead. Fish and water samples were taken but findings were not submitted. Lorsban (chlorpyrifos) is much more toxic to aquatic animals than pendimethalin by three orders of magnitude and is more soluble in water. It is more likely that Lorsban is the cause of the mortality to the fish. Pendimethalin is not expected to kill fish outright from runoff from one inch of rain on a corn field based on its EEC and toxicity.

In 1993 in Minnesota, an incident involving the deaths of 996 minnows was reported. There is very little information in this report which indicated that "250 -300 gallons yellow weed killer, Prowl" contributed to the deaths of the minnows in the Schwerin Creek. This information comes from a Minnesota Department of Natural Resources report showing a table of various spill incidents involving pesticides reported to Minnesota. It is likely that a significant spill of concentrated pendimethalin is the cause of deaths of the minnow in the creek.

5.0 Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to the CRLF or for modification to its designated critical habitat from the use of pendimethalin risk characterization provides an estimation (Section 5.1) and a description (Section 5.2) of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of adverse effects to the CRLF or its designated critical habitat (i.e., “no effect,” “likely to adversely affect,” or “may affect, but not likely to adversely affect”).

5.1 Risk Estimation

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

Risk to the aquatic-phase CRLF is estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended pendimethalin usage scenarios summarized in **Table 3-3** and the appropriate aquatic toxicity endpoint from **Table 4-1**. Risks to the terrestrial-phase CRLF and its prey (*e.g*. terrestrial insects, small mammals and terrestrial-phase frogs) are estimated based on exposures resulting from applications of pendimethalin (Tables 3.5 – 3.6) and the appropriate toxicity endpoint from **Table 4.3**. Exposures are also derived for terrestrial plants, as discussed in Section 3.7 and toxicity summarized in Section 4.2.4, based on the highest application rates of pendimethalin use within the action area.

5.1.1 Exposures in the Aquatic Habitat

5.1.1.1 Direct Effects to Aquatic-Phase CRLF

Direct effects to the aquatic-phase CRLF are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60-day EECs and the lowest chronic toxicity value for freshwater fish are used. Based on exceedances of the acute LOC (0.05) **for listed species**, pendimethalin may directly affect the aquatic-phase of the CRLF. The results of the RQ calculations are in Table 5.1 below.

Table 5-1 Summary of Direct Effect RQs[a] for the Aquatic-phase CRLF

EEC Scenario	Peak EEC (µg/L) [b]	60-day EEC (µg/L) [b]	Acute RQ	Chronic RQ	Probability of Individual Effect at ES LOC	Probability of Individual Effect at RQ
CAForestryRLF (forest trees and Christmas tree plantations)	16.6	4.9	0.12	0.8 [e]	4.18E+08	1 in 5.85E+04 (1 in 30.5 to 1 in 1.73E+16)[c]
CArowcropRLF [g]	11.9	2.9	0.09	<1.0 [e]		1 in 7.91E+05 (1 in 54.8 to 1 in 4.10E+20)[c]
Rice model (Rice)	48	Not available	0.35	Not applicable		1 in 49.8 (1 in 5.53 to 1 in 4.91E+04)[c]
Cagrapes_WirrigSTD, CAwinegrapesRLF (grapes)	11.4	1.8	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
CAalmond_WirrigSTD[h]	11.7	2.3	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
CATurfRLF [j]	11.5	1.9	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
CAalfalfa_WirrigOP (alfalfa, lupine)	11.3	2.0	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
Cafruit_WirrigSTD [i]	11.2	1.9	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
CAOliveRLF (olives)	11.2	1.7	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
Cacitrus_WirrigSTD [K]	11.1	1.5	0.08	<1.0 [e]		1 in 2.51E+06 (1 in 70.8 to 1 in 3.64E+22)[c]
CAcornOP (corn and sunflower)	6.8 [d]	1.5	0.05	<1.0 [e]		1 in 4.18E+08 (1 in 216 to 1 in 1.75E+31)[c]

[a] RQs associated with acute and chronic direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. The toxicity value used as surrogate species is rainbow trout LC_{50} of 138 ppb (µg/L) and Fathead minnow NOAEC of 6.3 ppb (µg/L).
[b] The highest EEC based on foliar use of pendimethalin on forestry at 4.0 lb ai/A (see Table 3-3).
[c] A probit slope value for the acute rainbow trout toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986). Not calculated for chronic endpoints.
[d] Peak EEC below 6.8 ppb will result in RQ < acute endangered species LOC of 0.05.
[e] RQ < chronic LOC of 1.0.
[g] This scenario represents artichoke, asparagus, beans, carrot (including tops), garbanzos (including chick peas), legume vegetables, peanuts (unspecified), peas, and pepper.
[h] This scenario represents almond, beech nut, brazil nut, butternut, cashew, chestnut, chinquapin, filbert (hazelnut), hickory nut, macadamia nut (bushnut), mayhaw (hawthorn), pecan, pistachio, walnut (English or black)
[i] This scenario represents apple, apricot, cherry, crabapple, fig, loquat, nectarine, peach, pear, pepino (melon pear), plum, pomegranate, prune, quince, and small fruits.
[j] This scenario represents commercial/industrial lawns, golf course turf, ornamental lawns and turf, ornamental sod farm (turf), recreation area lawns, and residential lawns.

[K] This scenario represents calamondin, citron (citrus), citrus hybrids other than tangelo, grapefruit, kumquat, lemon, lime, orange, pummelo (shaddock), and tangelo.

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

a) <u>Non-vascular Aquatic Plants</u>

Indirect effects of pendimethalin to the aquatic-phase CRLF (tadpoles) via reduction in non-vascular aquatic plants in its diet are based on peak EECs from the standard pond and the lowest toxicity value (EC_{50}) for aquatic non-vascular plants. Based on exceedances of the acute LOC (1.0) for aquatic plants, pendimethalin is likely to indirectly affect the CRLF via reduction in non-vascular plants. The results of the RQ calculations are in Table 5.2 below.

Table 5-2 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Non-Vascular Aquatic Plants [a] (diet of CRLF in tadpole life stage and habitat of aquatic-phase CRLF)

Uses	Application rate (lb ai/A) and type	Peak EEC (µg/L)	Indirect effects RQ* (food and habitat)
Rice model (Rice)	1 lb ai/A (aerial)	48	**9.2**
CAForestryRLF (forest trees and Christmas tree plantations)	4 lb ai/A (aerial)	16.6 [b]	**3.2**
CArowcropRLF [e]	4 lb ai/A (aerial)	11.9	**2.3**
CAalmond_WirrigSTD[f]	4 lb ai/A (aerial)	11.7	**2.3**
CATurfRLF [h]	4 lb ai/A (aerial)	11.5	**2.2**
Cagrapes_WirrigSTD, CAwinegrapesRLF (grapes)	4 lb ai/A (aerial)	11.4	**2.2**
CAalmond_WirrigSTD [f]	6 lb ai/A (ground)	6.6	**1.3**
CAalfalfa_WirrigOP (alfalfa, lupine)	4 lb ai/A (aerial)	11.3	**2.2**
Cafruit_WirrigSTD [g]	4 lb ai/A (aerial)	11.2	**2.2**
CAOliveRLF (olives)	4 lb ai/A (aerial)	11.2	**2.2**
Cacitrus_WirrigSTD [i]	4 lb ai/A (aerial)	11.1	**2.1**
CAcornOP (corn and sunflower)	2 lb ai/A (aerial)	6.8	**1.3**
CAwheatRLF (sorghum and wheat)	1.5 lb ai/A (aerial)	6.1	**1.2**
CAcotton_WirrigSTD (cotton)	2 lb ai/A (aerial)	5.8	**1.1**
CAOnion_WirrigSTD (onion and shallot)	2 lb ai/A (aerial)	5.6 [c]	**1.1**
* LOC exceedances (RQ $\geq$ 1) are bolded and shaded. RQ = use-specific peak EEC/ marine diatom (*Skeletonema costatum*) EC_{50} of 5.2 ppb.			

[a] The toxicity value used as surrogate species is marine diatom (*Skeletonema costatum*) EC_{50} of 5.2 ppb (µg/L).
[b] The highest EEC based on foliar use of pendimethalin is on forestry at 4.0 lb ai/A (see Table 3-3).
[c] Peak EEC below 5.2 ppb will result in RQ < acute LOC of 1.0.

[e] This scenario represents artichoke, asparagus, beans, carrot (including tops), garbanzos (including chick peas), legume vegetables, peanuts (unspecified), peas, and pepper.
[f] This scenario represents almond, beech nut, brazil nut, butternut, cashew, chestnut, chinquapin, filbert (hazelnut), hickory nut, macadamia nut (bushnut), mayhaw (hawthorn), pecan, pistachio, walnut (English or black)
[g] This scenario represents apple, apricot, cherry, crabapple, fig, loquat, nectarine, peach, pear, pepino (melon pear), plum, pomegranate, prune, quince, and small fruits.
[h] This scenario represents commercial/industrial lawns, golf course turf, ornamental lawns and turf, ornamental sod farm (turf), recreation area lawns, and residential lawns.
[i] This scenario represents calamondin, citron (citrus), citrus hybrids other than tangelo, grapefruit, kumquat, lemon, lime, orange, pummelo (shaddock), and tangelo.

b) Aquatic Invertebrates

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. For chronic risks, 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive RQs. A summary of the acute and chronic RQ values for exposure to aquatic invertebrates (as prey items of aquatic-phase CRLFs) is provided in **Table 5-3**. Based on the acute LOC (0.5) and chronic LOC (1.0) not being exceeded, pendimethalin has no effect, indirectly on the CRLF based on effects to aquatic invertebrates. The table shows only the use sites that exceed the LOC plus the highest EEC that does not exceed the LOC.

Table 5-3 Summary of Acute and Chronic RQs[a] Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats)

EEC Scenario	Peak EEC (µg/L)[b]	21-day EEC (µg/L)[b]	Acute RQ	Chronic RQ	Probability of Individual Effect at ES LOC	Probability of Individual Effect at RQ
Rice model (Rice)	48	Not available	0.17 [f]	Not applicable		1 in 3,740 (1 in 16.2 to 1 in 4.62E+11)[c]
CAForestryRLF (Forest trees and Christmas tree plantations)	16.6	6.4	0.06 [b]	0.4 [e]		1 in 5.22E+07 (1 in 138 to 1 in 5.04E+27)[c]
CArowcropRLF [h] (artichoke/asparagus)	11.9	4.0	0.04 [f]	<1.0 [e]		Not applicable

[a] RQs associated with acute and chronic direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. The toxicity value used as surrogate species is *Daphnia magna* EC_{50} of 280 ppb (µg/L) and *Daphnia magna* NOAEC of 14.5 ppb (µg/L).
[b] The highest EEC based on foliar use of pendimethalin on forestry and Christmas trees at 4.0 lb ai/A (see Table 3-3).
[c] A probit slope value for the acute *Daphnia magna* toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986). Not calculated for chronic endpoints.
[d] Peak EEC below 5.2 ppb will result in RQ < acute endangered species LOC of 0.05.
[e] RQ < chronic LOC of 1.0.
[f] RQ < acute LOC of 0.5.

[h] This scenario represents artichoke, asparagus, beans, carrot (including tops), garbanzos (including chick peas), legume vegetables, peanuts (unspecified), peas, and pepper.

c) Fish and Frogs

Fish and frogs also represent potential prey items of adult aquatic-phase CRLFs. RQs associated with acute and chronic direct toxicity to the CRLF (Table 5.1) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. Based on listed species LOC exceedances using the surrogate rainbow trout acute LC_{50} toxicity endpoint and the fathead minnow chronic NOAEC endpoint, pendimethalin may indirectly affect the CRLF via reduction in freshwater fish and frogs as food items.

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

Indirect effects to the CRLF via direct toxicity to aquatic plants are estimated using the most sensitive non-vascular and vascular plant toxicity endpoints. Because there are no obligate relationships between the CRLF and any aquatic plant species, the most sensitive EC_{50} values, rather than NOAEC values, were used to derive RQs. Based on vascular aquatic plant LOC (1.0) exceedances, pendimethalin may indirectly affect the CRLF via reduction in vascular plants from uses on forestry and Christmas tree plantations and from rice use. Table 5-4 shows only the use sites that exceed the LOC plus the highest EEC that does not exceed the LOC.

Table 5-4 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Vascular Aquatic Plants (habitat of aquatic-phase CRLF)[a]

Uses	Application rate (lb ai/A) and type	Peak EEC (µg/L)	Indirect effects RQ* (food and habitat)
Rice model (Rice)	1 lb ai/A (aerial)	48	**3.8**
CAForestryRLF (forest trees and Christmas tree plantations)	4 lb ai/A (aerial)	16.6	**1.3**

[a] RQs used to estimate indirect effects to the CRLF via toxicity to vascular aquatic plants are summarized in Table 5.2. The toxicity value used as surrogate species is duckweed (*Lemna gibba*) EC_{50} of 12.5 ppb (µg/L).
[b] The highest EEC based on foliar use of pendimethalin on forestry at 4.0 lb ai/A (see Table 3-3).
[c] Peak EEC below 12.5 ppb will result in RQ < acute LOC of 1.0.
* = LOC exceedances (RQ $\geq$ 1) are bolded. RQ = use-specific peak EEC / duckweed EC_{50} of 12.5 ppb.

5.1.2 Exposures in the Terrestrial Habitat

5.1.2.1 Direct Effects to Terrestrial-phase CRLF

Potential direct acute effects to the terrestrial-phase CRLF are derived by considering dose- and dietary-based EECs modeled in T-REX for a small bird (20 g) consuming small invertebrates (Table 3.5) and acute oral and subacute dietary toxicity endpoints for avian species.

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

Based on RQ exceedances of listed species acute LOC (0.1) and chronic LOC (1.0) from all use sites, pendimethalin may directly affect the terrestrial-phase of the CRLF.

Table 5-5 Summary of Acute RQs* Used to Estimate Direct Effects to the Terrestrial-phase CRLF

Use Site	Application rate (lbs ai/A)	Dietary-based Acute RQ[1]	Dose-based Acute RQ[1]	Probability of Individual Effect at RQ
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes.	6.0	**0.2**	**1.25**	Dose-based: 1 in 1.5 (1 in 1.73 to 1 in 1.24)[2] Dietary-based: 1 in 1.5 (1 in 1.73 to 1 in 1.24)[2]
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa	4.0	**0.1**	**0.8**	Dose-based: 1 in 3.02 (1 in 2.36 to 1 in 5.22)[2] Dietary-based: 1 in 2.94E+05 (1 in 44 to 8.86E+18)[2]
Asparagus, artichoke	3.9	**0.1**	**0.8**	Dose-based: 1 in 3.02 (1 in 2.36 to 1 in 5.22)[2] Dietary-based: 1 in 2.94E+05 (1 in 44 to 8.86E+18)[2]
golf course turf, airports/landing fields	3.5	**0.1**	**0.7**	Dose-based: 1 in 4.12 (1 in 2.64 to 1 in 12.2)[2] Dietary-based: 1 in 2.94E+05 (1 in 44 to 8.86E+18)[2]
residential lawns	3.0	**0.1**	**0.6**	Dose-based: 1 in 1.5 (1 in 1.73 to 1 in 1.24)[2] Dietary-based: 1 in 2.94E+05 (1 in 44 to 8.86E+18)[2]
Shallot, onion, corn (sweet, pop, field)	2.0	<0.1	**0.4**	Dose-based: 1 in 27.3 (1 in 4.69 to 1 in 5.85E+03)[2] Dietary-based: n/a
Carrot	1.9	<0.1	**0.4**	Dose-based: 1 in 27.3 (1 in 4.69 to 1 in 5.85E+03)[2] Dietary-based: n/a
Sunflower	1.73	<0.1	**0.4**	Dose-based: 1 in 27.3 (1 in 4.69 to 1 in 5.85E+03)[2] Dietary-based: n/a
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton,	1.485	<0.1	**0.3**	Dose-based: 1 in 107 (1 in 6.76 to 7.91E+05)[2] Dietary-based: n/a

Use Site	Application rate (lbs ai/A)	Dietary-based Acute RQ[1]	Dose-based Acute RQ[1]	Probability of Individual Effect at RQ
cowpea (southern pea, black-eyed bean),				
Wheat, pepper, pepino (melon pear), groundcherry, eggplant	1.425	<0.1	**0.3**	Dose-based: 1 in 107 (1 in 6.76 to 7.91E+05)[2] Dietary-based: n/a
Strawberry	1.485 (2 applications w/ 30-day interval)	<0.1	**0.5**	Dose-based: 1 in 15.5 (1 in 4 to 1 in 832)[2] Dietary-based: n/a
Legume vegetables	1.24	<0.1	**0.3**	Dose-based: 1 in 107 (1 in 6.76 to 7.91E+05)[2] Dietary-based: n/a
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables	1.0	<0.1	**0.2**	Dose-based: 1.21E+03 (1 in 12.3 to 6.33E+09)[2] Dietary-based: n/a

* = LOC exceedances (acute RQ $\geq$ 0.1) are bolded and shaded.

[1] Based on mallard LD_{50} of 1421 mg/kg-bw and bobwhite LC_{50} of 4187 ppm.

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

Table 5-6 Summary of Chronic RQs* Used to Estimate Direct Effects to the Terrestrial-phase CRLF

Use Site	Application rate (lbs ai/A)	Dietary-based Chronic RQ[1]
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes.	6.0	**5.7**
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa	4.0	**3.8**
Asparagus, artichoke	3.9	**3.7**
golf course turf, airports/landing fields	3.5	**3.35**
residential lawns	3.0	**2.9**
Shallot, onion, corn (sweet, pop, field)	2.0	**1.9**
Carrot	1.9	**1.8**
Sunflower	1.73	**1.7**
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean),	1.485	**1.4**
Wheat, pepper, pepino (melon pear), groundcherry, eggplant	1.425	**1.4**

Use Site	Application rate (lbs ai/A)	Dietary-based Chronic RQ[1]
Strawberry	1.485 (2 applications w/ 30-day interval)	**2.1**
Legume vegetables	1.24	**1.2**
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables	1.0	**1.0**
* = LOC exceedances (chronic RQ $\geq$ 1) are bolded and shaded. [1] Based on bobwhite NOAEC of 141 ppm.		

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

5.1.2.2.1 Terrestrial Invertebrates

In order to assess the risks of pendimethalin to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the honey bee is used as a surrogate for terrestrial invertebrates. The toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available acute contact LD_{50} of greater than 49.8 µg a.i./bee by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs (µg a.i./g of bee) calculated by T-REX for small and large insects are divided by the calculated toxicity value for terrestrial invertebrates, which is >388.4 µg a.i./g of bee. Based on RQ ranges from 2.09 to 0.05, pendimethalin may indirectly affect the CRLF via reduction in terrestrial invertebrate prey items

Table 5-7 Summary of RQs Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Terrestrial Invertebrates as Dietary Food Items

Use	Small Insect RQ*	Large Insect RQ*	Probability of Individual Effect at RQ of Small Insect
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes. (6.0 lb ai/A)	**2.09**	**0.23**	1 in 1.08 (1 in 1.35 to 1 in 1.0)[a]
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa (4.0 lb ai/A)	**1.39**	**0.15**	1 in 1.35 (1 in 1.11 to 1 in 1.63)[a]
Asparagus, artichoke (3.9 lb ai/A)	**1.36**	**0.15**	1 in 1.38 (1 in 1.13 to 1 in 1.65)[a]

golf course turf, airports/landing fields (3.5 lb ai/A)	**1.22**	**0.14**	1 in 1.54 (1 in 1.28 to 1 in 1.76)[a]
residential lawns (3.0 lb ai/A)	**1.04**	**0.12**	1 in 1.88 (1 in 1.78 to 1 in 1.95)[a]
Shallot, onion, corn (sweet, pop, field) (2.0 lb ai/A)	**0.70**	**0.08**	1 in 4.12 (1 in 2.64 to 1 in 12.2)[a]
Carrot (1.9 lb ai/A)	**0.66**	**0.07**	1 in 4.8 (1 in 2.78 to 1 in 19.2)[a]
Sunflower (1.73 lb ai/A)	**0.60**	**0.07**	1 in 6.29 (1 in 3.04 to 1 in 43.6)[a]
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean), (1.485 lb ai/A)	**0.51**	**0.06**	1 in 10.6 (1 in 3.58 to 1 in 236)[a]
Wheat, pepper, pepino (melon pear), groundcherry, eggplant (1.425 lb ai/A)	**0.49**	**0.05**	1 in 12.2 (1 in 3.73 to 1 in 377)[a]
Strawberry (1.485 lb ai/A (2 applications w/ 30-day interval))	**0.88**	**0.10**	1 in 249 (1 in 2.19 to 1 in 3.24)[a]
Legume vegetables (0.124 lb ai/A)	**0.43**	**0.05**	1 in 20.2 (1 in 4.31 to 1 in 2,060)[a]
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables (1.0 lb ai/A)	**0.35**	0.04	1 in 49.8 (1 in 5.53 to 1 in 4.91E+04)[a]
* = LOC exceedances (RQ ≥ 0.05) are bolded and shaded. Because a definitive endpoint was not established for terrestrial invertebrates (i.e., the value is greater than the highest test concentration), the RQ represents an upper bound value. a A probit slope value for the acute honey bee toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986). Probability of Individual Effect at RQ of 0.05 is 1 in 4.18E+08 (1 in 216 to 1 in 1.75E+31).			

5.1.2.2.2 Mammals

Risks associated with ingestion of small mammals by large terrestrial-phase CRLFs are derived for dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass. Acute and chronic effects are estimated using the most sensitive mammalian toxicity data. EECs are divided by the toxicity value to estimate acute and chronic dose-based RQs as well as chronic dietary-based RQs. Based on RQ ranges from 25.0 to 6.2 for chronic effects, pendimethalin is likely to indirectly affect the CRLF via reduction in small mammal prey items.

Table 5-8 Summary of Acute and Chronic RQs* Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Small Mammals as Dietary Food Items

Use (Application Rate)	Chronic RQ		Acute RQ	Probability of Individual Effect at RQ
	Dose-based Chronic RQ[1]	Dietary-based Chronic RQ[2]	Dose-based Acute RQ[3]	
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes. (6.0 lb ai/A)	**25.0**	**2.9**	**0.6**	Dose-based: 1 in 6.29 (1 in 1.73 to 1 in 1.24)[2]
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa (4.0 lb ai/A)	**16.7**	**1.9**	0.4	Dose-based: 1 in 27.3 (1 in 4.69 to 1 in 5.85E+03)[2]
Asparagus, artichoke (3.9 lb ai/A)	**16.2**	**1.9**	0.4	Dose-based: 1 in 27.3 (1 in 4.69 to 1 in 5.85E+03)[2]
golf course turf, airports/landing fields (3.5 lb ai/A)	**14.6**	**1.7**	0.35	Dose-based: 1 in 49.8 (1 in 5.53 to 1 in 4.91E+04)[2]
residential lawns (3.0 lb ai/A)	**12.5**	**1.4**	0.3	Dose-based: 1 in 107 (1 in 6.76 to 1 in 7.91E+05)[2]
Shallot, onion, corn (sweet, pop, field) (2.0 lb ai/A)	**8.3**	**1.0**	0.2	Dose-based: 1 in 1.21E+03 (1 in 12.3 to 1 in 6.33E+09)[2]
Carrot (1.9 lb ai/A)	**7.9**	**0.9**	0.2	Dose-based: 1 in 1.21E+03 (1 in 12.3 to 1 in 6.33E+09)[2]
Sunflower (1.73 lb ai/A)	**7.2**	**0.8**	0.2	Dose-based: 1 in 1.21E+03 (1 in 12.3 to 1 in 6.33E+09)[2]
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean), (1.485 lb ai/A)	**6.2**	**0.7**	0.2	Dose-based: 1 in 1.21E+03 (1 in 12.3 to 1 in 6.33E+09)[2]
Wheat, pepper, pepino (melon pear), groundcherry, eggplant (1.425 lb ai/A)	**5.9**	**0.7**	0.1	1 in 2.94E+05 (1 in 44 to 1 in 8.86E+18)[2]
Strawberry (1.485 lb ai/A (2 applications w/ 30-day interval))	**9.3**	**1.1**	0.2	Dose-based: 1 in 1.21E+03 (1 in 12.3 to 1 in 6.33E+09)[2]
Legume vegetables (0.124 lb ai/A)	**5.2**	**0.6**	0.1	1 in 2.94E+05 (1 in 44 to 1 in 8.86E+18)[2]
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese),	**4.2**	**0.5**	0.1	1 in 2.94E+05 (1 in 44 to 1 in 8.86E+18)[2]

	Chronic RQ		Acute RQ	
cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables (1.0 lb ai/A)				

* = LOC exceedances (acute RQ $\geq$ 0.1 and chronic RQ $\geq$ 1) are bolded and shaded.
[1] Based on dose-based EEC and pendimethalin rat NOAEL = 25 mg/kg-diet/day (500 ppm).
[2] Based on dietary-based EEC and pendimethalin rat NOAEC = 25 mg/kg-diet/day (500 ppm).
[3] Based on dose-based EEC and pendimethalin rat acute oral LD_{50} = 1050 mg/kg-bw.

5.1.2.2.3 Frogs

An additional prey item of the adult terrestrial-phase CRLF is other species of frogs. In order to assess risks to these organisms, dietary-based and dose-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates are used. See Section 5.1.2.1 and associated tables (Table 5-65 and 5.6) for results. Based on dose-based acute RQs the range from 1.25 to 0.2 and chronic RQs that range from 5.7 to 1.0, pendimethalin may indirectly affect the CRLF via reduction in frogs as prey items.

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

Potential indirect effects to the CRLF resulting from direct effects on riparian and upland vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. Based on LOC exceedances from all use sites, pendimethalin may indirectly affect the CRLF via reduction in terrestrial plants. Example output from TerrPlant v.1.2.2 is provided in **Appendix F.**

Table 5-9 RQs* for Monocots Inhabiting Dry and Semi-Aquatic Areas Exposed to Pendimethalin via Runoff and Drift

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ	Dry area RQ	Semi-aquatic area RQ
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes.	6.0 lb ai/A	ground	1	**6.0**	**12.0**	**66.0**
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch,	4.0 lb ai/A	ground	1	**4.0**	**8.0**	**44.0**

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ	Dry area RQ	Semi-aquatic area RQ
industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa		aerial	5	**20.0**	**24.0**	**60.0**
Asparagus, artichoke	3.9 lb ai/A	ground	1	**3.9**	**7.8**	**42.9**
		aerial	5	**19.5**	**23.4**	**58.5**
golf course turf, airports/landing fields	3.5 lb ai/A	ground	1	**3.5**	**7.0**	**38.5**
		aerial	5	**17.5**	**21.0**	**52.5**
residential lawns	3.0 lb ai/A	ground	1	**3.0**	**6.00**	**33.0**
		aerial	5	**15.0**	**18.0**	**43.0**
Shallot, onion, corn (sweet, pop, field)	2.0 lb ai/A	ground	1	**2.0**	**4.0**	**22.0**
		aerial	5	**10.0**	**12.0**	**30.0**
Carrot	1.9 lb ai/A	ground	1	**1.9**	**3.8**	**20.9**
		aerial	5	**9.5**	**11.4**	**28.5**
Sunflower	1.73 lb ai/A	ground	1	**1.7**	**3.5**	**19.0**
		aerial	5	**8.7**	**10.4**	**26.0**
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean)	1.485 lb ai/A	ground	1	**1.5**	**3.0**	**16.3**
		aerial	5	**7.4**	**8.9**	**22.3**
Wheat, pepper, pepino (melon pear), groundcherry, eggplant, strawberry	1.425 lb ai/A	ground	1	**1.4**	**2.9**	**15.7**
		aerial	5	**7.12**	**8.6**	**21.4**
Legume vegetables	1.24 lb ai/A	ground	1	**1.2**	**2.5**	**13.6**
		aerial	5	**6.2**	**7.4**	**18.6**
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables	1.0 lb ai/A	ground	1	**1.0**	**2.0**	**11.0**
		aerial	5	**5.0**	**6.0**	**15.0**
* = LOC exceedances (RQ $\geq$ 1) are bolded and shaded.						

Table 5-10 RQs* for Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Pendimethalin via Runoff and Drift

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ	Dry area RQ	Semi-aquatic area RQ
walnut (english/black), tangerines, tangelo, small fruits, pummelo (shaddock), pomegranate, pistachio, pecan, orange, macadamia nut (bushnut), lime, lemon, kumquat, hickory nut, grapefruit, filbert (hazelnut), citrus hybrids other than tangelo, citron (citrus), chinquapin, chestnut, cashew, calamondin, butternut, brazil nut, beech nut, almond, grapes.	6.0 lb ai/A	ground	1	0.7	**1.3**	**7.3**

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ	Dry area RQ	Semi-aquatic area RQ
Prune, plum, pear, peach, olive, nectarine, fig, cherry, apricot, apple, ornamental and/or shade trees, nonagricultural rights-of-way, fencerows, hedgerows, mulch, industrial areas (outdoor), forest trees (all or unspecified), Christmas tree plantations, recreation area lawns, loquat, shelterbelt plantings, quince, mayhaw, crabapple, alfalfa	4.0 lb ai/A	ground	1	0.4	0.9	**5.9**
		aerial	5	**2.2**	**2.7**	**6.7**
Asparagus, artichoke	3.9 lb ai/A	ground	1	0.4	0.9	**4.8**
		aerial	5	**2.2**	**2.6**	**6.5**
golf course turf, airports/landing fields	3.5 lb ai/A	ground	1	0.4	0.8	**4.3**
		aerial	5	**1.9**	**2.3**	**5.8**
residential lawns	3.0 lb ai/A	ground	1	0.3	0.7	**3.7**
		aerial	5	**1.7**	**2.0**	**5.0**
Shallot, onion, corn (sweet, pop, field)	2.0 lb ai/A	ground	1	0.2	0.4	**2.4**
		aerial	5	**1.1**	**1.3**	**3.3**
Carrot	1.9 lb ai/A	ground	1	0.2	0.4	**2.3**
		aerial	5	**1.1**	**1.3**	**3.2**
Sunflower	1.73 lb ai/A	ground	1	0.2	0.4	**2.1**
		aerial	5	**1.0**	**1.2**	**2.9**
Tomato, tomatillo, tobacco, sorghum, potato (white/Irish), lupine (grain), garlic, garbanzos (including chick peas) beans, succulent (snap or lima) beans, dried-type beans, cotton, cowpea (southern pea, black-eyed bean)	1.485 lb ai/A	ground	1	0.2	0.3	**1.8**
		aerial	5	0.8	**1.0**	**2.5**
Wheat, pepper, pepino (melon pear), groundcherry, eggplant, strawberry	1.425 lb ai/A	ground	1	0.2	0.3	**1.7**
		aerial	5	0.8	**1.0**	**2.4**
Legume vegetables	1.24 lb ai/A	ground	1	0.1	0.3	**1.5**
		aerial	5	0.7	0.8	**2.1**
Rice, mustard cabbage (gai choy, pak-choi), kohlrabi, cauliflower, cabbage (Chinese), cabbage, brussels sprouts, broccoli (Chinese), broccoli, *Brassica* (head and stem) vegetables	1.0 lb ai/A	ground	1	0.1	0.2	**1.2**
		aerial	5	0.6	0.7	**1.7**
* = LOC exceedances (RQ ≥ 1) are bolded and shaded.						

5.1.3 Primary Constituent Elements of Designated Critical Habitat

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

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

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

Based on the risk estimation for potential effects to aquatic and/or terrestrial plants provided in Sections 5.1.1.2, 5.1.1.3, and 5.1.2.3, pendimethalin may affect aquatic-phase PCEs of designated habitat related to effects on aquatic and/or terrestrial plants.

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." To assess the impact of pendimethalin on this PCE (*i.e.*, alteration of food sources), acute and chronic freshwater fish and invertebrate toxicity endpoints, as well as endpoints for aquatic non-vascular plants, are used as measures of effects. RQs for these endpoints were calculated in Sections 5.1.1.1 and 5.1.1.2. Based on RQ exceedances of LOC, pendimethalin may affect aquatic-phase PCEs of designated habitat related to effects of alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.

5.1.3.2 Terrestrial-Phase (Upland Habitat and Dispersal Habitat)

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

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

The risk estimation for terrestrial-phase PCEs of designated habitat related to potential effects on terrestrial plants is provided in Section 5.1.2.3. Based on exceedances of LOC for non-target terrestrial plants, all use sites of pendimethalin may affect the first and second terrestrial - phase PCEs.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of pendimethalin on this PCE, acute and chronic toxicity endpoints for birds, mammals, and terrestrial invertebrates are used as measures of effects. RQs for these endpoints were calculated in Section 5.1.2.3. Based on RQ exceedances of LOC from all use sites, pendimethalin may affect the third terrestrial - phase PCE.

The fourth terrestrial-phase PC is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Direct acute and chronic RQs for terrestrial-phase CRLFs are presented in Section 5.1.2.1. Based on RQ exceedances of LOC from all use sites, pendimethalin may affect the forth terrestrial - phase PCE.

5.2 Risk Description

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

Based on the RQs presented in the Risk Estimation (Section 5.1) a preliminary effects determination is "may affect" for the CRLF and critical habitat.

The direct or indirect effect LOCs are exceeded and effects may modify the PCEs of the CRLF's critical habitat, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding pendimethalin. A summary of the results of the risk estimation results are provided in **Error! Not a valid bookmark self-reference.**1 for direct and indirect effects to the CRLF and in **Table 5-12**2 for the PCEs of designated critical habitat for the CRLF.

Table 5-11 Risk Estimation Summary for Pendimethalin - Direct and Indirect Effects to CRLF

Assessment Endpoint	LOC Exceedances (Y/N)	Description of Results of Risk Estimation
Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	Yes	There are acute LOC exceedances for fish, the surrogate for the aquatic-phase CRLF.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	Yes	There are LOC exceedances for non-target aquatic non-vascular plants. There are ***no*** acute and chronic LOC exceedances for aquatic invertebrates.
Indirect Effects Survival, growth, and reproduction	Yes	There are exceedances of the LOC for both vascular and non-vascular aquatic plants.

Assessment Endpoint	LOC Exceedances (Y/N)	Description of Results of Risk Estimation
of CRLF individuals via effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)		
Indirect Effects 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.	Yes	There are LOC exceedances for non-target aquatic vascular and terrestrial plants. Effects are possible for riparian vegetation.
Terrestrial Phase (Juveniles and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Yes	There are acute and chronic LOC exceedances to birds, the surrogate for the terrestrial-phase CRLF.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial mammals and terrestrial phase amphibians)	Yes	There are acute and chronic LOC exceedances to birds, the surrogate for the terrestrial-phase amphibians. There are LOC exceedances (>0.05) for terrestrial invertebrates. There are acute and chronic LOC exceedances for small mammals.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat (*i.e.*, riparian vegetation)	Yes	There are LOC exceedances for non-target aquatic vascular and terrestrial plants. Effects are possible for riparian vegetation.

Table 5-12 Risk Estimation Summary for Pendimethalin – PCEs of Designated Critical Habitat for the CRLF

Assessment Endpoint	Habitat Effects (Y/N)	Description of Results of Risk Estimation
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Yes	There are LOC exceedances for non-target aquatic vascular and terrestrial plants. Effects are possible to non-target terrestrial and aquatic vascular plants inhabiting riparian areas.

Assessment Endpoint	Habitat Effects (Y/N)	Description of Results of Risk Estimation
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Yes	There are LOC exceedances for non-target aquatic vascular and terrestrial plants. Alteration in water chemistry/quality is possible due to effects on aquatic/terrestrial plant communities in riparian areas.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Yes	Due to potential effects on non-target aquatic plants and terrestrial riparian plant species, alteration in chemical characteristics of aquatic habitat (*e.g*. dissolved oxygen) may occur.
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (e.g., algae)	Yes	There are LOC exceedances for non-vascular aquatic plants (i.e. algae).
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	Yes	There are LOC exceedances for non-target terrestrial plants.
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	Yes	There are LOC exceedances for non-target terrestrial plants. These effects may alter plant communities necessary for dispersal habitat.
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Yes	Acute and chronic effects are possible on amphibians and mammal that serve as prey for CRLFs
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Yes	Changes in aquatic vegetation and riparian communities may alter the chemical characteristic of CRLF habitat

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

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

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

A description of the risk and effects determination for each of the established assessment endpoints for the CRLF and its designated critical habitat is provided in Sections 5.2.1 through 5.2.4.

5.2.1 Direct Effects

5.2.1.1 Aquatic-Phase CRLF

The aquatic-phase considers life stages of the frog that are obligatory aquatic organisms, including eggs and larvae. It also considers submerged terrestrial-phase juveniles and adults, which spend a portion of their time in water bodies that may receive runoff and spray drift containing pendimethalin.

This assessment used the most sensitive acute and chronic toxicity values across fish species tested since there was no amphibian data available. RQs were based on acute studies in rainbow trout (LC_{50} = 138 ug/L, MRID 00046291) and a chronic NOAEC in fathead minnow (NOAEC = 6.3 ug/L, MRID 00037940).

The highest acute RQ was 0.12 which exceeds the Agency's listed species acute LOC of 0.05. Based on a default probit slope value of 4.5 for the rainbow trout with 95% confidence intervals of 2 to 9, the associated probability of an individual effect would be approximately 1 in 5.85E+04.

The most sensitive chronic toxicity value is based on a life cycle study in fathead minnow. The chronic RQ (0.8) was based on a NOAEC of 6.3 ug/L which does not exceed the Agency's chronic LOC of 1.0. The NOAEC is from an acceptable life-cycle fathead minnow study (MRID 00024377). Most sensitive endpoint was reduction in egg production that was observed at LOAEC of 44 ug/L

Eleven aquatic EEC scenarios when compared to the acute toxicity for fish as a surrogate for aquatic-phase CRLF have acute RQs that exceeded the listed species LOC (0.05). None of the use sites has exceeded the chronic LOC for the CRLF. For the scenarios that exceeded the acute LOC for listed species, the probability of individual effect at acute RQ ranges from 1 in 5.85E+04 to 1 in 2.51E+06. The acute and chronic RQs are presented in Section 5.1.1.1. Direct effects to the aquatic-phase CRLF are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60-day EECs and the lowest chronic toxicity value for freshwater fish are used. Based on exceedances of the acute LOC for listed species (0.05), pendimethalin is likely to directly affect the aquatic-phase of the CRLF (LAA).

Incident data provided to the Agency indicate that there are two alleged fish kill incidents that involve pendimethalin. However, these incidents do not show that pendimethalin registered use contributed to the alleged fish kill incidents. One of the alleged incidents is a spill in which an up to an estimated 300 gallons of undiluted Prowl was spilled into a creek. Another alleged incident involved pendimethalin applied as part of a mixture with Chlorpyrifos, which is highly toxic to fish. Further information on the pendimethalin incidents are provided in Appendix H.

Monitoring data indicate that EECs modeled in PRZM-EXAMS are conservative. The highest detected pendimethalin is 0.679 ppb in San Joaquin-Tulare River Basin. The peak EECs range from 16.6 ppb to 6.8 ppb for those scenarios that exceed the listed species acute LOC (0.05).

Based on the acute listed species LOC exceedances for CRLF and the widespread use sites that exceed the acute listed species LOC, pendimethalin is Likely to Adversely Affect (LAA) the aquatic-phase CRLF directly.

5.2.1.2 Terrestrial-Phase CRLF

Acute and chronic LOCs were exceeded for birds (surrogate for terrestrial-phase CRLF).

Dose-based acute RQs ranged from 1.25 (6.0 lb ai/A application rate) to 0.2 (1.0 lb ai/A application rate). Dietary-based acute RQs ranged from 0.2 (6.0 lb ai/A application rate) to <0.1 (less than 2 lb ai/A application rate). The RQs that exceed the endangered species LOC (0.1) are associated with a probability of an individual effect of approximately 1 in 1.5 to 1.21E+03 based on a default probit slope of 4.5.

Avian chronic RQs ranged from 1.0 (1 lb ai/A) to 5.7 (6.0 lb ai/A). No treatment related effects were observed in the bobwhite quail and the LOAEL is greater than 1410 ppm. The mallard duck study (MRID 44907601) showed the parameter of 14-day survivor bodyweight was reduced at 1410 ppm (LOAEL). The NOAEL for the mallard study is 410 ppm. No other treatment related effects were observed. Avian body weight reduction may not necessary be a good parameter to measure effects to frog due to different physiological and caloric requirements. Therefore it is uncertain as to whether there is a potential chronic risk to CRLF. Since the chronic LOC is exceeded for birds which are surrogates for CRLF, chronic risk can not be precluded to CRLF. Therefore, the direct effects determination from chronic effects to CRLF is LAA.

Birds were used as surrogate species for terrestrial phase CRLFs. Terrestrial phase amphibians are poikilotherms, which mean that their body temperature varies with environmental temperature; while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). As a consequence, the caloric requirements of terrestrial phase amphibians are markedly lower than birds. Therefore, on a daily dietary intake basis, birds consume more food than terrestrial phase amphibians. This can be seen when comparing the caloric requirements for free living iguanid lizards (used in this case as a surrogate for terrestrial phase amphibians) to song birds (U.S. EPA, 1993):

$$\textbf{iguanid FMR (kcal/day)= 0.0535 (bw g)}^{0.799}$$

$$\textbf{passerine FMR (kcal/day) = 2.123 (bw g)}^{0.749}$$

With relatively comparable slopes to the allometric functions, one can see that, given a comparable body weight, the free living metabolic rate (FMR) of birds can be 40 times higher than reptiles, though the requirement differences narrow with high body weights.

Because the existing risk assessment process is driven by the dietary route of exposure, a finding of safety for birds, with their much higher feeding rates and, therefore, higher potential dietary exposure is reasoned to be protective of terrestrial phase amphibians. For this not to be the case, terrestrial phase amphibians would have to be 40 times more sensitive than birds for the differences in dietary uptake to be negated. However, existing dietary toxicity studies in amphibians are lacking. To quantify the potential differences in food intake between birds and terrestrial phase CRLF, food intake equations for the iguanid lizard replaced the food intake equation in T-REX for birds, and additional food items of the CRLF were evaluated. These functions were encompassed in a model called T-HERPS. T-HERPS is available at:
http://www.epa.gov/oppefed1/models/terrestrial/index.htm.
Results of this analysis are presented in Table 5.13 (use pattern (1.0 lb ai/A) with lowest EECs and RQs) through Table 5.16 (use pattern (6.0 lb ai/A) with highest EECs and RQs).

Table 5-13 Upper Bound Kenaga, Acute Terrestrial Herpetofauna Dose-Based Risk Quotients (1 lbs a.i./acre, 1 application)

Size Class (grams)	Adjusted LD50	EECs and RQs									
		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Small Herbivore Mammals		Small Insectivore Mammal		Small Amphibians	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1.4	1421.00	5.24	0.00	0.58	0.00	N/A	N/A	N/A	N/A	N/A	N/A
37	1421.00	5.15	0.00	0.57	0.00	92.77	0.07	5.80	0.00	0.18	0.00
238	1421.00	3.38	0.00	0.38	0.00	14.42	0.01	0.90	0.00	0.12	0.00

Table 5-14 Upper Bound Kenaga, Acute Terrestrial Herpetofauna Dose-Based Risk Quotients (1.24 lbs a.i./acre, 1 application)

Size Class (grams)	Adjusted LD50	EECs and RQs									
		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Small Herbivore Mammals		Small Insectivore Mammal		Small Amphibians	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1.4	1421.00	6.50	0.00	0.72	0.00	N/A	N/A	N/A	N/A	N/A	N/A
37	1421.00	6.39	0.00	0.71	0.00	115.03	0.08	7.19	0.01	0.22	0.00
238	1421.00	4.19	0.00	0.47	0.00	17.88	0.01	1.12	0.00	0.15	0.00

Table 5-15. Upper Bound Kenaga, Acute Terrestrial Herpetofauna Dose-Based Risk Quotients (1.425 lbs a.i./acre, 1 application)

Size Class (grams)	Adjusted LD50	EECs and RQs									
		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Small Herbivore Mammals		Small Insectivore Mammal		Small Amphibians	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ
1.4	1421.00	7.79	0.01	0.87	0.00	N/A	N/A	N/A	N/A	N/A	N/A
37	1421.00	7.65	0.01	0.85	0.00	137.76	**0.10**	8.61	0.01	0.27	0.00
238	1421.00	5.02	0.00	0.56	0.00	21.42	0.02	1.34	0.00	0.17	0.00

Table 5-16. Upper Bound Kenaga, Acute Terrestrial Herpetofauna Dose-Based Risk Quotients (6 lbs a.i./Acre, 1 application)

Size Class (grams)	Adjusted LD50	EECs and RQs									
		Broadleaf Plants/ Small Insects		Fruits/Pods/ Seeds/ Large Insects		Small Herbivore Mammals		Small Insectivore Mammal		Small Amphibians	
		EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ	EEC	RQ

1.4	1421.00	31.47	0.02	3.50	0.00	N/A	N/A	N/A	N/A	N/A	N/A
37	1421.00	30.93	0.02	3.44	0.00	556.59	**0.39**	34.79	0.02	1.07	0.00
238	1421.00	20.27	0.01	2.25	0.00	86.53	0.06	5.41	0.00	0.70	0.00

These data suggest that dietary exposures from consumption of insects by terrestrial phase CRLFs is likely to result in exposures that do not exceed LOCs. However, the endangered species LOC was exceeded for large terrestrial phase CRLFs that consume small herbivorous mammals in use sites that receive only 1.425 lbs a.i./acre or more of pendimethalin applications. The California mouse is a prey item of the CRLF, and this mouse reportedly eats grasses. However, some assumptions included in the assessment of small mammals as a food item are conservative because the CRLF eats a variety of food items and LOCs were not exceeded for CRLFs that eat insectivorous mammals. The RQs for a 37-gram and a 238-gram CRLF that consumes a small herbivore mammal that recently consumed contaminated short grass are found below in Table 5.17.

Table 5-17 RQ Comparisons among Weight Class and Applications Rates for CRLF Consuming Small Herbivore Mammal That Recently Consumed Contaminated Short Grass

Use site application rate	CRLF weight class	Dose-based RQ for small herbivorous mammals
6.0	37 gram	**0.39**
6.0	238 gram	0.06
1.425	37 gram	**0.10**
1.425	238 gram	0.02
1.24	37 gram	0.08
1.24	238 gram	0.01
1.0	37 gram	0.07
1.0	238 gram	0.01

RQs remain above the endangered species LOC for CRLFs that consume herbivorous mammals for all uses except where applications are less than 1.425 lb ai/A. Refinements incorporating dietary habits of CRLFs did not preclude potential risks for CRLFs that consume herbivorous mammals.

Current assessment methods of potential risks from chronic exposures for birds do not consider food intake levels. Therefore, T-HERPS does not quantify potential effects of reduced food intake of terrestrial phase CRLFs relative to birds for chronic risk assessments. However, chronic RQs would be expected to be reduced by a similar magnitude seen in the acute analysis.

Incident data provided to the Agency indicate that there are two alleged terrestrial incidents in which birds and squirrels were killed. In both of these incidents there was no chemical analysis for pendimethalin made of the corpses. Therefore, the allegation that pendimethalin was responsible for the deaths of the birds and squirrels was not confirmed but yet pendimethalin can not be precluded.

Acute and chronic LOCs were exceeded for birds (as surrogate for CRLF). The available toxicity data suggest that amphibians are less sensitive than birds to pendimethalin, and considering factors such as lower food intake of terrestrial phase amphibians relative to birds reduces EECs and RQs, but does not reduce RQs to levels that are below LOCs. Potential effects to CRLFs that consume herbivorous mammals cannot be precluded. Based on the weight-of-evidence, there is a potential direct impact to the terrestrial-phase of the CRLF based on the avian acute and chronic toxicity endpoints as a surrogate for terrestrial-phase CRLF. The effects determination of likely to adversely affect (LAA) terrestrial-phase CRLF from direct effects is based on acute and chronic listed species LOC exceedances for birds.

5.2.2 Indirect Effects (via Reductions in Prey Base)

5.2.2.1 Algae (non-vascular plants)

As discussed in Section 2.5.3, the diet of CRLF tadpoles is composed primarily of unicellular aquatic plants (i.e., algae and diatoms) and detritus. Because the aquatic nonvascular plant RQs exceed the LOC for 15 out of 25 pendimethalin use sites, pendimethalin is considered likely to indirectly affect the aquatic-phase CRLF via effects on aquatic nonvascular plants.

There were 604 measurements of pendimethalin in the Sacramento River and San Joaquin-Tulare River basins. There was measurable pendimethalin in 319 of the 604 samples (53% positive). The highest concentration recorded (0.679 ppb) in the San Joaquin-Tulare River Basin. All 9 measurements at this site were positive for pendimethalin, with a range of 0.262 to 0.679 ppb. LOCs that were exceeded have EECs from the modeled PRZM_EXAMS ranging from peak of 48 ppb (rice model scenario) to 5.6 ppb. EECs that fall below 5.2 ppb did not exceed the LOC for aquatic plants. The lowest LOC exceedance which has a peak EEC of 5.6 also has a 60-day EEC of 0.8 ppb which is similar to the peak monitoring concentration detected in surface water in California.

There are four aquatic non-vascular plant studies submitted to the Agency. The EC_{50} results of these studies range from 5.2 ppb to >174 ppb. Three of the four species have similar results. The EC_{50} data on the species are below:

Species tested	EC_{50}	MRID Source
Green algae (*Selenastrum capricornutum*)	5.4 ppb	42372204
Marine diatom (*Skeletonema costatum*)	5.2 ppb	42372205
Freshwater diatom (*Navicula pelliculosa*)	6.7 ppb	42372206
Bluegreen algae (*Anabaena flos-aquae*)	>174 ppb	42372207

Based on the Agency's LOC for aquatic plants being exceeded and that 3 out of 4 species have sensitive EC_{50} similarities; there is a potential indirect impact to the CRLF from reduction of aquatic food items. The effects determination for the CRLF based on potential reductions in algae is "likely to adversely affect" (LAA).

5.2.2.2 Aquatic Invertebrates

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

There are no aquatic invertebrate's chronic (1.0) or acute (0.5) exceedances of LOC found in section 5.1.1.2. There are two scenarios (rice and forestry) in which the RQ lies between the listed species LOC of 0.05 and the acute LOC of 0.5. The probability of individual effect at RQ for RQ of 0.17 is 1 in 3740 and for the listed species of 0.06 is 1 in 5.22E+07. The scenario with an RQ of 0.17 used a conservative scenario (Rice model) which is a direct instantaneous deposition to a water column. It does not take into account runoffs, dilution, or holding patterns before releasing into the environment. Thus the EEC may be an overestimation of the amount of pendimethalin concentration found waters from rice fields that are released into environs. The probability of individual effect at RQ analysis indicates that the chance of adverse effect to the aquatic invertebrate population is not significant.

Other aquatic invertebrate acute toxicity studies were submitted to the Agency. Another waterflea (*Daphnia magna*) study tested with a formulation of 45.6% active ingredient of pendimethalin. This study showed an EC_{50} of 5.1 ppm formulated product. A submitted crayfish (*Procambarus simulans*) study showed an EC_{50} greater than 1.0 ppm (1,000 ppb). This study is considered to be supplemental due to precipitation was seen of concentrations over 1 ppm, the dissolved O_2 concentration is less than 40% of saturation, and DMSO was used as a solvent which tends to increase mortalities rather than decrease them. Both studies show that other aquatic invertebrates have orders of magnitude less sensitivity than the *Daphnia magna* surrogate.

There were 604 measurements of pendimethalin in the Sacramento River and San Joaquin-Tulare River basins. There was measurable pendimethalin in 319 of the 604 samples (53% positive). The highest concentration recorded (0.679 ppb) in the San Joaquin-Tulare River Basin. All 9 measurements at this site were positive for pendimethalin, with a range of 0.262 to 0.679 ppb which is well below the toxicity level of *Daphnia magna* EC_{50} of 280 ppb by three orders of magnitude.

Based on the weight-of-evidence of chronic and acute LOC not being exceeded for aquatic invertebrates; the probit slope analysis showing probability of effect being insignificant; and species sensitivity among other aquatic invertebrates being less sensitive than the surrogate invertebrate; the effects determination for the CRLF based on potential reductions in aquatic invertebrates is “not likely to adversely affect” (NLAA).

5.2.2.3 Fish and Aquatic-phase Frogs

In the absence of toxicity data for amphibians, the most sensitive acute and chronic toxicity values across fish species tested. RQs were based on acute studies in rainbow trout (LC_{50} = 138 ug/L, MRID 00046291) and a chronic NOAEC in fathead minnow (NOAEC = 6.3 ug/L, MRID 00037940).

The highest acute RQ from the rice model was 0.0.35. The acute LOC is 0.5. Based on a default probit slope value of 4.5 for the rainbow trout with 95% confidence intervals of 2 to 9, the associated probability of an individual effect would be approximately 1 in 49.8. The scenario with an RQ of 0.12 used a conservative scenario (Rice model) which is a direct instantaneous deposition to a water column. It does not take into account runoffs, dilution, or holding patterns before releasing into the environment. Thus the EEC may be an overestimation of the amount of pendimethalin concentration found waters from rice fields that are released into environs.

The next highest RQ is 0.12 from a forestry and Christmas tree use sites. The associated probability of an individual effect would be approximately 1 in 5.85E+04. Eleven scenarios have LOCs that are between the acute LOC (0.5) and the listed species LOC (0.05) and their RQs range from 0.12 to 0.05. The probability of individual effect at RQ for RQs of 0.17 to 0.05 is 1 in 5.85E+04 to 1 in 4.18E+08. The probability of individual effect at RQ analysis indicates that the chance of adverse effect to the aquatic invertebrate population is not be significant.

The most sensitive chronic toxicity value is based on a life cycle study in fathead minnow. The chronic RQ (0.8) is based on a NOAEC of 6.3 ug/L from an acceptable life-cycle study (MRID 00024377). Most sensitive endpoint was reduction in egg production that was observed at LOAEC of 44 ug/L.

Based on no acute or chronic exceedances and the low probability of an individual effect; the effects determination for the CRLF based on potential reductions in fish and other amphibians as food items of the aquatic-phase CRLF is “**not** likely to adversely affect” (NLAA).

5.2.2.4 Terrestrial Invertebrates

When the terrestrial-phase CRLF reaches juvenile and adult stages, its diet is mainly composed of terrestrial invertebrates.

Toxicity data from honey bee study (MRID 00099890) show the LD50 to be greater than 49.8 µg/Bee. No mortalities were observed at the highest concentration.

Based upon an average fresh weight per honey bee of 128 milligrams, the LD_{50} of honey bees (µg /bee) can be multiplied by 7.8 to determine the ppm toxicity. The toxicity equivalence in ppm would be 388 ppm. According to the Hoerger, Kenaga[5] nomogram modified by Fletcher[6], the highest EEC exposure from 6 lb ai/A application to large insects would be 90 ppm and to small insects would be 810 ppm. The EEC of small insects is about 2X more than the highest dose tested. The EEC of the largest insect is less than 2X the dose tested. Although there are no mortalities of the honey bee at the highest dose tested and that under the Agency's guidelines, pendimethalin is considered to be practically non-toxic to honey bee; the honey bee study did not test up to the highest dose that could be expected from 6 lb ai/A directly onto small insects at the site of application.

There is some uncertainty due to the highest concentration dose tested on the bee was well below the equivalent of 6 lb ai/A maximum application. There was no mortality at the highest dose tested, yet it is uncertain if mortality will exist if a higher dose was used in the bee study that would reflect the maximum application rate. Therefore, potential risk can not be precluded to terrestrial invertebrates as a food item. Because potential risk can not be precluded to terrestrial invertebrates as a food item; the effects determination for the CRLF based on potential reductions in terrestrial invertebrates as prey items is "likely to adversely affect" (LAA).

5.2.2.5 Mammals

Terrestrial phase CRLFs consume small mammals. This assessment used a 15-gram herbivorous mammal to determine if there could be a potential reduction in mammal abundance. Acute dose-based RQs for a 15-gram mammal ranged from 0.1 to 0.6 depending on the use pattern. Assuming a probit slope of 4.5, the probability of an individual effect would be approximately 1 in 6.9. Assuming that probability of an individual effect provides insight into the potential for reductions in a local population of small mammals, a probability of 1 in 6.9 (15.9%) would result in a measurable impact to mammal abundance and would, therefore, constitute a significant effect.

Reproduction RQs ranged from 5.2 to 25.0. The toxicity endpoint used in the RQs was based on a parental systemic and reproductive NOAEL of 25 mg/kg-bw/day. The

[5] Hoerger, F. and E.E. Kenaga. 1972. Pesticide residues on plants: correlation of representative data as a basis for estimation of their magnitude in the environment. IN: F. Coulston and F. Corte, eds., Environmental Quality and Safety: Chemistry, Toxicology and Technology. Vol 1. Georg Theime Publishers, Stuttgart, Germany. pp. 9-28

[6] Fletcher, J.S., J.E. Nellesson and T. G. Pfleeger. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants. Environ. Tox. and Chem. 13(9):1383-1391

parental systemic endpoint was based on decreased body weight gain and food consumption at the LOAEL of 125 mg/kg/day (**500 ppm**). The reproductive/offspring NOAEL is 25 mg/kg/day (**500 ppm**), based on decreases in the number of pups born and pup weight at the LOAEL of 125 mg/kg/day (**2500 ppm**) which may be a significant population effect. The RQs indicate that potential exposures exceed the NOAEL for all uses. Due to the chronic LOC being exceeded for small mammal prey and the reproductive endpoint is based on decreasing numbers of pups born and pup weight, the effects determination for the potential for pendimethalin to indirectly affect the CRLF from potential impacts to mammalian prey is likely to adversely affect (LAA).

5.2.2.6 Terrestrial-phase Amphibians

The effects determination for terrestrial phase CRLF consuming small mammalian prey was "likely to adversely affect" (LAA). This determination was based solely on frogs that consume potentially contaminated herbivore mammals. Terrestrial amphibian prey of the CRLF includes small amphibians such as tree frogs that do not prey on mammals. Therefore, the mammalian food group is not relevant in the evaluation of potential reductions in amphibian prey abundance.

Avian (as surrogate for frog and CRLF) listed species RQs exceeded LOCs (0.1) (Section 5.1). *Acute* LOCs (0.5) were not exceeded for *insectivorous* amphibians using the T-HERPS model (Table 5.16) at the highest rate of application (6 lb ai/A). Therefore, reductions from acute effects in amphibian prey as a food item at levels likely to affect the CRLF are not likely to occur, and the effects determination for the CRLF based on potential reductions in terrestrial amphibians is "not likely to adversely affect" (NLAA).

Since the chronic LOC have been exceeded, the effects determination for the CRLF based on potential reductions in terrestrial-phase amphibians as food item is "likely to adversely affect" (LAA) from chronic LOC exceedances.

5.2.3 Indirect Effects (via Habitat Effects)

5.2.3.1 Aquatic Plants (Vascular and Non-vascular)

Aquatic plants serve several important functions in aquatic ecosystems. Non-vascular aquatic plants are primary producers and provide the autochthonous energy base for aquatic ecosystems. Vascular plants provide structure as attachment sites and refugia for many aquatic invertebrates, fish, and juvenile organisms, such as fish and frogs. In addition, vascular plants also provide primary productivity and oxygen to the aquatic ecosystem. Rooted plants help reduce sediment loading and provide stability to nearshore areas and lower streambanks. In addition, vascular aquatic plants are important as attachment sites for egg masses of CRLFs.

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production were assessed using RQs from freshwater aquatic vascular and non-vascular plant data. Section 5.2.2.1 indicates that pendimethalin is likely to adversely impact non-target aquatic plants.

LOCs are exceeded for aquatic vascular plants and algae from exposure to pendimethalin from runoff or spray drift. The non-vascular RQs that exceed LOC range from 1.1 to 9.2 and exceed the LOC for 15 out of 25 pendimethalin aquatic model scenarios. The vascular plant LOC is exceeded for 2 of the 25 aquatic model scenarios with the RQs of 1.3 and 3.8.

There were 604 measurements of pendimethalin in the Sacramento River and San Joaquin-Tulare River basins. There was measurable pendimethalin in 319 of the 604 samples (53% positive). The highest concentration recorded (0.679 ppb) were found in the San Joaquin-Tulare River Basin. All 9 measurements at this site were positive for pendimethalin, with a range of 0.262 to 0.679 ppb. LOCs that were exceeded have EECs from the modeled PRZM_EXAMS ranging from peak of 48 ppb (rice model scenario) to 5.6 ppb. EECs that fall below 5.2 ppb did not exceed the LOC for aquatic nonvascular plants and 12.5 ppb for the aquatic vascular plants.

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production were assessed using RQs from freshwater aquatic vascular and non-vascular plant data. Based on the LOC exceedances, there is a potential indirect impact to the aquatic-phase-CRLF from aquatic habitat degradation. The effects determination for the aquatic-phase CRLF is "likely to adversely affect" (LAA).

5.2.3.2 Terrestrial Plants

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

The terrestrial non-target plant LOC is exceeded for all use sites. The RQs are variable according to the method of application used (aerial or ground application) and the amount of active ingredient used. Table 5.18 below shows the range of RQs from different application methods.

Table 5-18. Range of Risk Quotients for Non-Target Terrestrial Plants from Pendimethalin Usage

	Application	Spray	Runoff to Low-Lying	Runoff to dry

Application Rate	Method	Drift RQ	semi-aquatic areas	adjacent areas
6.0 lb ai/A	ground	**6.0**	**66.0**	**12.0**
4.0 lb ai/A	ground	**4.0**	**44.0**	**8.0**
3.5 lb ai/A	ground	**3.5**	**38.5**	**7.0**
2.0 lb ai/A	ground	**2.0**	**22.0**	**4.0**
1.485 lb ai/A	ground	**1.5**	**16.3**	**3.0**
1.0 lb ai/A	ground	**1.0**	**11.0**	**2.0**
4.0 lb ai/A	aerial	**20.0**	**60.0**	**24.0**
3.5 lb ai/A	aerial	**17.5**	**52.5**	**21.0**
2.0 lb ai/A	aerial	**10.0**	**30.0**	**12.0**
1.485 lb ai/A	aerial	**7.4**	**22.3**	**8.9**
1.0 lb ai/A	aerial	**5.0**	**15.0**	**6.0**

Bold denotes that the RQ has exceeded the LOC.

Although the endpoint used for runoff (seedling emergence) is 3X more sensitive than the spray drift toxicity endpoint (vegetative vigor), there is more LOC exceedances from aerial application than from runoff. This is due to the fate characteristics of pendimethalin. Pendimethalin binds more closely to the soil and is usually carried with soil during a runoff event rather than with water.

The most sensitive monocot appears to be more sensitive than the most sensitive dicot tested by an order of magnitude. Differences of responses between the dicots and monocots are mixed and do overlap. Overall, monocots and dicots are both sensitive to pendimethalin. The herbicidal mode of action of pendimethalin is that it disrupts the process of mitosis in the growth of shoots and roots. It acts as a microtubule disruptor by inhibiting cell division and cell elongation in plants. Absorption of the chemical into plant is via roots and shoots.

Based on the weight-of-evidence, the Agency concludes that there is a potential indirect impact to CRLF by terrestrial habitat degradation from pendimethalin exposure and therefore pendimethalin is Likely to Adversely Affect (LAA) the CRLF both riparian and upland vegetation.

If aerial application was to be eliminated at least 1000 feet of CRLF habitat, potential risk would be reduced.

5.2.4 Effects to Designated Critical Habitat

Risk conclusions for the designated critical habitat are the same as those for indirect effects. Agency concludes that there is a potential indirect impact to CRLF by terrestrial and aquatic habitat degradation from pendimethalin exposure.

5.2.4.1 Aquatic-Phase PCEs

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

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

Conclusions for potential indirect effects to the CRLF via direct effects to aquatic and terrestrial plants are used to determine whether modification to critical habitat may occur. There is a potential for habitat effects via impacts to aquatic plants (Sections 5.2.2.1 and 5.2.3.1) and terrestrial plants (5.2.3.2)

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." Other than impacts to algae as food items for tadpoles (discussed above), this PCE is assessed by considering direct and indirect effects to the aquatic-phase CRLF via acute and chronic freshwater fish and invertebrate toxicity endpoints as measures of effects. There is a potential for habitat effects via impacts to aquatic-phase CRLFs (Sections 5.2.1.1) and effects to freshwater invertebrates and fish as food items (Sections 5.2.2.2 and 5.2.2.3).

5.2.4.2 Terrestrial-Phase PCEs

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

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

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

There is a potential for habitat effects via impacts to terrestrial plants (5.2.3.2).

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

The fourth terrestrial-phase PCE is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. There is a potential for habitat modification via direct (Section 5.2.1.2) and indirect effects (Sections 5.2.2.4, 5.2.2.5, and 5.2.2.6) to terrestrial-phase CRLFs.

5.2.5 Spatial Extent of Potential Effects

An LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the CRLF or its designated critical habitat. To determine this area, the footprint of pendimethalin's use pattern is identified, using land cover data that correspond to pendimethalin's use pattern. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift. The identified direct/indirect effects and/or modification to critical habitat are anticipated to occur only for those currently occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that overlap with the initial area of concern plus at least 1000 feet from its boundary. It is assumed that non-flowing waterbodies (or potential CRLF habitat) are included within this area.

In addition to the spray drift buffer, the results of the downstream dilution extent analysis result in a distance of 272 kilometers which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern (based on the forestry use; see Appendix D). If any of these streams reaches flow into CRLF habitat, there is potential to affect either the CRLF or modify its habitat. These lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of pendimethalin sufficient to result in LAA determination or effects to critical habitat.

The determination of the buffer distance and downstream dilution for spatial extent of the effects determination is described below.

5.2.5.1 Spray Drift

In order to determine terrestrial and aquatic habitats of concern due to pendimethalin exposures through spray drift, it is necessary to estimate the distance that spray applications can drift from the treated area and still be present at concentrations that exceed levels of concern. An analysis of spray drift distances was completed using the AgDrift model.

In order to characterize the spatial extent of the effects determination that is relevant to the CRLF (i.e. NLAA versus LAA), an analysis was conducted using the most sensitive non-endangered plant EC_{25} of 0.01 lbs ai/acre (ryegrass seedling emergence). Typically the NOAEC is used when there is an obligate relationship between the species being assessed and endangered plants (or other taxa). However, there is no obligate relationship between the CRLF and any endangered plant; therefore the LAA/NLAA determination is based on the area defined by the non-listed species LOC (i.e., EEC/EC_{50}).

The most sensitive effect of concern was the lowest EC25 for seedling emergence, 0.01 lb/acre for ryegrass. Tier 1 ground spray analysis (terrestrial assessment) was performed with the AgDrift model. The following settings were used: High boom, ASAE very fine to fine spray, point deposition, and an application rate of 6 lb/acre. The resulting buffer distance for ground spray was 899 feet.

A similar analysis was performed using AgDrift, using the Tier 1 aerial (terrestrial) assessment with ASAE very fine to fine spray, point deposition, and an application rate of 4 lb/acre. The resulting buffer exceeds the limit of the AgDrift model (approximately 1000 feet). A Tier 2 AgDrift aerial analysis was also conducted, with the same result (over 1000 feet). A summary of the modeled distances by application rate is presented in Table 5.19.

Table 5-19 Summary of AgDrift Predicted Terrestrial Spray Drift Distances

Application Rate (method)	Uses Represented	EC_{25} Distance (ft)
6.0 (ground)		899
4.0 (aerial)		Over 1000

Given that the greatest buffer distance is 1,000 feet for terrestrial plants, this value was used to define the spatial extent of the effects determination (i.e., this buffer distance is added to the initial area of concern).

Similar to the analysis described above, the buffer distance needed to get below the most sensitive aquatic LOC was determined. This distance identifies those locations where water bodies can be impacted by spray drift deposition alone (no runoff considered) resulting in concentrations above the LOC. The most sensitive aquatic endpoint is for aquatic non-vascular plants (*Skeletonema*) with an EC_{50} value of 5.2 µg/L. The analysis yields a much lower ground-spray buffer distance than the terrestrial buffer with a distance of 79 feet (based on the non-listed LOC using the EC_{50} value). However, the Tier 1 and 2 aerial analysis again yields a distance of over 1,000 feet. The results of the analysis are presented in Table 5.20.

Table 5-20 Summary of AgDrift Predicted Aquatic Spray Drift Distances

Application Rate (method)	Uses Represented	EC_{50} Distance (ft)

Application Rate (method)	Uses Represented	EC_{50} Distance (ft)
6.0 (ground)		79
4.0 (aerial)		Over 1000

5.2.5.2 Downstream Dilution Analysis

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

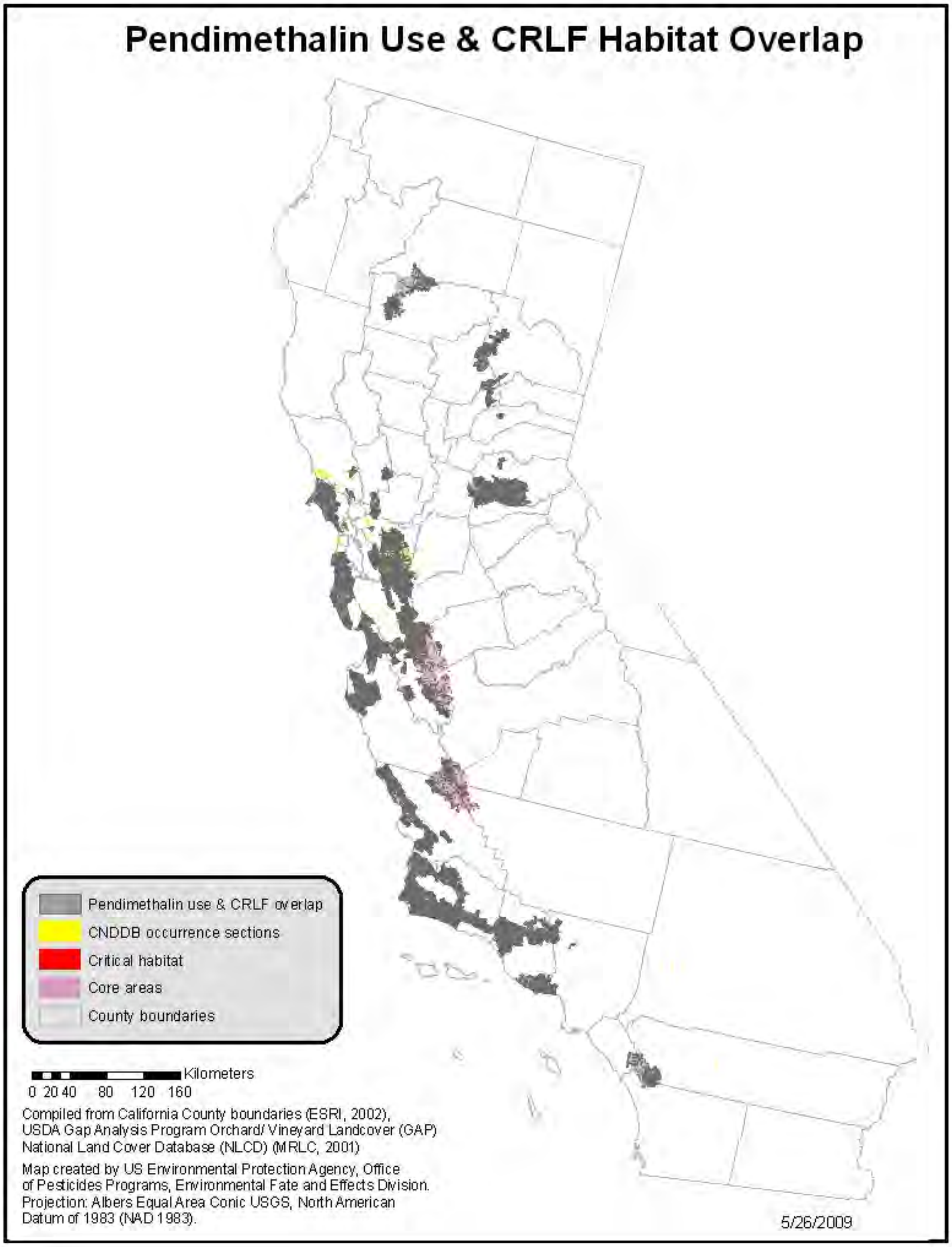
Using an EC_{50} value of 5.2 ug/L for non-vascular aquatic plants (the most sensitive species is *Skeletonema costatum*) and a maximum peak EEC for applications to rice of 48 ug/L yields an RQ/LOC ratio of 9.2 (9.2/1), which is applied to the pasture/hay and cultivated crop land cover class. RQ/LOC ratios for other use categories range from 2.3 to 3.2. Using the downstream dilution approach (described in more detail in **Appendix D**) yields a target percent crop area (PCA) of 11% for the ratio of 9.2. This value has been input into the downstream dilution approach and results in a distance of 47 kilometers. However, the forestry RQ/LOC ratio of 3.2 yields a downstream dilution distance of 272 kilometers, which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern, for the forestry land cover class. Similar to the spray drift buffer described above, the LAA/NLAA determination is based on the area defined by the point where concentrations exceed the EC_{50} value.

5.2.5.3 Overlap between CRLF habitat and Spatial Extent of Potential Effects

An LAA effects determination is made to those areas where it is expected that the pesticide's use will directly or indirectly affect the CRLF or its designated critical habitat and the area overlaps with the core areas, critical habitat and available occurrence data for CRLF.

For pendimethalin, the use patterns fall into the following land cover classes: Cultivated Crops; Developed, High Intensity; Developed, Low Intensity; Developed, Medium Intensity; Developed, Open Space; Forest; Open Water; Orchards and vineyards; Pasture/Hay; Wetlands; Turf; and Rights-of-way. The overlap area also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift, where it overlaps with CRLF habitat. Appendix D provides maps of the initial area of concern, along with CRLF habitat areas, including currently occupied core areas, CNDDB occurrence sections, and designated critical habitat. It is expected that any additional areas of CRLF habitat that are located at least 1000 ft (to account for offsite migration via spray drift) and 272 kilometers of stream reach (to account for downstream dilution) outside the initial area of concern may also be impacted and are part of the full spatial extent of the LAA and effects to critical habitat determination.

Figure 2.6. Overlap Map: CRLF Habitat and Pendimethalin Initial Area of Concern



In order to confirm that uses of pendimethalin have the potential to affect CRLF through direct applications to target areas and runoff and spray drift to non-target areas, it is necessary to determine whether or not the spatial extent of potential effects based on agricultural and orchard crops and turf use of pendimethalin overlap with CRLF habitats. Spatial analysis using ArcGIS 9.1 indicates that lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of pendimethalin sufficient to result in RQ values that exceed LOCs. In addition, terrestrial habitats (and potentially lentic aquatic habitats) of the final action areas for agricultural, forestry, rights-of ways, ornamental, and turf uses of pendimethalin overlap with the core areas, critical habitat and available occurrence data for CRLF (**Figure 2.6**). Thus, uses of pendimethalin on agricultural and orchard crops and turf use could result in exposures of the CRLF to pendimethalin in aquatic and terrestrial habitats.

6.0 Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

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

6.1.2 Aquatic Exposure Modeling of Pendimethalin

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

The Agency acknowledges that there are some unique aquatic habitats that are not accurately captured by this modeling scenario and modeling results may, therefore, under- or over-estimate exposure, depending on a number of variables. For example, aquatic-phase CRLFs may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than the EXAMS pond. The Agency does not currently have sufficient information regarding the hydrology of these aquatic habitats to develop a specific alternate scenario for the CRLF. CRLFs prefer habitat with perennial (present year-round) or near-perennial water and do not frequently inhabit vernal (temporary) pools because conditions in these habitats are generally not suitable (Hayes and Jennings 1988). Therefore, the EXAMS pond is assumed to be representative of exposure to aquatic-phase CRLFs. In addition, the Services agree that the existing EXAMS pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004).

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

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

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

In order to account for uncertainties associated with modeling, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for pendimethalin concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (e.g. application rates and timing, crops) associated with the agricultural areas are unknown, however, they are assumed to be representative of potential pendimethalin use areas.

The monitoring data available are within same order of magnitude as the PRZM-EXAMS predictions, or slightly lower, for the agricultural and forestry scenarios. The monitoring data indicated that the maximum observed concentration in Sacramento River valley streams was 0.7 ppb, and in San Joaquin Valley streams it was 3.5 ppb. PRZM-EXAMS prediction (not including the scenarios for impervious surfaces) estimated pendimethalin to be in the surface waters at peak concentrations from 3 to 16 ppb. The impervious scenario was much higher at 143 ppb.

6.1.3 Usage Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. Thirteen years of data (1994 – 2006) were included in this analysis. Because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was not provided by CDPR for years before 2002, these data are less accurate. No methodology for removing outliers was provided by CDPR for 2001 and earlier pesticide data; therefore, this information was included separately in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been cancelled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide usage data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

6.1.4 Terrestrial Exposure Modeling of Pendimethalin

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

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

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

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

6.1.5 Spray Drift Modeling

Although there may be multiple pendimethalin applications at a single site, it is unlikely that the same organism would be exposed to the maximum amount of spray drift from every application made. In order for an organism to receive the maximum concentration of pendimethalin from multiple applications, each application of pendimethalin would have to occur under identical atmospheric conditions (*e.g.*, same wind speed and – for plants – same wind direction) and (if it is an animal) the animal being exposed would have to be present directly downwind at the same distance after each application. Although there may be sites where the dominant wind direction is fairly consistent (at least during the relatively quiescent conditions that are most favorable for aerial spray applications), it is nevertheless highly unlikely that plants in any specific area would receive the maximum amount of spray drift repeatedly. It appears that in most areas (based upon available meteorological data) wind direction is temporally very changeable, even within the same day. Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT/AGDISP model (*i.e*., it models spray drift from aerial and ground applications in a flat area with little to no ground cover and a steady, constant wind speed and direction). Therefore, in most cases, the drift estimates from AgDRIFT/AGDISP may overestimate exposure even from single applications, especially as the distance increases from the site of application, since the model does not account for potential obstructions (*e.g*., large hills, berms, buildings, trees, *etc*.). Furthermore, conservative assumptions are often made regarding the droplet size distributions being modeled ('ASAE Very Fine to Fine' for orchard uses and 'ASAE Very Fine' for agricultural uses), the application method (*e*.g., aerial), release heights and wind speeds. Alterations in any of these inputs would change the area of potential effect.

6.1.6 Volatility

Pendimethalin is a semi-volatile compound that may be lost from moist soil. The volatilization half-life from moist soil was found to be 12.5 days (MRID 00153766). Pendimethalin has been observed in rainwater in California (Vogel et al., 2008). This effect was accounted for in the PRZM-EXAMS modeling by invoking the PRZM volatilization routine, thus allowing voltilization to compete with runoff and metabolism as a dissipation route. Comparison of the highest EEC scenario (forestry) shows that the effect is small (16.6 ppb with volatility invoked and 18.1 ppb without). The relatively slow volatilization rate from even moist soil is not believed to result in as large or immediate an aquatic exposure as spray drift at the time of application. Terrestrial exposure of plants and animals is accounted for at least in part by the AgDrift and AgDISP effect area analysis.

6.1.7 Bioaccumulation

Pendimethalin is believed to be bioaccumulative, as it has a logKow of 5.18, and a whole-body BCF of 5100x in bluegill sunfish (MRID 00156726). PRZM-EXAMS modeling indicates that pendimethalin may accumulate in sediments as well. Thus, food-chain exposure via accumulation in aquatic organisms may be a completed exposure pathway. However, several factors indicate that such exposure may not be a concern. First, additional bioaccumulation data in catfish (approximate BCF = 1600x), guppies (no accumulation, with metabolism) (MRID 00046293) and crayfish (MRID 00071124) whole body BCF = 1.5x) indicate that bioaccumulation is not the only response of aquatic organisms to pendimethalin. Second, the bluegill sunfish exposed to pendimethalin accumulated 15 ppm body burden with no ill effects, followed by depuration.

KABAM modeling (Appendix K) indicated some marginal chronic risk for large river otters (chronic dose-based RQ 1.3, but dietary-based RQ 0.169) and marginal acute risk for small CRLF (acute dose-based RQ 0.14 to 0.38, but dietary-based RQ 0.007 to 0.008. However, the assumption of no metabolism in aquatic organisms is probably incorrect, so the results from KABAM showing marginal risks are therefore discountable.

6.2 Effects Assessment Uncertainties

6.2.1 Age Class and Sensitivity of Effects Thresholds

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

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

6.2.2 Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on pendimethalin are not available for frogs or any other aquatic-phase amphibian; therefore, freshwater fish are used as surrogate species for aquatic-phase amphibians. Therefore, endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase amphibians including the CRLF, and extrapolation of the risk conclusions from the most sensitive tested species to the aquatic-phase CRLF is likely to overestimate the potential risks to those species. Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency's LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

6.2.3 Sublethal Effects

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

To the extent to which sublethal effects are not considered in this assessment, the potential direct and indirect effects of pendimethalin on CRLF may be underestimated.

6.2.4 Location of Wildlife Species

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

6.2.5 Toxicity to Honeybees.

Pendimethalin is rated as practically non-toxic to honeybees. The honeybee contact toxicity data is used as a surrogate assessment endpoint for all terrestrial invertebrates. Because the calculated exposure (TREX EEC for large and small insects) exceeds the highest tested dose, even though there were no mortalities at the highest dose, there is some residual uncertainty about potential effects to terrestrial invertebrates. This results in a May Affect determination, however, it is considered discountable.

7.0 Risk Conclusions

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

Based on the best available information, the Agency makes a Likely to Adversely Affect/May Affect, determination for the CRLF from the use of pendimethalin. The Agency has determined that there is the potential for effects to CRLF designated critical habitat from the use of the chemical. All of the uses might affect the frog or its critical habitat. The LAA determination is from **direct and indirect effects to CRLF from the use of pendimethalin.** Given the LAA determination for the CRLF and potential effects to designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in Attachment 2.

The LAA effects determination applies to those areas where it is expected that the pesticide’s use will directly or indirectly affect the CRLF or its designated critical habitat. To determine this area, the footprint of pendimethalin’s use pattern is identified, using land cover data that correspond to pendimethalin’s use pattern. The spatial extent of the

LAA effects determination also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift. The identified direct and indirect effects and modification to critical habitat are anticipated to occur only for those currently occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that overlap with the initial area of concern plus at least 1000 feet from its boundary (refer to analysis in Section 5.1.4). It is assumed that non-flowing waterbodies (or potential CRLF habitat) are included within this area.

In addition to the spray drift buffer, the results of the downstream dilution extent analysis result in a distance of 272 kilometers which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern (refer to analysis in Section 5.1.4). If any of these streams reaches flow into CRLF habitat, there is potential to affect either the CRLF or affect its habitat. These lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of pendimethalin sufficient to result in LAA determination or effects to critical habitat.

Appendix K provides maps of the initial area of concern, along with CRLF habitat areas, including currently occupied core areas, CNDDB occurrence sections, and designated critical habitat. It is expected that any additional areas of CRLF habitat that are located at least 1000 ft (to account for offsite migration via spray drift) and 272 kilometers of stream distance (to account for downstream dilution) outside the initial area of concern may also be impacted and are part of the full spatial extent of the LAA and critical habitat effects determination.

A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat, given the uncertainties discussed in Section 6, is presented in Table 7.0-1 and Table 7-2.

Table 7-1 Effects Determination Summary for Pendimethalin Use and the CRLF

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Survival, growth, and/or reproduction of CRLF individuals	LAA[1]	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults): Acute LOCs were exceeded for fish or aquatic-phase amphibians
		Terrestrial-phase (Juveniles and Adults): Acute and chronic LOCs were exceeded for birds. The available toxicity data suggest that amphibians are less sensitive than birds to pendimethalin, and considering factors such as lower food intake of terrestrial phase amphibians relative to birds reduces EECs and RQs, but does not reduce RQs to levels that are below LOCs. Likely to adversely affect CRLF.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity: LOC is exceeded only for non-vascular aquatic plants. RQs are below LOC for freshwater invertebrates (chronic and acute effects) and fish or frogs (chronic and acute effects). Pendimethalin could potentially impact terrestrial and aquatic plants to an extent that could result in indirect effects to the CRLF or modification of critical habitat.
		Terrestrial prey items, riparian habitat:

Assessment Endpoint	Effects Determination [1]	Basis for Determination
		Chronic LOC is exceeded for mammal and birds (surrogate for frog). Pendimethalin is practically non-toxic to honeybees with no mortalities observed in testing. LOC is exceeded for terrestrial invertebrates. Uncertainty in toxicity to insects from EEC that is above highest bee concentration tested does not preclude potential risk. Pendimethalin may adversely affect insects. Acute LOCs were not exceeded for insectivorous amphibians using the T-HERPS model at the highest rate of application. LOC is exceeded for non-target terrestrial plants and thereby critical habitat could be affected as a result of these potential impacts.

[1] No effect (NE); May affect, but not likely to adversely affect (NLAA); May affect, likely to adversely affect (LAA)

Table 7-2 Effects Determination Summary for Pendimethalin Use and CRLF Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination	Basis for Determination
Modification of aquatic-phase PCE	**Habitat Effects**	Effects to riparian vegetation (terrestrial plants) and aquatic non-vascular and vascular plants result in LOC exceedances. These effects may indirectly affect the CRLF via reduction in food supply, changes in available cover, physical parameters of the waterbody *(e.g.* increase temperature or turbidity) LOC is exceeded for effects to non-vascular aquatic plants, freshwater invertebrates (chronic and acute effects) and fish or frogs (chronic and acute effects).
Modification of terrestrial-phase PCE		Effects to riparian vegetation (terrestrial plants) result in LOC exceedances. Effects may result in changes in community composition or relative abundance of riparian plant species, possibly altering terrestrial – phase CRLF habitat. Chronic LOC is exceeded for mammal. Although there are NLAA determinations for other prey items, small mammals constitute up to half of the food intake for CRLF and reduction in small mammalian populations may be significant.

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

When evaluating the significance of this risk assessment's direct/indirect and habitat 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.

8.0 References

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

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 overharvest 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.

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.

D.W. Sparling, G.M. Fellers, L.L. McConnell. 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/doc/recovery_plans/2002/020528.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.

Vogel, J.R., Majewski, M.S., and Capel, P.D. (2008) Pesticides in Rain in Four Agricultural Watersheds in the United States. J. Environ. Qual. V. 37 May-June 2008, pp. 1101-1115.