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

Pesticide Effects Determination

Environmental Fate and Effects Division
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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 Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) regulatory actions regarding use of dicofol 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 (U.S. FWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (U.S. FWS/NMFS 1998) and procedures outlined in the Agency's Overview Document (U.S. EPA 2004).

The CRLF was listed as a threatened species by U.S. FWS 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 (U.S. FWS 1996) in California.

Dicofol is a broad-spectrum acaricide, insecticide, and miticide, initially registered as a pesticide in 1957. The current technical formula containing dicofol was reregistered in 1998. The following uses of dicofol are considered as part of the federal action evaluated in this assessment: beans (dry, snap, and lima), citrus (specifically, grapefruit, kumquats, lemons, limes, oranges, tangelos, and tangerines), cotton, cucurbits (specifically, cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash), grapes, hops, mint, pecans, peppers, pome fruits (specifically, apples, crabapples, pears, and quince), stone fruits (specifically, apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes), strawberries, tomatoes, walnuts, bermudagrass, turf/ornamental uses (specifically, turf grasses, nursery stock, flowers, shade trees, woody shrubs and vines, and sod farms) and outside building surfaces (nonagricultural).

Dicofol is composed of two isomers, *p,p*'-dicofol and *o,p'*-dicofol (see Figure 1), that occur at a ratio of 4.5: 1 in formulated end-use products. Based on the available environmental fate data for dicofol, this chemical and its degradates are expected to persist with a half-life of up to 313 days, depending upon the specific environmental conditions. Major routes of dissipation are hydrolysis under neutral and alkaline conditions and aerobic and anaerobic soil metabolism, with the *o,p'*-isomer degrading more quickly. Dicofol is classified as slightly mobile (Kashuba, *et al.* 2006). Leaching and photodegradation are not expected to be significant routes of dissipation of dicofol in the environment. Because of its low vapor pressure (3.9×10^{-7} torr) and Henry's Law Constant (1.4×10^{-7} atm-m^3/mol), low levels of volatilization are possible, but not expected.

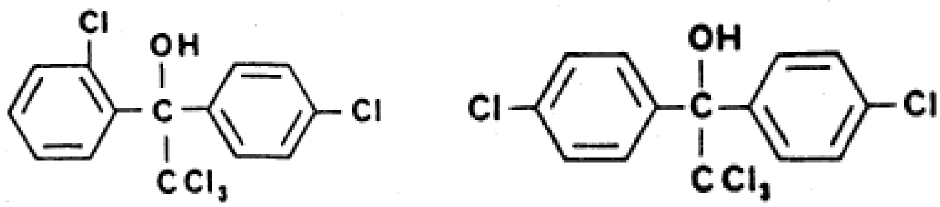


Figure 1. Chemical Structures for *o,p'*- and *p,p'*-dicofol.

Major degradates of dicofol are the *o,p*'- and *p,p*' isomers of dichlorobenzophenone (DCBP); 1, 1-(*p*-ch1orophenyl-) 2,2-dichloroethanol (FW-152); dichlorobenzhydrol (DCBH); hydroxyl-dichlorobenzophenone (OH-DCBP); and chlorobenzoic acid (CBA). DCBP was identified in the hydrolysis, photolysis and metabolism studies while the other degradates were only present in metabolism studies. There are currently no submitted studies addressing the environmental fate and transport of these major degradates. However, the studies submitted in support of the aerobic soil metabolism indicate a large difference between half lives for dicofol alone (8.5 and 32 days for *o,p*'- and *p,p*'-dicofol, respectively) and the half lives for dicofol plus its degradates (186 and 313 days for total *o,p*'- and *p,p*'-dicofol, respectively).

In order to estimate aquatic exposure concentrations of dicofol and its degradates of concern, separate modeling runs were conducted for the *o,p*'- and *p,p*'-dicofol parent and *o,p*'- and *p,p*'-dicofol and degradates. The EECs were then summed to derive an estimate for total parent and the total toxic residue. In this risk assessment, degradates of concern included: DCBP, FW-152, DCBH and OH-DCBP. It is assumed in this assessment that for aquatic animals, the degradates of concern are of equal toxicity compared to the parent. Additionally, due to reported DDT contamination (≤0.1%) in dicofol products and the established toxicity and ecological risks of DDT, screening-level charaterization of DDT was also considered in this assessment (see **Appendix F**).

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey and its habitats to dicofol are assessed separately for the two habitats. Tier-II aquatic exposure models (PRZM/EXAMS) are used to estimate high-end exposures of dicofol in aquatic habitats resulting from runoff and spray drift from different uses. Peak model-estimated environmental concentrations resulting from different dicofol uses range from 0.15 to 18.0 µg/L for the total parent (*o,p*'- and *p,p*'-dicofol, respectively) and 0.38 to 59.6 µg/L for the total residues of concern (dicofol and degradates). These estimates are supplemented with analysis of available California surface water monitoring data from the California Department of Pesticide Regulation. The maximum surface water concentration of dicofol reported in the California Department of Pesticide Regulation surface water database (0.27 µg/L) is roughly 190 times lower than the highest peak model-estimated environmental concentration.

Based on available bioaccumulation data, dicofol and its degradates have the potential to accumulate in aquatic organisms. KABAM ($\underline{K}_{OW}$ (based) Aquatic BioAccumulation Model) v.1.0 is used to estimate potential bioaccumulation of dicofol residues in a freshwater aquatic food web and subsequent risks these residues pose to aquatic-phase CRLF via consumption of contaminated aquatic prey (i.e., aquatic invertebrates and fish).

In order to characterize the long range transport potential (LRTP) of dicofol, the OECD P_{ov} and LRTP Screening Tool was used. Three chemicals known to move via long range transport, DDT, aldrin and endrin, were also modeled to provide a context for dicofol estimated LRTP. Modeling results indicate that dicofol has comparable or higher LRTP estimates than all three chemicals with known potential to move via long range transport.

The T-REX model is used to estimate dicofol exposures to terrestrial-phase CRLF, its potential prey, and its designated critical habitat resulting from uses involving foliar applications. T-HERPS is used to further characterize exposures of terrestrial-phase CRLF to dietary and dose-based exposures of dicofol resulting from foliar applications. AgDRIFT is also used to estimate deposition of dicofol on terrestrial and aquatic habitats from spray drift.

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 effects to 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, 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.

Dicofol is very highly toxic to freshwater fish and highly toxic to freshwater invertebrates on an acute exposure basis. The no observed adverse effect concentration (NOAEC) for chronic effects to the rainbow trout is 4.4 µg/L, with a lowest observed adverse affect concentration (LOAEC) of 7.9 µg/L based on reduction in growth. Available chronic toxicity data for aquatic invertebrates include a NOAEC of 19 µg/L, with a LOAEC of 33 µg/L based on reduction in growth. Dicofol is moderately toxic to birds on an acute oral and subacute dietary exposure basis, and slightly toxic to mammals on an acute oral exposure basis. Dicofol is classified as practically nontoxic to honey bees on an acute contact exposure basis. Chronic exposures of the American kestrel to dicofol indicate effects to number of eggs laid at concentrations greater than 40 ppm, with a LOAEC of 3 ppm based on decreased egg shell thickness. Chronic exposures of rats to dicofol indicate a NOAEC of 5 ppm, corresponding to a LOAEC of 25 ppm where reproductive effects were observed. The EC_{50} for algae exposed to dicofol is greater than 5,000 but less than 10,000 µg/L. No data are available for quantitatively defining an endpoint to represent the effects of dicofol exposures to vascular plants.

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) for

Federally-listed threatened (listed) species to identify if dicofol use within the action area has any direct or indirect effect on the CRLF and its designated critical habitat. For this assessment, RQs were based on EECs representing total residues of concern (dicofol, DCBP, FW-152, DCBH and OH-DCBP). Based on estimated environmental concentrations in the aquatic and terrestrial habitats resulting from all currently registered uses of dicofol, RQ values exceed the Agency's LOC for direct acute and chronic risk to the CRLF; this represents a "may affect" determination. RQs exceed the LOC for risks to aquatic invertebrates, fish, aquatic-phase amphibians, terrestrial-phase amphibians and mammals. RQ values for terrestrial invertebrates potentially exceed the LOC for this taxon. RQ values for non-vascular aquatic plants do not exceed the LOC. The effects determination for indirect effects to the CRLF due to effects on its prey base is "may affect." Due to a lack of effects data for vascular plants exposed to dicofol, potential risk of dicofol to the designated critical habitat of the CRLF cannot be quantified and potential indirect effects to the CRLF through effects to its habitat cannot be discounted. Therefore, the determination for indirect effects to the CRLF through effects to its habitat is "may affect." In addition, dicofol can potentially result in effects to the CRLF's aquatic and terrestrial habitats based on potential impacts to its principal constituent elements (PCEs).

Refinement of all "may affect" determinations results in: a "LAA" determination based on direct effects to the aquatic and terrestrial-phase CRLF, indirect effects to the CRLF based on effects to its prey and indirect effects to the CRLF based on effects to its habitat (Table 1). Consideration of CRLF critical habitat indicates a determination of "habitat modification" for aquatic and terrestrial designated critical habitats (Table 2).

Table 1. Description of evidence supporting effects determination for dicofol use in California. Assessment endpoints include survival, growth and reproduction of CRLF individuals.

Assessment Endpoint	Effects Determination	Basis for Determination
Direct effects to CRLF	LAA	-Acute RQs for aquatic-phase CRLF exceed the LOC for all uses of dicofol, except Bermuda grass and outside buildings. - Analysis of individual effects indicates that up to 1 in 2 individual CRLF could experience mortality after acute exposures to dicofol in the aquatic habitat. - Chronic RQs for aquatic-phase CRLF exceed the LOC for all uses of dicofol, except Bermuda grass, turf and outside buildings. - Chronic EECs in the aquatic environment are above levels where growth effects were observed in fish. - Acute and chronic RQs for aquatic-phase CRLF consuming aquatic organisms contaminated with dicofol (resulting from accumulation) exceed LOCs. - Refined acute, dose-based RQs (derived using T-HERPS) for medium sized CRLF consuming small herbivore mammals exceed LOCs for all uses of dicofol. - Refined acute, dietary-based RQs (derived using T-HERPS) for CRLF consuming small insects and small herbivore mammals exceed LOCs for several uses of dicofol. - Chronic dietary-based RQs for CRLF exceed LOCs for all uses of dicofol, for CRLF consuming any terrestrial food item (i.e., insects, mammals and terrestrial-phase amphibians). - Chronic, dietary-based EECs are above levels where reduced number of eggs laid was observed in birds (i.e., EECs are >40 ppm).
Indirect effects to tadpole CRLF via reduction of prey (*i.e.*, algae)		RQ values for algae are below the LOC for all uses of dicofol.
Indirect effects to juvenile CRLF via reduction of prey (*i.e.*, invertebrates)		- Acute RQs for aquatic invertebrates exceed the LOC the majority of dicofol uses. - The likelihood of individual acute effects to aquatic invertebrates is ≤3%. Based on this, indirect effects to the CRLF through acute effects to aquatic invertebrates is discountable. - Chronic RQs for aquatic invertebrates do not exceed the LOC for dicofol use on cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings. - Chronic RQs for aquatic invertebrates exceed the LOC for dicofol use on beans, citrus, cotton, grapes, hops, mint, pome fruits, stone fruits, strawberry, walnuts, and pecans.
Indirect effects to adult CRLF via reduction of prey (*i.e.*, invertebrates, fish, frogs, mice)		- Acute RQs for aquatic invertebrates exceed the LOC the majority of dicofol uses. - The likelihood of individual acute effects to aquatic invertebrates is ≤3%. Based on this, indirect effects to the CRLF through acute effects to aquatic invertebrates is discountable. - Chronic RQs for aquatic invertebrates do not exceed the LOC for dicofol use on cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings. - Chronic RQs for aquatic invertebrates exceed the LOC for dicofol use on beans, citrus, cotton, grapes, hops, mint, pome fruits, stone fruits, strawberry, walnuts and pecans. -Acute RQs for aquatic-phase amphibians and fish exceed the LOC for all uses of dicofol, except Bermuda grass and outside buildings.

Assessment Endpoint	Effects Determination	Basis for Determination
		- Use of dicofol on beans, citrus, cotton, hops, mint, pome fruits, strawberries, walnuts, and pecans results in >10% likelihood of individual mortality (from acute exposures) to fish and aquatic-phase amphibians. -Use of dicofol on cucurbits, grapes, pepper, stone fruits, tomatoes, Bermuda grass, ornamentals, turf, and outside buildings result in <10% chance of effects to an individual fish and aquatic-phase amphibians representing prey of the CRLF. - Chronic RQs for fish and aquatic-phase amphibians exceed the LOC for all uses of dicofol, except Bermuda grass, turf, and outside buildings. - Because the LD_{50} used in deriving RQs for terrestrial invertebrates is not quantified, RQs for acute exposures of small and large terrestrial invertebrates to dicofol *potentially* exceed the LOC of 0.05 for all uses. - Given that dicofol is intended for control of insects, it has the potential to impact non-target insects (other than honey bees). -For use of dicofol on grapes, mint, hops, peppers, tomatoes, cucurbits, ornamentals, turf and Bermuda grass, dicofol exposures result in a chance of individual mortality to <10% of terrestrial insects. Therefore, indirect effects to the CRLF through potential effects to terrestrial invertebrates resulting from these dicofol uses are considered discountable. - Use of dicofol on citrus, pome fruits, strawberries, walnuts, pecans, beans, cotton and stone fruits could potentially result in ≥10% of mortality to small invertebrates. Although there is uncertainty in the actual effects of these exposures to terrestrial invertebrates, given that no LD50 was established, mortality to small insects resulting from dicofol applied to these crops has the potential to result in indirect effects to the CRLF. - RQ values representing acute exposures to terrestrial mammals exceed the LOC (0.1) for all uses of dicofol except: ornamentals, turf, outside buildings and Bermuda grass - Use of dicofol on citrus and pome fruits could potential result in 10.7% mortality to individual terrestrial mammals. Therefore, dicofol use on citrus and pome fruits could potentially result in indirect effects to the CRLF due to acute effects to terrestrial mammals. All other uses of dicofol result in ≤2.0% mortality to small mammals resulting from acute exposures to dicofol. Therefore, indirect effects to the CRLF through potential effects to terrestrial mammals resulting from all dicofol uses, except citrus and pome fruits, are considered discountable. - Chronic RQs exceed the LOC for terrestrial mammals for all uses of dicofol. Chronic EECs are sufficient to exceed the LOAEC for mammals where reproductive effects were observed. Therefore, chronic exposures of dicofol from all uses have the potential to indirectly affect the CRLF via impacts to terrestrial mammals serving as potential prey items. - Acute and chronic exposures of small mammals to dicofol through consumption of contaminated earthworms from fields treated with dicofol have the potential to result in effects to mammals. - Acute, dose-based RQs for terrestrial-phase amphibians serving as prey to the CRLF do not exceed the LOC. - Acute, dietary-based RQs for terrestrial-phase amphibians exceed the LOC for several uses. - Analysis of the likelihood of individual mortality using acute dietary-based RQs for terrestrial amphibians indicates that all uses of dicofol result in ≤2% chance of effects to an individual terrestrial amphibian representing prey of the CRLF. Therefore, the impact of the indirect effects to terrestrial-phase CRLFs via acute effects on terrestrial amphibians is discountable for all uses of dicofol. - Chronic, dietary-based RQs exceed the LOC by factors ranging 2x to 474x. Therefore, for all dicofol uses, there is potential for indirect effects to the CRLF resulting from chronic effects to terrestrial frogs.
Indirect effects to CRLF via		-Due to a lack of quantitative effects data for non-target plants exposed to dicofol, potential risk of dicofol to the aquatic and terrestrial habitats of the CRLF cannot be quantified and effects of dicofol to plants cannot be discounted.

Assessment Endpoint	Effects Determination	Basis for Determination
reduction of habitat and/or primary productivity (*i.e.*, plants)		-Qualitative data suggest that dicofol may result in phytotoxicity. -There is one reported incident involving effects of dicofol to plants. -Dicofol exposures to plants have the potential to cause indirect effects to aquatic phase CLRF through reduction of habitat.

Table 2. Summary of effects determination for CRLF critical habitat based on uses of dicofol in California.

Assessment Endpoint	Effects Determination	Basis for Determination
Modification of aquatic-phase primary constituent elements	**Habitat Effects**	<u>Dicofol has the potential to modify habitat based on the aquatic-phase PCEs.</u> - Dicofol has the potential to directly affect the aquatic-phase CRLF (See Table 1). - Dicofol has the potential to indirectly affect the aquatic-phase CRLF through effects to its prey (see Table 1). -Effects of dicofol to plants making up the aquatic habitat of the CRLF cannot be discounted.
Modification of terrestrial-phase primary constituent elements		<u>Dicofol has the potential to modify habitat based on the terrestrial-phase PCEs.</u> - Dicofol has the potential to directly affect the terrestrial-phase CRLF (See Table 1). - Dicofol has the potential to indirectly affect the terrestrial-phase CRLF through effects to its prey (see Table 1). -Effects of dicofol to plants making up the terrestrial habitat of the CRLF cannot be discounted.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated. When evaluating the significance of this risk assessment's direct, indirect, and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (*i.e*., food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (*i.e*., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of 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. Environmental Protection Agency's (EPA's) Guidance for Ecological Risk Assessment (U.S. EPA 1998a), the Services' Endangered Species Consultation Handbook (U.S. FWS/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 (U.S. FWS/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 dicofol on the following: beans (dry, snap, and lima), citrus (specifically, grapefruit, kumquats, lemons, limes, oranges, tangelos, and tangerines), cotton, cucurbits (specifically, cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash), grapes, hops, mint, pecans, peppers, pome fruits (specifically, apples, crabapples, pears, and quince), stone fruits (specifically, apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes), strawberries, tomatoes, walnuts, Bermuda grass, turf/ornamental uses (specifically, turf grasses, nursery stock, flowers, shade trees, woody shrubs and vines, and sod farms) and outside building surfaces (non-agricultural). 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 GENEEC, PRZM-EXAMS, T-REX, TerrPlant, and AgDRIFT, all of which are described at length in the Overview Document (U.S. EPA 2004). 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 dicofol 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 dicofol 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 dicofol 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 CRLFs are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat.

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

If a determination is made that use of dicofol 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 dicofol use sites) and further evaluation of the potential impact of dicofol 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. 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 dicofol is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for dicofol 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 dicofol 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

Dicofol is an organochlorine, broad-spectrum acaricide, insecticide, and miticide currently registered nationwide for application to a variety of crops, including: beans (dry, snap, and lima), citrus (specifically, grapefruit, kumquats, lemons, limes, oranges, tangelos, and tangerines), cotton, cucurbits (specifically, cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash), grapes, hops, mint, pecans, peppers, pome fruits (specifically, apples, crabapples, pears, and quince), stone fruits (specifically, apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes), strawberries, tomatoes, walnuts, Bermuda grass, turf/ornamental uses (specifically, turf grasses, nursery stock, flowers, shade trees, woody shrubs and vines, and sod farms) and outside building surfaces (non-agricultural). Application rates range from 0.4 – 3 lbs a.i./A with no more than one application per year for food crops. Dicofol may be applied as an aerial or ground spray. The current technical formula containing dicofol was reregistered in 1998. The terms of reregistration included cancellation of residential uses, with remaining uses limited to one annual application, and application rate reductions. The current labels for products containing dicofol comport with the changes implemented through reregistration and are being used to define parameters of the action being assessed in this ecological risk assessment and effects determination. Prior to 1990, dicofol contained approximately 10% DDT since DDT is an intermediate in the production of dicofol; however, refinements in the manufacturing process have reduced contamination in the current formulation to less than 0.1 % DDT contamination.

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

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

Major degradates of the two isomers of dicofol are the *o,p*'- and *p,p*' isomers of dichlorobenzophenone (DCBP); 1, 1-(p-ch1orophenyl-) 2,2-dichloroethanol (FW-152); dichlorobenzhydrol (DCBH); hydroxyl-dichlorobenzophenone (OH-DCBP); and chlorobenzoic acid (CBA). DCBP was identified in the hydrolysis, photolysis and metabolism studies while the others were only present in metabolism studies. The structures of dicofol and its major degradates are provided in **Appendix A**. There are currently no submitted studies addressing the environmental fate and transport of these major degradates. In addition, no empirical data are available to define the toxicities of these degradates to non-target organisms. In order to characterize the relative toxicities of these degradates to dicofol, the Ecosar[1] model was run. The result indicates that the toxicities of DCBP, FW-152, DCBH and OH-DCBP are within an order of magnitude of dicofol (for a full description of the results, see Section 4.2). Therefore, these degradates were considered to be of concern for this risk assessment. It is assumed in this assessment that for aquatic animals, total residues are of equal toxicity to that of the parent.

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; U.S. FWS/NMFS 2004).

Registered products that contain dicofol do not list any other active ingredients on their labels. However, as mentioned earlier, prior to 1990, dicofol contained approximately 10% DDT. Refinements in the manufacturing process have reduced contamination in the current formulation to less than 0.1 % DDT contamination. No other data on mixtures including dicofol are available.

2.3. Previous Assessments

In November 1998, EPA completed its Registration Eligibility Decision (RED) for dicofol. EPA concluded that the available field data suggested that dicofol did not pose significant adverse effects on avian reproduction and did not present an unreasonable risk to ecosystems. However, based on laboratory data, the potential for such effects appeared significant for certain species. Dicofol was found to be moderately to slightly toxic on an acute exposure basis to terrestrial animals and practically non-toxic to honey bees on an acute contact exposure basis. In laboratory studies dicofol was also shown to cause reproductive effects in avian and mammalian species. Dicofol was found to be highly toxic on an acute basis to both cold and warm water species of fish and freshwater

[1] USEPA 2009. Ecological Structure Activity Relationships (ECOSAR) version 1.00a. Office of Pollution Prevention and Toxic. http://www.epa.gov/oppt/newchems/tools/21ecosar.htm

invertebrates and was very highly toxic to estuarine/marine invertebrates. Additionally, laboratory studies showed that dicofol had some potential to bioaccumulate in fish, but that dicofol residues depurated relatively quickly. Because of its apparent structural similarity to DDT, dicofol has been identified as a potential endocrine disrupter. However, based on the data available, no conclusions could be made regarding the potential for dicofol to act as an endocrine disrupter (USEPA, 1998b).

2.4. Stressor Source and Distribution

2.4.1. Environmental Fate Assessment

Based on the available environmental fate data for dicofol, this chemical is not expected to persist in the environment, with half-lives less than 90 days, depending upon the specific environmental conditions. However, studies submitted on the fate of dicofol do not provide sufficient information to estimate persistence of dicofol degradates in the environment. As a result, conservative estimates for persistence of dicofol (considering the parent and major degradates) are as high as 313 days. The primary route of dissipation is soil metabolism and the primary route of transport is surface runoff.

Dicofol occurs in formulated end-use products as two isomers, *o,p*'-dicofol and *p,p*'-dicofol, at a ratio of 1:4.5. Major degradates of dicofol include the *o,p*'- and *p,p*'-isomers of DCBP, FW-152, DCBH, OH-DCBP, and CBA.

Table 3 lists the environmental fate properties of the dicofol isomers. The *o,p*'-isomer hydrolyzed with half-lives of 47 days, 0.33 days, and 0.006 days at pHs 5, 7 and 9, respectively (MRID 40042033). An aerobic soil metabolism study showed that the *o,p*'-isomer degraded with half-life of 8.5 days in a loam soil under slightly alkaline conditions (pH = 7.5, MRID 41094201). Parent plus major residues degraded with a half-life of 186 days. An anaerobic soil metabolism study showed that the *o,p*'-isomer degraded with half-life of 6 days in a silt loam soil under slightly alkaline conditions (pH = 7.9, MRID 43908701). Adsorption data indicate that the *o,p*'-isomer is not very mobile, with a majority of the *o,p*'-dicofol remaining in the upper 2 inches of the soil columns. Less than 2.5% of *o,p*'-dicofol was found in leachate (MRID 41509802).

The *p,p*'-isomer hydrolyzed with half-lives of 85 days, 2.8 days and 0.018 days at pHs 5, 7 and 9, respectively (MRIDs 40042032, 40460105). An aerobic soil metabolism study showed that the *p,p*'-isomer degraded with a half-life of 32 days in a silt loam soil under slightly alkaline conditions (pH = 7.8, MRID 41050701). Parent plus major residues degraded with a half-life of 313 days. An anaerobic soil metabolism study showed that the *p,p*'-isomer degraded with half-life of less than 30 days in a silt loam soil under slightly alkaline conditions (pH = 7.8, MRID 40042039). Adsorption data indicate that the *p,p*'-isomer is not very mobile (MRID 41509801). A regression analysis between the K_d and organic carbon content values indicated a high r-squared value (0.98) and statistical significance (<0.01). To assess the appropriateness of the K_{oc} model, the coefficient of variation for the K_{oc} (CV = 19) was compared to the coefficient of variation for K_d (CV = 58). Since the CV for the K_{oc} was less than the CV for K_d, the average K_{oc} of 7,060 mL/g was used (Kashuba *et al.* 2006). For *o,p'*-dicofol, the majority of dicofol remained in upper 2 inches of soil columns, with less than 2.5% of dicofol found in leachate.

Of the major dicofol degradates, DCBP was identified in the hydrolysis, photolysis and metabolism studies, while the other degradates were only present in metabolism studies.

Table 4 summarizes the maximum amount of the individual degradates that were observed in submitted environmental fate studies for dicofol and when the maximum amount occurred. There are currently no submitted studies quantifying the environmental fate and transport (*e.g.*, half-lives) of the major degradates of dicofol individually.

Available registrant-submitted data indicate that dicofol has potential to bioaccumulate in aquatic ecosystems. Dicofol has a octanol-water partitioning coefficient (K_{ow}) of 1.15 x 10^{-6} (MRID 00141578). In a bioconcentration study, parent *p,p'*-dicofol residues in bluegill sunfish resulted in bioconcentration factors of 6,600 in fillet, 17,000 in viscera, and 10,000 in whole fish. The half-life of elimination (depuration) was estimated to be 33 days (MRID 265330).

Based on the available fate data, the major routes of dissipation for dicofol are hydrolysis under neutral and alkaline conditions, and aerobic and anaerobic soil metabolism under slightly alkaline conditions (pH from 7.5 to 7.9), with the *o,p*'-isomer degrading more quickly. Dicofol can be classified as slightly mobile (Kashuba, *et al.* 2006) and has the potential to bioaccumulate in the environment. Leaching and photodegradation are not expected to be significant routes of dissipation. Based on dicofol's vapor pressure (3.9×10^{-7} torr), low levels of volatilitization are possible, but not expected. Dicofol can be expected to partition between the gas and particle phases in the atmosphere, and is likely to exist largely in the particle phase, potentially contributing to its long-range transport. Given dicofol's K_{ow} and K_{oc} values, it is anticipated that dicofol that enters surface water through soil erosion, runoff, or spray drift will have an affinity to reside in the sediment. Anaerobic soil metabolism studies indicate that dicofol will degrade relatively rapidly in sediment with a half-life less than 30 days. It is unclear how dicofol degradates would partition in the water column; however, estimates of the K_{ow} values (9,120-77,625) and K_{oc} values (1,933-8,950) using EPISuite[2] indicate a similar affinity for the sediment. As there are no data quantifying the fate and transport of the dicofol degradates, two stressors will be examined in this assessment: the parent compound (both isomers of dicofol) and the total residues of concern (both isomers of dicofol and their degradates). Based on toxicity data, the degradate CBA will not be considered in the total residues of concern (see Section 4.2.1).

[2] USEPA 2009. Estimation Program Interface (EPI) Suite version 4.0. Office of Pollution Prevention and Toxics. http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm

Table 3. Summary of dicofol environmental fate properties.

Chemical/Fate Parameter	**Value *o,p'*-dicofol**	**Value *p,p'*-dicofol**	**MRID[1]**	**Study Classification**
Molecular weight	370.5 g/mol		00141704 00142595	Acceptable
Vapor pressure (20°C)	3.9×10^{-7} torr			
Water solubility (25°C)	1.32 mg/L			
Kow	1.15×10^{6}		00141578	Acceptable
Hydrolysis half-life pH 5 pH 7 pH 9	 47 days 3.3×10^{-1} days 6.3×10^{-3} days	 85 days 2.8 days 1.8×10^{-2} days	 40042033 40042032 40460105	 Acceptable Acceptable Acceptable
Direct Aqueous Photolysis[2] half-life	27.5 days	244 days	40849702 40849701	Acceptable Acceptable
Soil Photolysis half-life	56 days	21 days	40042037 40042036	Supplemental Supplemental
Aerobic Soil Metabolism half-life	8.5 days (parent) 104.5 days (parent and major degradates)	32 days (parent) 313 days (parent and major degradates)	41094201 41050701	Acceptable Acceptable
Anaerobic Soil Metabolism half-life	6 days	< 30 days	43908701 40042039	Acceptable Supplemental
Leaching & Adsorption/Desorption	Majority of parent remained in upper 2 inches of soil columns. ≤2.5% of parent found in leachate.	K_{oc}=7,060 mL/g	41509802 41509801	Acceptable Acceptable
Terrestrial Field Dissipation half-life	3.7, 22 days	4.7, 72 days	41381801 42118601	Supplemental Supplemental

1. First MRID listed corresponds to data for *o,p'*-dicofol, while the second MRID corresponds to data for *p,p'*-dicofol.
2. Data corrected for dark control.

Table 4. Summary of dicofol degradates observed in submitted environmental fate studies for dicofol. Data represent % of total residue detected as specific degradate and study day residues were measured.

Fate Study	Dicofol Isomer	FW-152[1]	DCBP[2]	DCBH[3]	OH-DCBP[4]	CBA[5]	MRID
Hydrolysis pH 7	*o,p'*	ND	53% Day 1	ND	ND	ND	40042033
	p,p'	ND	50% Day 7	ND	ND	ND	40042032
Direct Aqueous Photolysis[1]	*o,p'*	ND	26% Day 30	ND	ND	ND	40849702
	p,p'	ND	7% Day 30	ND	ND	ND	40849701
Soil Photolysis	*o,p'*	ND	29% Day 30	ND	ND	ND	40042036
	p,p'	ND	25% Day 30	ND	ND	ND	40042037
Aerobic Soil Metabolism	*o,p'*	31% Day 31	19% Day 275	12% Day 366	12% Day 92	14% Day 92	41094201
	p,p'	45% Day 62	18% Day 275	ND	17% Day 275	ND	41050701
Anaerobic Soil Metabolism	*o,p'*	43% Day 30	<10% Day 1	15% Day 30	ND	ND	43908701
	p,p'	38% Day 60	5.4% Day 0	6.4% Day 60	ND	ND	40042039

ND = not detected

[1] 1,1-(*p*-ch1orophenyl-) 2,2-dichloroethanol
[2] Dichlorobenzophenone
[3] Dichlorobenzhydrol
[4] Hydroxyl-dichlorobenzo-phenone
[5] Chlorobenzoic acid

2.4.2. Environmental Transport Assessment

Potential transport mechanisms include runoff in soluble and soil-bound forms, spray drift, and atmospheric transport in soil-bound residues leading to deposition into nearby or more distant ecosystems.

Dicofol is expected to have limited mobility in the environment and a low potential to migrate to groundwater. In soil column leaching experiments in sand, sandy loam, and clay loam (MRID 41509802), 75 to 98% of the applied radioactivity of the *o,p*'-dicofol isomer remained in the upper 1 or 2 inches of the columns. Less than 3% of the applied radioactivity was in the leachate. Batch equilibrium studies on the *p,p*'-isomer resulted in organic carbon sorption coefficients of 7,060 mL/g_{oc}, (MRID 41509801). Two supplemental leaching studies conducted on *p,p*'-dicofol suggest that the chemical does not significantly leach under the testing conditions (IDs GS0021002 and GS0021007).

No data are available on the mobility of aged dicofol or on the mobility of the major degradates of dicofol. Based on the results of the terrestrial field dissipation studies, it appears that dicofol metabolites are not very mobile under normal dicofol use conditions. Depending on soil, site and meteorological conditions dicofol may be transported off-site in soil-bound erosion from runoff.

Although supplemental, two terrestrial field dissipation studies confirm the results of the laboratory persistence and mobility studies. These studies suggest that dicofol does not persist in the field for long periods (on an order of several days to several weeks). In a dissipation study on cotton in Madera, California (MRID 41381801), dicofol residues had a DT_{50} value (the length of time required for 50% of the parent to dissipate from the surface 6-inches of the soil) of less than 7 days. In a second dissipation study on strawberries in Thermal, California (MRID 42118601), the rate of dissipation was slower (DT_{50}s of 22 days for *o,p*'-dicofol and 72 days for *p,p*'-dicofol). Dicofol dissipated from the upper 6 inches in the Madera study site at a rate that was an order of magnitude faster than that of the Thermal site, despite the fact that the soils at the Thermal site had an alkaline pH more favorable to hydrolysis (8.4 at Thermal versus 6.2 at Madera) and a higher organic matter content (0.8% at Thermal versus 0.2% at Madera). Greater amounts of irrigation were used in the cotton study (44.28 inches of water over the first 228 days in Madera versus 27.04 inches of water over 365 days). Results of these studies suggest that hydrolysis at the Madera site may have played a greater role than at the Thermal site, where metabolism appeared to be the dominant route of dissipation in the field. Neither dicofol nor its residues moved significantly below 6 inches in either study. The major degradates observed in these field studies, *o,p*' and *p,p*'-DCBP, *o,p*'-DCBH, 4-CBA, and *p,p*'-FW 152. Analysis of the data indicates that the half-lives for the major degradates, *o,p*'-DCBP and *p,p*'-DCBP, were between 29 and 45 days, and 55 and 132 days, respectively.

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; 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; 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 dicofol's ability to be mobilized into air and its eventual removal through wet and dry deposition of particles and photochemical reactions in the atmosphere. Therefore, physicochemical properties of dicofol that describe its potential to enter the air from water or soil, pesticide use data, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevada Mountains are considered in evaluating the potential for atmospheric transport of dicofol to locations where it could impact the CRLF.

Because of its low vapor pressure and persistence in the air (estimated half-life > 2 days), the United Nations Economic Commission for Europe's (UNECE) Convention on Long-range Transboundary Air Pollution has indicated that dicofol has the potential for long range transport (Rasenberg *et al.* 2003). According to the report, "dicofol is expected to partition between the gas and particle phases in the atmosphere and is likely to exist largely in the particle phase."

2.4.3. Mechanism of Action

According to the World Health Organization (WHO, 1996), dicofol produces stimulation of axonal transmission of nerve signals, believed to be related to inhibition of ATPases in the central nervous system (CNS). The signs of toxicity are consistent with CNS depression. However, the Insecticide Resistance Action Committee (IRAC) has recently classified the mode of action for dicofol as unknown or uncertain (IRAC, 2008).

2.4.4. Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for dicofol represent the FIFRA regulatory actions; 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.

Dicofol is an organochlorine, broad-spectrum acaricide, insecticide, and miticide currently registered nationwide for application on a variety of crops and non-agricultural uses. Table 5 presents the uses and corresponding application rates and methods of application considered in this assessment. The reported application rates represent the maximum application rate used in any crop/use site within each group. The information was extracted from existing product labels (EPA Registration Numbers 11603-26, 66222-21, 66222-56, and 66222-95). Dicofol is used for non-residential purposes only.

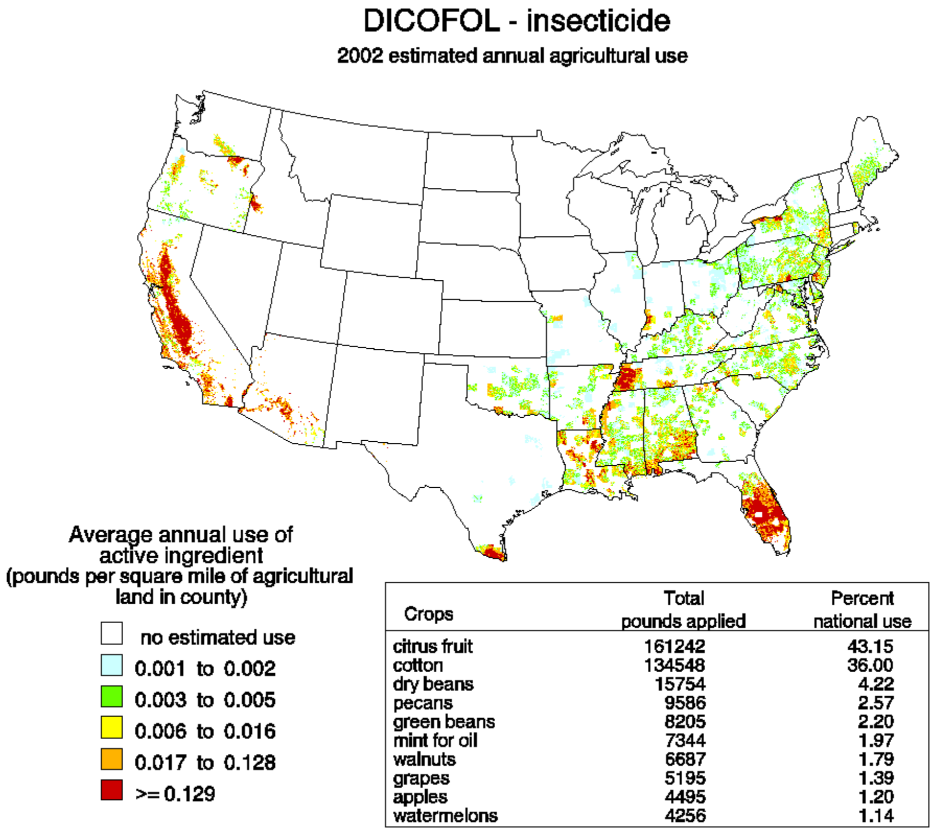
Table 5. Methods and rates of application of currently registered uses of dicofol in California[1].

Use (Application Method)	**Max. Single Appl. Rate (lb a.i./A)**	**Application Method(s)**
Beans (dry, snap, lima)	1.5	ULV, Aircraft, Hi- and low-volume ground sprayer
Citrus[2]	3	ULV, Aircraft, Hi- and low-volume ground sprayer
Cotton	1.5	ULV, Aircraft, Hi- and low-volume ground sprayer
Cucurbits[3]	0.625	ULV, Aircraft, Hi- and low-volume ground sprayer
Grapes	1.25	ULV, Aircraft and ground sprayer
Hops	1.165	ULV, Aircraft, Hi- and low-volume ground sprayer
Mint/Peppermint/Spearmint	1.25	ULV, Aircraft, Hi- and low-volume ground sprayer

Use (Application Method)	Max. Single Appl. Rate (lb a.i./A)	Application Method(s)
Pecans	2	ULV, Aircraft, Hi- and low-volume ground sprayer
Peppers	0.75	ULV, Aircraft, Hi- and low-volume ground sprayer
Pome Fruits[4]	3	ULV, Aircraft, Hi- and low-volume ground sprayer
Stone Fruits[5]	1.5	ULV, Aircraft and ground sprayer
Strawberries	2	ULV, Aircraft, Hi- and low-volume ground sprayer
Tomatoes	0.75	ULV, Aircraft, Hi- and low-volume ground sprayer
Walnuts (English/black)	2	ULV, Aircraft, Hi- and low-volume ground sprayer
Bermuda grass	0.4	Hi- and low-volume ground sprayer
Turf grasses	0.5	Hi- and low-volume ground sprayer
Sod farms	0.5	Hi- and low-volume ground sprayer
Ornamentals[6]	0.5	Hi- and low-volume ground sprayer
Outside building surfaces	0.5	Hi- and low-volume ground sprayer

1. Applications of dicofol are limited to no more than one per year on any one field.
2. Specifically: grapefruit, kumquats, lemons, limes, oranges, tangelos, and tangerines.
3. Specifically: cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash.
4. Specifically: apples, crabapples, pears, and quince.
5. Specifically: apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes.
6. Specifically: nurseries, flowers, and shade trees.

Figure 2 below shows the estimated poundage of dicofol uses across the United States. The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website (http://water.usgs.gov/nawqa/pnsp/usage/maps/).



Crops	Total pounds applied	Percent national use
citrus fruit	161242	43.15
cotton	134548	36.00
dry beans	15754	4.22
pecans	9586	2.57
green beans	8205	2.20
mint for oil	7344	1.97
walnuts	6687	1.79
grapes	5195	1.39
apples	4495	1.20
watermelons	4256	1.14

Figure 2. Estimated national agricultural use of dicofol for 2002.

The Agency's Biological and Economic Analysis Division (EPA/OPP/BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[3], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[4] . CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for dicofol 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. EPA/OPP/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,

[3] United States Depart of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.usda.gov/nass/pubs/estindx1.htm#agchem.
[4] The California Department of Pesticide Regulation's Pesticide Use Reporting database provides a census of pesticide applications in the state. See http://www.cdpr.ca.gov/docs/pur/purmain.htm.

average annual area treated, and average and maximum application rate across all eight years. The units of area treated are also provided where available.

Eight years (1999-2006) of usage data from CDPR PUR were obtained for every difocol application made on every use site in California at the field level. Total annual pounds applied and total annual area treated were calculated at the county level by site and pesticide active ingredient. Pesticide usage was also aggregated across all observations for eight years for each chemical-county-unit-treated combination. Because pesticide applications are made in different area units, the units of area treated are provided where available. Years in which there is no reported use in a county are included as zeros in the calculation of the eight-year averages for pounds and area treated. Averages reflect years without use.

In California between 1999 and 2006, the majority of dicofol applied was used on cotton (64%), with lesser percentages applied to beans (13%), citrus (6%), and grapes (5%). Overall usage of dicofol in California fell from 1999 to 2002 to roughly 182,000 lbs/year, then increased to 212,000 lbs/year in 2004, and decreased to 101,000 lbs in 2006. Approximately 20% of dicofol applied in California is used in the 20 counties that contain CRLF critical habitat areas. A summary of dicofol usage for all California use sites is provided below in Table 6. These rates are consistent with the maximum application rates specified on the label and used in the modeling analysis, depicted in Table 9, with a few exceptions. For cucurbits, the maximum label application rate is 0.625 lbs dicofol/A, while the application rates depicted in the CDPR PUR database were above this level. This can be attributed to an outlier reported for 1999 in San Joaquin County where 50 acres of squash were reportedly treated with 2,815 lbs of dicfol. For tomatoes, the maximum label application rate is 0.75 lbs dicofol/A, while the CDPR PUR reported application rates are above this level. Data available in the CDPR PUR database for tomatoes is divided into two groups, tomatoes and tomato processing. It appears that the use rates for tomato processing applications are increasing the values derived from the CDPR PUR database, as the statistical application rates data for tomatoes all fall below the maximum label rate, while all of the statistics for tomato processing are above the maximum label use rate. For Bermuda grass, the maximum label rate is 0.4 lbs dicofol/A. There was only one reported value for Bemuda grass in the CDPR PUR database for 0.48 lbs dicofol/A. Lastly, the maximum label application rate for ornamentals is 0.5 lbs dicofol/A. Outdoor flowers, transplants, and plants in containers were grouped into this category. It’s unclear as to how the area treated, reported in acres or square feet, was estimated in the database. As such, an underestimation in the area treated could result in an application rate higher than the maximum label rate. It should be noted that 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 6. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) data and calculated annual application rates (1999 - 2006) for currently registered dicofol uses.[1]

Site Name	Annual Average Pounds	Avg App Rate (lbs ai/acre)	Avg 95th% App Rate (lbs ai/acre)	Avg 99th% App Rate (lbs ai/acre)	Avg Max App Rate (lbs ai/acre)
Beans (dry, snap, lima)	28,568	1.27	1.46	1.46	1.46
Citrus[2]	13,427	2.26	2.70	2.70	2.70
Cotton	142,539	1.01	1.25	1.25	1.25
Cucurbits[3]	6,853	0.77	1.26	1.26	1.26
Grapes	11,642	1.10	1.26	1.26	1.26
Mint/Peppermint/Spearmint	138	0.87	1.00	1.00	1.00
Peppers	184	0.66	0.71	0.71	0.71
Pome Fruits[4]	1,769	1.64	1.89	1.89	1.89
Stone Fruits[5]	7,676	1.34	1.55	1.55	1.55
Strawberries	1,327	1.01	1.36	1.36	1.36
Tomatoes	1,008	0.78	0.93	0.93	0.93
Walnuts (English/black)	7,013	1.75	2.00	2.00	2.00
Bermuda grass	90	0.48	0.48	0.48	0.48
Ornamentals[6]	582	0.93	1.24	1.24	1.24

1. Dicofol was not applied to hops, pecans, turf, sod farms, or outside building surfaces from 1999-2006, according to the PUR database.
2. Specifically: grapefruit, lemons, oranges, tangelos, and tangerines.
3. Specifically: cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash.
4. Specifically: apples and pears.
5. Specifically: apricots, cherries, nectarines, peaches, plums, and prunes.
6. Specifically: outdoor flowers and plants.

2.5. Assessed Species

The CRLF was federally listed as a threatened species by U.S. FWS effective June 24, 1996 (U.S. FWS 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (U.S. FWS 2002). A brief summary of information regarding CRLF distribution, reproduction, diet, and habitat requirements is provided below. 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 U.S. FWS on April 13, 2006 (U.S. FWS 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 (U.S. FWS 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (U.S. FWS 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) (U.S. FWS 2002).

Populations currently exist along the northern California coast, northern Transverse Ranges (U.S. FWS 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 (U.S. FWS 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) (U.S. FWS 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 (Figure 3). 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 U.S. FWS 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 and Western Sacramento River Valley
3. North Coast and North San Francisco Bay
4. South and East San Francisco Bay
5. Central Coast
6. Diablo Range and Salinas Valley
7. Northern Transverse Ranges and Tehachapi Mountains
8. Southern Transverse and Peninsular Ranges

Core Areas

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

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

Figure 3. 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 (U.S. FWS 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, U.S. FWS 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers 2005b, U.S. FWS 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 (U.S. FWS 2002). Figure 4 depicts CRLF annual reproductive timing.

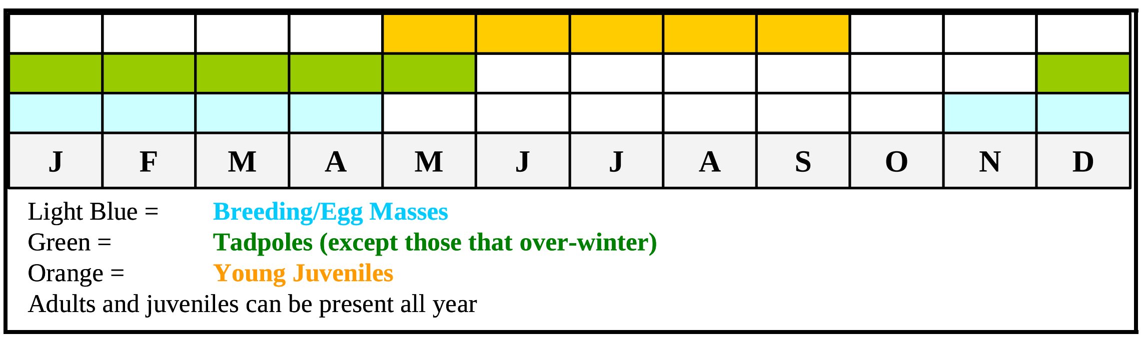


Figure 4. CRLF reproductive events by month.

2.5.3. Diet

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus (U.S. FWS 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 (U.S. FWS 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 (U.S. FWS 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 (U.S. FWS 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 (U.S. FWS 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 U.S. FWS (U.S. FWS 2006; FR 51 19244-19346). A summary of the 34 critical habitat units relative to U.S. FWS-designated recovery units and core areas (previously discussed in Section 2.5) is provided in Attachment 1.

'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 1.

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, U.S. FWS 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. See Attachment I for a full explanation on this special rule.

U.S. FWS has established adverse modification standards for designated critical habitat (U.S. FWS 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 dicofol that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to U.S. FWS (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 dicofol is expected to directly impact living organisms within the action area, critical habitat analysis for dicofol 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 dicofol is likely to encompass considerable portions of the United States based on the large array of agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the state of California. The Agency's approach to defining the action area under the provisions of the Overview Document (U.S. EPA 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 dicofol may be expected to have on the environment, the exposure levels to dicofol that are associated with those effects, and the best available information concerning the use of dicofol and its fate and transport within the state of California. Specific measures of ecological effect for the CRLF that define the action area include any direct and indirect toxic effect to the CRLF and any potential effects to 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 dicofol. 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 states other than California and several currently labeled uses on FIFRA section 3 labels are restricted to specific states other than California and therefore, are excluded from this assessment. For those uses relevant to the CRLF, the analysis indicates that, for dicofol, the following agricultural uses are considered as part of the federal action evaluated in this assessment: beans (dry, snap, and lima), citrus (specifically, grapefruit, kumquats, lemons, limes, oranges, tangelos, and tangerines), cotton, cucurbits (specifically, cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash), grapes, hops, mint, pecans, peppers, pome fruits (specifically, apples, crabapples, pears, and quince), stone fruits (specifically, apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes), strawberries, tomatoes, and walnuts. In addition, the following non-food and non-agricultural uses are considered: Bermuda grass, turf/ornamental uses (specifically, turf grasses, nursery stock, flowers, shade trees, woody shrubs and vines, and sod farms) and outside building surfaces (nonagricultural).

Following a determination of the assessed uses, an evaluation of the potential “footprint” of dicofol 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 dicofol is presented in Figure 5. In this figure, potential uses of dicofol on all field crops as well as orchards and vineyards are represented by the cultivated crops landcover data obtained from NLCD. In addition, potential use areas of dicofol on tree fruits and grapes are represented by the orchard and vineyard land cover data obtained from California GAP. Turf uses of dicofol are depicted as a derived NLCD class based on developed classes and the impervious surface layer with corrections applied. Additional information on the landcover data used to define the initial area of concern is provided in **Appendix B**.

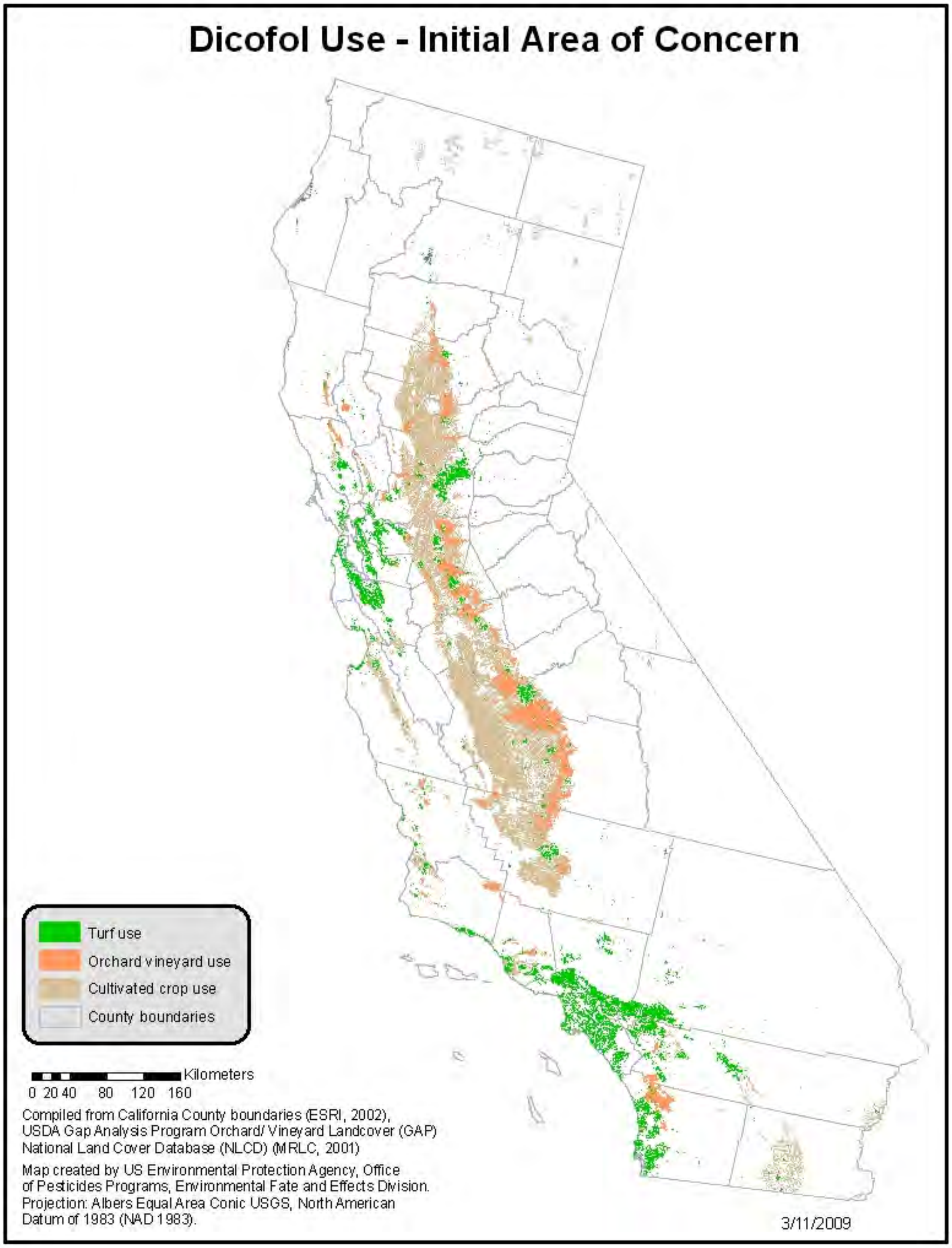


Figure 5. Initial area of concern for crops described by agricultural landcover which corresponds to potential dicofol use sites. This map represents the area potentially directly affected by the federal action.

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.

Once the potential boundaries of the area of concern are defined, the next step is to compare the extent of that area with the results of the screening-level risk assessment. In this assessment, transport of dicofol through erosion and spray drift is considered in deriving quantitative estimates of dicofol exposure to CRLF, its prey and its habitats. Since this screening-level risk assessment defines taxa that are predicted to be exposed through runoff and drift to dicofol at concentrations above the Agency's Levels of Concern (LOC), there is a need to expand the action area to include areas that are affected indirectly by this federal action. Because of the lack of a NOAEC in several chronic toxicity studies with birds, described later in Section 4.3.1, the action area for dicofol is established as the entire state of California. Additional analysis related to the intersection of the dicofol action area and CRLF habitat used in determining the action area is described in section 5.2.5 and in **Appendix B**.

2.8. Assessment Endpoints and Measures of Ecological Effect

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

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

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 (U.S. EPA 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 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 dicofol is provided in Table 7.

Table 7. Assessment endpoints and measures of ecological effects for dicofol.

Assessment Endpoint	Measures of Ecological Effects[3]
Aquatic-Phase CRLF (Eggs, larvae, juveniles, and adults)[1]	
Direct Effects	
1. Survival, growth, and reproduction of CRLF	1a. LC_{50} = 53.0 µg/L, based on most sensitive acute exposure data available for fish 1b. NOAEC = 4.4 µg a.i./L, based on most sensitive chronic exposure data available for fish
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. EC_{50} = 140 µg/L, based on most sensitive acute exposure data available for aquatic invertebrates 2b. NOAEC = 19 µg a.i./L, based on most sensitive chronic exposure data available for aquatic invertebrates 2c. LC_{50} = 53.0 µg/L, based on most sensitive acute exposure data available for fish 2d. NOAEC = 4.4 µg a.i./L, based on most sensitive chronic exposure data available for fish 2e. EC_{50} > 5,000, <10,000 µg/L, based on available data for green algae
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. EC_{50} > 5,000, <10,000 µg/L, based on available data for green algae
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation	No data are available to quantify an endpoint to represent effects of dicofol exposures to vascular plants.
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	4a. LD_{50} = 265 mg a.i./kg bw, based on most sensitive acute oral exposure data available for birds[2] 4b. LC_{50} = 903 ppm, based on most sensitive subacute dietary exposure data available for birds[2] 4c. NOAEC = 1 ppm, based on most sensitive chronic exposure data available for birds[2]
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)	5a. LD_{50}>50 µg a.i./bee, based on most sensitive acute oral exposure data available for terrestrial invertebrates 5b. LD_{50} = 587 mg/kg-bw, based on most sensitive acute oral exposure data available for mammals 5c. NOAEC = 5 ppm, based on most sensitive chronic exposure data available for mammals 5d. LD_{50} = 265 mg a.i./kg bw, based on most sensitive acute oral exposure data available for birds[2] 5e. LC_{50} = 903 ppm, based on most sensitive subacute dietary exposure data available for birds[2] 5f. NOAEC = 1 ppm, based on most sensitive chronic exposure data available for birds[2]
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian and upland vegetation)	No data are available to quantify an endpoint to represent effects of dicofol exposures to vascular plants.

[1] 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.
[2] Birds are used as surrogates for terrestrial phase amphibians.
[3]See Table 22 and Table 27 for citations and additional information.

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 dicofol 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 dicofol 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 dicofol on critical habitat of the CRLF are described in Table 8. 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 U.S. FWS (2006).

Table 8. Summary of dicofol assessment endpoints and measures of ecological effect for primary constituent elements of designated critical habitat[1].

Assessment Endpoint	**Measures of Ecological Effect[3]**
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.	No data are available to quantify an endpoint to represent effects of dicofol exposures to vascular plants.
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.	1e. EC_{50} > 5,000, <10,000 µg/L, based on available data for green algae No data are available for assessing the effects of exposures of dicofol to vascular plants.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	1a. LC_{50} = 53.0 µg/L, based on most sensitive acute exposure data available for fish 1b. NOAEC = 4.4 µg a.i./L, based on most sensitive chronic exposure data available for fish 1c. EC_{50} = 140 µg/L, based on most sensitive acute exposure data available for aquatic invertebrates 1d. NOAEC = 19 µg a.i./L, based on most sensitive chronic exposure data available for aquatic invertebrates 1e. EC_{50} > 5,000, <10,000 µg/L, based on available data for green algae
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	1e. EC_{50} > 5,000, <10,000 µg/L, based on available data for green algae
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	No data are available to quantify an endpoint to represent effects of dicofol exposures to vascular 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	No data are available to quantify an endpoint to represent effects of dicofol exposures to vascular plants.
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	2a. LD_{50}>50 µg a.i./bee, based on most sensitive acute exposure data available for terrestrial invertebrates 2b. LD_{50} = 587 mg/kg-bw, based on most sensitive acute oral exposure data available for mammals 2c. NOAEC = 5 mg/kg-bw, based on most sensitive chronic exposure data available for mammals 2d. LD_{50} = 265 mg a.i./kg bw, based on most sensitive acute oral exposure data available for birds[2] 2e. LC_{50} = 903 mg/kg-bw, based on most sensitive subacute dietary exposure data available for birds[2] 2f. NOAEC = 1 mg/kg-bw, based on most sensitive chronic exposure data available for birds[2]

Assessment Endpoint	Measures of Ecological Effect[3]
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	3a. LD_{50} = 265 mg a.i./kg bw, based on most sensitive acute oral exposure data available for birds[2] 3b. LC_{50} = 903 mg/kg-bw, based on most sensitive subacute dietary exposure data available for birds[2] 3c. NOAEC = 1 mg/kg-bw, based on most sensitive chronic exposure data available for birds[2]

1 Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.
2 Birds are used as surrogates for terrestrial phase amphibians.
3 See Table 22 and Table 27 for citations and additional information.

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 1998a). For this assessment, the risk is stressor-linked, where the stressor is the release of dicofol to the environment. The following risk hypotheses are presumed for this endangered species assessment:

The labeled use of dicofol 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 affect 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 affect 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 effects to 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; or,

- 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 dicofol release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial exposures are shown in Figure 6 and in Figure 7, 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.

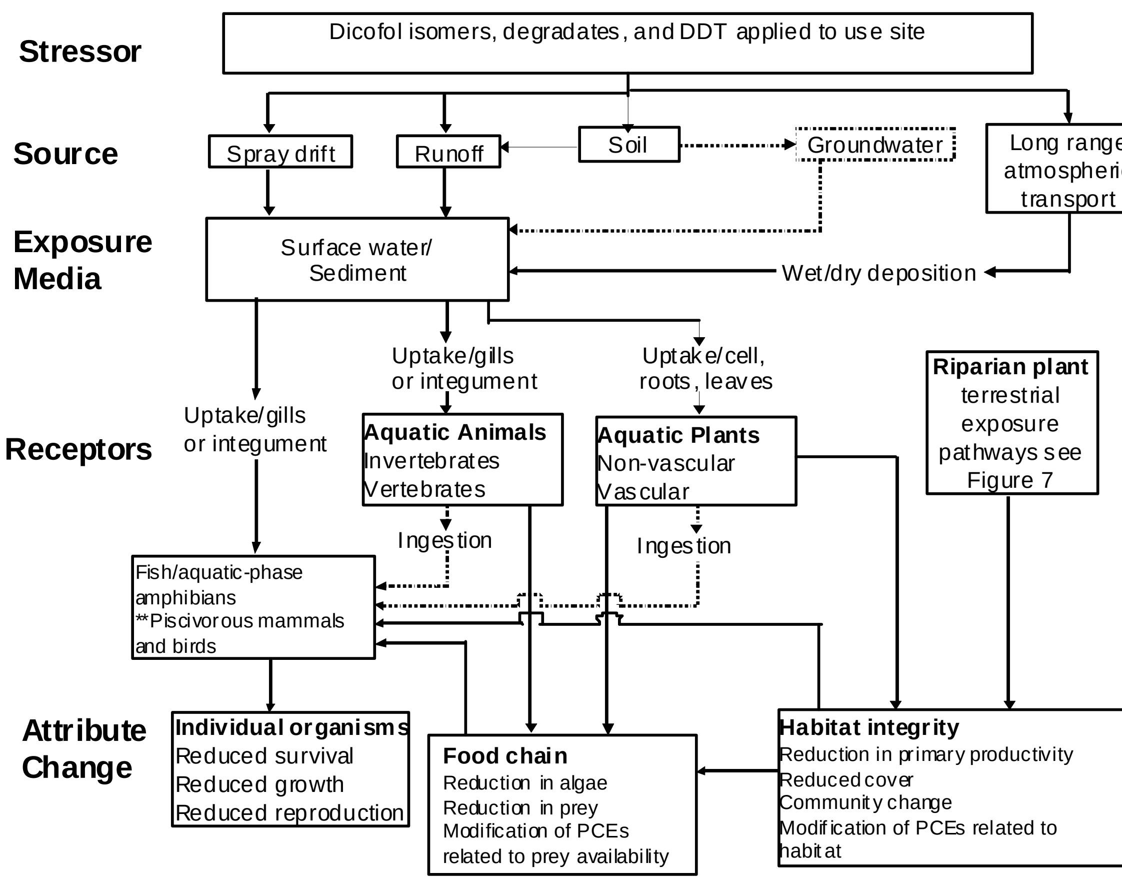


Figure 6. Conceptual model for dicofol effects on aquatic-phase of the CRLF.

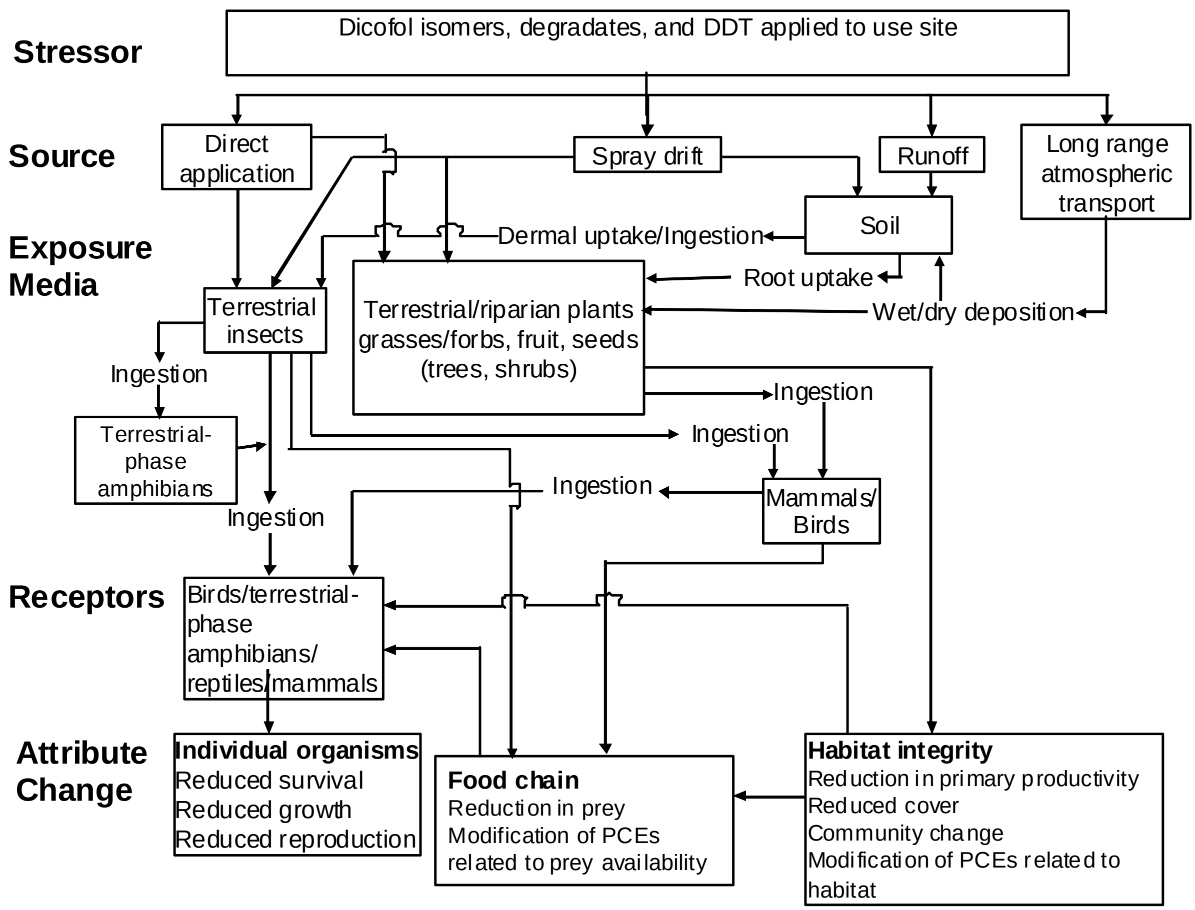


Figure 7. Conceptual model for dicofol effects on terrestrial phase of the CRLF.

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 dicofol 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 dicofol 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 of Exposure

The environmental fate properties of dicofol along with available monitoring data indicate that runoff and spray drift are the principle potential transport mechanisms of dicofol to the aquatic and terrestrial habitats of the CRLF. In this assessment, transport of dicofol through runoff and spray drift is considered in deriving quantitative estimates of dicofol exposure to CRLF, its prey and its habitats. Because of its low vapor pressure and persistence in the air ($T_{1/2} > 2$ days), dicofol has the potential for long range transport. It should be noted, however, that recent ambient air monitoring in agricultural communities in California does not indicate volatilization of dicofol (See Section 3.2.4.2).

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of dicofol using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to 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. Additionally, the Generic Estimated Environmental Concentration Model (GENEEC2) was used to characterize the potential impacts due to the DDT manufacturing intermediate in dicofol (see **Appendix F**).

PRZM (v3.12.2, May 2005) and EXAMS (v2.98.4.6, April 2005) are simulation models coupled with the input shell pe5.pl (Aug 2007) to generate daily exposures and 1-in-10 year EECs of dicofol that may occur in surface water bodies adjacent to application sites receiving dicofol 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 dicofol. 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.

GENEEC2 Version 2.0 is a screening-level model used in pesticide aquatic ecological risk assessments. Similar to PRZM/EXAMS, GENEEC2 uses the soil/water partition coefficient and degradation kinetic data to estimate runoff from a ten hectare field into a one hectare by two meter deep “standard” pond.

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 dicofol 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 dicofol 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.

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

KABAM (<u>K</u>$_{OW}$ (based) <u>A</u>quatic <u>B</u>io<u>A</u>ccumulation <u>M</u>odel) v.1.0 is used to estimate potential bioaccumulation of dicofol in freshwater aquatic food webs and subsequent risks to mammals and birds via consumption of contaminated aquatic prey. In this case, exposures to birds are used as a surrogate for CRLF consuming aquatic organisms that have bioaccumulated dicofol and its degradates of concern.

Lastly, in order to characterize the long range transport potential (LRTP) of dicofol and its degradates, the OECD P_{ov} and LRTP Screening Tool was used. Three chemicals known to move via long range transport, DDT, aldrin and endrin, were also modeled to provide a context for the dicofol-estimated LRTP. It should be noted that OPP is not able to quantify the extent to which dicofol and its degradates will undergo long-range atmospheric transport once it has been released from a treatment site and, as such, cannot quantify the amount of exposure that could potentially occur to nontarget animals distant from the use sites.

2.10.2. Measures of Effect

Data identified in Section 4 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 U.S. EPA, 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 dicofol 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 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.

2.10.3. 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 dicofol, 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 dicofol 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) (U.S. EPA 2004) (see **Appendix C**).

For this endangered species assessment, listed species LOCs are used for comparing RQ values for acute and chronic exposures of dicofol directly to the CRLF. If estimated exposures directly to the CRLF of dicofol 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 dicofol 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 an 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**.

2.10.4. Data Gaps

There are currently no submitted studies quantifying the environmental fate and transport of the major degradates of dicofol individually. Additionally, aerobic and anaerobic soil metabolism studies were conducted using slightly alkaline (pH from 7.5 to 7.9) soil, so soil metabolism studies under acidic soil conditions are missing. It should also be noted that a study on photodegradation in air for dicofol and its degradates has not been submitted.

No data are available for assessing the effects of exposures of dicofol to freshwater vascular plants. Generally, data for duckweed (*Lemna gibba*) are used to assess these effects.

In addition, no data are available to quantify an endpoint to represent effects of dicofol exposures to riparian and terrestrial vegetation (vascular plants), which are generally represented by effects data for terrestrial agricultural crop species.

Limited data are available to determine the toxicity of dicofol's major degradates to aquatic or terrestrial organisms.

3.0 Exposure Assessment

Dicofol is formulated as a wettable powder and emulsifiable formulation. Application equipment includes: ground application, aerial application, and various sprayers (high- and low-volume. Risks from ground boom and aerial applications are expected to result in the highest off-target levels of dicofol 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

Dicofol labels may be categorized into two types: labels for manufacturing uses (including technical grade dicofol and its formulated products) and end-use products. While technical products, which contain dicofol 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 mites. The formulated product labels legally limit dicofol's potential use to only those sites that are specified on the labels.

Currently registered agricultural and non-agricultural uses of dicofol within California include: beans (dry, snap, and lima), citrus (specifically, grapefruit, kumquats, lemons, limes, oranges, tangelos, and tangerines), cotton, cucurbits (specifically, cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash), grapes, hops, mint, pecans, peppers, pome fruits (specifically, apples, crabapples, pears, and quince), stone fruits (specifically, apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes), strawberries, tomatoes, walnuts, Bermuda grass, turf/ornamental uses (specifically, turf grasses, nursery stock, flowers, shade trees, woody shrubs and vines, and sod farms) and outside building surfaces (non-agricultural). The model scenarios and application input parameters for the uses included in this risk assessment are summarized in Table 9.

Table 9. Dicofol uses and application information for the CRLF risk assessment[1].

Crop	Uses Represented by Scenario	PRZM/EXAMS Scenario	Application Rate (lbs a.i./acre)	Number of Applications	Application Interval	Application Method
Beans (dry, green, lima)		CA row crop RLF	1.5	1	Annually	ULV, Aerial, ground
Citrus	Grapefruit, kumquats, lemons, limes, oranges, tangelos, tangerines	CA citrus	3	1	Annually	ULV, Aerial, ground
Cotton		CA cotton	1.5	1	Annually	ULV, Aerial, ground
Cucurbits	Cantaloupes, cucumbers, melons, pumpkins, watermelons, winter and summer squash	CA melons RLF	0.625	1	Annually	ULV, Aerial, ground
Grapes		CA wine grapes RLF	1.25	1	Annually	ULV, Aerial, ground
Hops		OR hops	1.165	1	Annually	ULV, Aerial, ground
Mint	Mint, peppermint, spearmint	OR mint	1.25	1	Annually	ULV, Aerial, ground
Pecans		CA almonds	2	1	Annually	ULV, Aerial, ground
Peppers		CA row crop RLF	0.75	1	Annually	ULV, Aerial, ground
Pome fruits	Apples, crabapples, pears, quince	CA fruit	3	1	Annually	ULV, Aerial, ground
Stone fruits	Apricots, sweet and sour cherries, nectarines, peaches, plums, prunes	CA fruit	1.5	1	Annually	ULV, Aerial, ground

Crop	Uses Represented by Scenario	PRZM/EXAMS Scenario	Application Rate (lbs a.i./acre)	Number of Applications	Application Interval	Application Method
Strawberries		CA strawberries (non-plastic)	2	1	Annually	ULV, Aerial, ground
Tomatoes		CA tomato	0.75	1	Annually	ULV, Aerial, ground
Walnuts		CA almonds	2	1	Annually	ULV, Aerial, ground
Bermudagrass		CA turf RLF	0.4	1	Annually	Ground
Turf grasses		CA turf RLF	0.5	1	Annually	Ground
Sod farm turf		CA turf RLF	0.5	1	Annually	Ground
Ornamentals	Nurseries, ornamentals, flowers, shade trees	CA nursery	0.5	1	Annually	Ground
Outside building surfaces		CA impervious RLF and CA turf RLF	0.5	1	Annually	Ground

1. Uses assessed based on maximum label rates for registered dicofol products.

The labels for dicofol also specify that applications using ground equipment should not be made within 25 feet, or by air within 150 feet, of lakes, reservoirs, rivers, permanent streams, marshes, natural ponds, estuaries, or commercial fish farm ponds. The spray drift buffer zone is 450 feet when ultra low volume application is made.

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 dicofol use in California. 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 more shallow or have larger drainage areas (or both). Shallow water bodies tend to have limited storage capacity, and thus, tend to overflow and carry pesticide in their 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 and which is all concurrently treated with the pesticide. Headwater streams can also have peak concentrations higher than the standard pond, but these peaks in pesticide concentrations 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 dicofol were used for modeling, including application rates, buffer widths and resulting spray drift values modeled from AgDRIFT and the first application date for each crop. The date of first application was developed based on several sources of information including data provided by EPA/OPP/BEAD, a summary of individual applications from the CDPR PUR data, and Crop Profiles maintained by the USDA. A sample of the distribution of dicofol applications to cotton from the CDPR PUR data for 2004 used to pick an application date is shown in Figure 8. More detail on the crop profiles and the previous assessments may be found at: http://www.ipmcenters.org/CropProfiles/.

In defining the date of application, available CDPR PUR data were analyzed to determine the time period when greater than 90% of applications took place. An initial first application date was then selected from the month at the beginning of this range. Then, the corresponding PRZM/EXAMS scenarios used in the modeling effort were examined and dates for crop emergence, maturation, and harvest were evaluated. As mites usually rely on leaves and fruit as food sources, the midpoint date between emergence and maturation was estimated. If the crop scenario indicated that the crop was grown all year, a date of January 15th was selected to result in a conservative EEC that would result from increased rainfall experienced in California during the winter months. If the PRZM/EXAMS midpoint date occurred within the time period of the CDPR PUR 90%, then the PRZM/EXAMS midpoint date was used as the date of first application. Otherwise, the initial CDPR PUR date was used. For example, according to the CDPR PUR data, 90% of the dicofol use on cotton was between May and August, and May 3rd was selected as the initial date of first application. In the PRZM/EXAMS scenario for California cotton, crop emergence occurs on May 1st and crop maturation occurs on September 20th, with a midpoint around July 11th. As this midpoint lies within the range of the 90% data obtained from CDPR PUR, July 11th was selected as the first application date for modeling purposes.

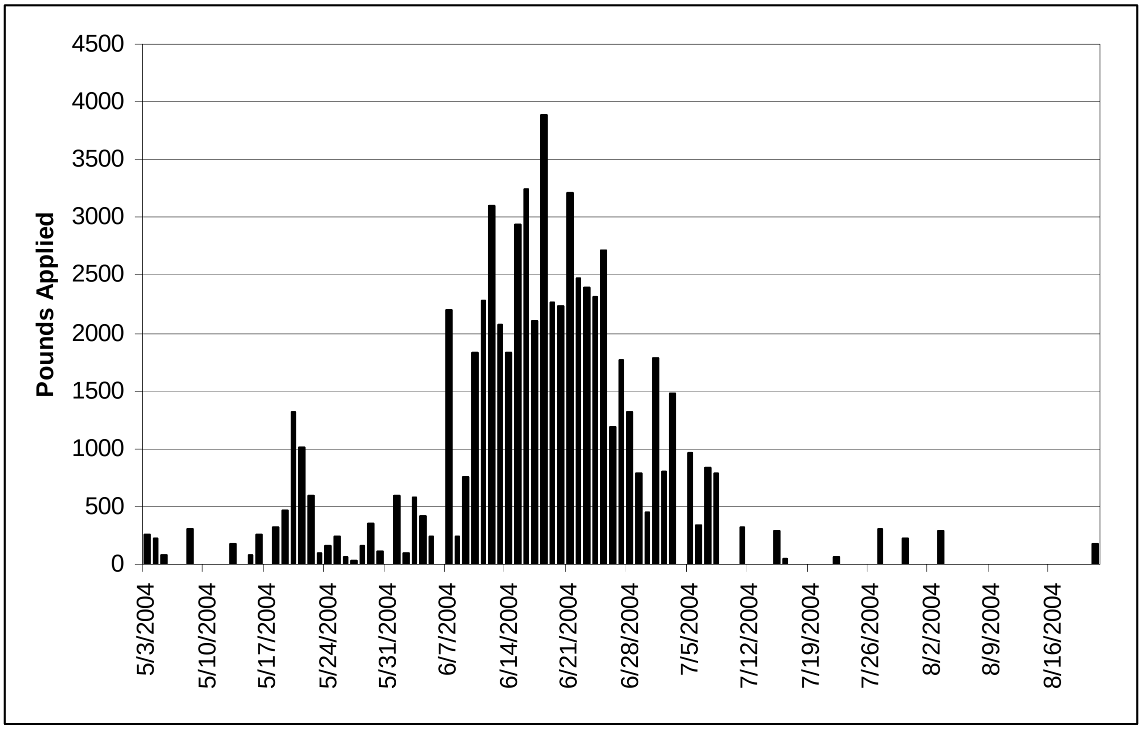


Figure 8. Summary of applications of dicofol to cotton in 2004 from CDPR PUR data.

Once the separate PRZM/EXAMS runs for *o,p*'- and *p,p*'-dicofol are finished, the daily EECs are summed to generate a total daily parent dicofol EEC. This was done to facilitate comparison of the various EECs to the appropriate endpoints, which were based on total dicofol. Average 21-day, 60-day, and annual EECs of these total daily dicofol EECs were calculated. Maximum values were then estimated for each year and 1-in-10 year return peak and rolling means for the 21-day, 60-day, and annual concentrations were estimated for each scenario. The same analyses were conducted for the *o,p*'- and *p,p'*-dicofol and degradate scenarios.

3.2.2. PRZM Scenarios

PRZM scenarios used to model aquatic exposures resulting from applications of specific uses are identified in Table 9**.** In cases where a scenario does not exist for a specific use, it is necessary to assign a surrogate scenario. Those surrogates are assigned to be most representative of the use being considered. Justifications for assignments of surrogates are defined below.

Row crop scenario

This scenario is intended to represent production of carrots, beans, peppers and other crops in CA, and is therefore, directly relevant to these uses.

Citrus scenario

This scenario is intended to represent applications of pesticides to oranges, grapefruit, kumquats, lemons, limes, taneglos, and tangerines in CA and is therefore, directly relevant to this use.

Cotton scenario

This scenario is intended to represent applications of pesticides to cotton in CA and is therefore, directly relevant to this use.

Melon scenario

This scenario is intended to represent applications of pesticides to cantaloupes, cucumbers, melons, pumpkins, watermelons, winter and summer squash in CA and is therefore, directly relevant to this use.

Wine grapes scenario

From 2002 to 2007, CA PUR data indicate that dicofol was used mostly on grapes grown for wine production, as opposed to grapes grown for consumption, in 31 counties. This scenario is intended to represent applications of pesticides to wine grapes in CA and is therefore, directly relevant to this use.

Hops

This scenario, developed based on a hops vineyard in the Pacific Northwest, represents a vineyard located north of the area where hops are grown in CA Since the locations where hops are grown in CA are mostly in the northern part of the state, this scenario was deemed appropriate for modeling hops grown in CA.

Mint

According to NASS data, mint (grown for oil) has been grown in Lassen, Shasta and Siskiyou Counties. These counties are located in northern CA, bordering OR. Although this scenario represents a field located north of the area where mint is grown in CA, it was developed based on a mint field in the Pacific Northwest. Since the locations where mint is grown in CA are in the northern part of the state, this scenario was deemed appropriate for modeling mint grown in CA.

Almond scenario

This scenario is intended to represent almond production in CA and is therefore, directly relevant to this use. Walnuts and pecans are nut trees with similar practices and have been assigned to this scenario.

Fruit scenario

The CA fruit scenario represents a deciduous fruit tree orchard in Fresno County, which is located in the Central Valley. This scenario is intended to represent non-citrus fruit, including apples, crabapples, pears, quince, apricots, sweet and sour cherries, nectarines, peaches, plums, and prunes.

Strawberry scenario

This scenario is intended to represent applications of pesticides to strawberries, non-tarped, in CA. While the majority of strawberry growers use tarps, this scenario is considered a conservative approach and is therefore, directly relevant to this use.

Tomato scenario

This scenario is intended to represent applications of pesticides to tomatoes in CA and is therefore, directly relevant to this use.

Turf scenario

This scenario is intended to represent applications of pesticides to sod farms, parks, recreational fields, grass for seed, and golf courses in CA and is therefore, directly relevant to this use.

Nursery scenario

This scenario is intended to represent applications of pesticides in outdoor nurseries in CA and is therefore, directly relevant to this use.

Outside buildings

Two scenarios were used to assess this use pattern: CA impervious and CA turf. The label indicates that to control clover mites, “thoroughly spray the outside walls, foundations, and windowsills and plants and lawn at the base of infested buildings.” For the 10-hectare scenario used in PRZM/EXAMS, it was assumed that a building was at the center of each hectare. Each building was assumed to be a square measuring 15,000 square feet, with turf on three sides of the building and impervious surface on one side. It was assumed a 10-foot swath was treated on the sides with turf and that the side with the impervious surface would be treated up to a height of three feet along the building wall. This results in approximately 3.75% of the watershed being treated. A detailed description of the rationale for this value is provided in **Appendix D.**

3.2.3. Model Inputs

The appropriate chemical-specific PRZM input parameters are selected from reviewed environmental fate data submitted by the registrant (Table 3) and in accordance with EFED water model input parameter selection guidance (U.S. EPA 2002). The input parameters selected are similar to those used in the 1998 dicofol RED (U.S. EPA, 1998b). A summary of the chemical specific model inputs used in this assessment are provided in Table 10 and Table 11.

Table 10. Summary of PRZM/EXAMS environmental fate data used for aquatic exposure inputs for *o,p'*-dicofol. [1]

Fate Property	Value (unit)	MRID (or source)	Comment
Molecular Weight	370.5 g/mole	00141704; 00142595	
Henry's constant	1.44×10^{-7} atm-m^3/mol		Estimated using VP, MW and solubility: HLC=VPxMW/Sol
Vapor Pressure	3×10^{-7} torr	00141704; 00142595	
Solubility in Water	1.32 mg/L	00141704; 00142595	
Photolysis in Water	27.5 days	40849702	
Aerobic Soil Metabolism Half-lives	25.5 days (parent) 313.5 days (total)	41094201	3x single value
Hydrolysis	3.3×10^{-1} days	40042033	
Aerobic Aquatic Metabolism (water column)	51 days (parent) 627 days (total)	--	Assumed: 2x aerobic soil half-life
Anaerobic Aquatic Metabolism (benthic)	0 d	--	Assumed stable, no reviewed data
Koc	7,060 mL/g	41509802	≤2.5% of parent found in leachate. Used value from *p,p'*-dicofol.

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

Table 11. Summary of PRZM/EXAMS environmental fate data used for aquatic exposure inputs for *p,p'*-dicofol. [1]

Fate Property	Value (unit)	MRID (or source)	Comment
Molecular Weight	370.5 g/mole	00141704; 00142595	
Henry's constant	1.44×10^{-7} atm-m^3/mol		Estimated using VP, MW and solubility, HLC=VPxMW/Sol
Vapor Pressure	3×10^{-7} torr	00141704; 00142595	
Solubility in Water	1.32 mg/L	00141704; 00142595	
Photolysis in Water	244 days	40849701	
Aerobic Soil Metabolism Half-lives	96 days (parent) 939 days (total)	41050701	3x single value
Hydrolysis	2.8 days	40042032	
Aerobic Aquatic Metabolism (water column)	192 days (parent) 1,878 days (total)		2x aerobic soil half-life
Anaerobic Aquatic Metabolism (benthic)	0 d		Assumed stable, no reviewed data
K_{oc}	7060 mL/g	41509801	Average K_{oc}

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

For *p,p'*-dicofol, a regression analysis between the K_d and organic carbon content values indicated a high r-squared value (0.98) and statistical significance (<0.01). To assess the appropriateness of the K*oc* model, a comparison of the coefficient of variation for the $K_{oc.}$ (CV = 19) was compared to the coefficient of variation for K_d (CV = 58). Since the CV for the K_{oc} was less than the CV for K_d, the average K_{oc} of 7060 mL/g was used (Kashuba *et al.* 2006). For *o,p*'-dicofol, the majority of dicofol remained in upper 2 inches of soil columns, with less than 2.5% of dicofol found in leachate. As a result, a K_{oc} of 0 was used during modeling.

As depicted in Table 3, the aerobic soil half-lives for the parent dicofol isomers were significantly less than the half-lives estimated for the total residues of parent and degradates of concern (8.5 vs. 104.5 days for *o,p*'-dicofol and 32 vs 313 days for *p,p*'-dicofol). As these values indicate a significant increase in persistence in the environment, separate model runs were conducted for the parent isomers and the parent plus degradate.

For the PRZM input "chemical application method" (CAM), a value of 2 was selected to represent foliar applications. For aerial applications, using the 150-foot buffer zone stipulated on the label, an application efficiency of 0.95 was derived using AgDrift, with a spray drift fraction of 0.039. For ground applications, using the 25-foot buffer zone stipulated on the label, an application efficiency of 0.99 was derived using AgDrift, with a spray drift fraction of 0.027. For ULV applications, using the 450-foot buffer zone required on the label, an application efficiency of 0.727 was derived using AgDrift, with a spray drift fraction of 0.109, for orchards (*e.g.*, citrus, pome fruit, and stone fruit), and an application efficiency of 0.72 was derived using AgDrift, with a spray drift fraction of 0.117, for other crops. It should be noted that if the buffer zone for ULV is not used, spray drift fractions increase to 0.5 for both orchards and crops. Parameters used in the derivation of the application efficiency and spray drift for ULV applications are discussed further in **Appendix P**.

3.2.4. Model Results

The aquatic EECs for the various scenarios and application practices for the sum of the *o,p'* and *p,p'* isomers of dicofol and for total dicofol (*e.g.*, including degradates) are listed in Table 12 and Table 13. Example PRZM/EXAMS outputs are available in Appendix E.

Table 12. Aquatic EECs (µg/L) for Dicofol Uses in California, Total *o,p*' and *p,p*' Isomers.

Crop/Application Represented	Application Rate (lbs a.i./acre)	Date of First Application	Scenario	Peak EEC	21-day average EEC	60-day average EEC
Beans Aerial	1.5	May-01	CA row crop RLF	3.24	0.46	0.18
Beans Ground	1.5	May-01	CA row crop RLF	2.25	0.32	0.12
Beans ULV	1.5	May-01	CA row crop RLF	9.72	1.38	0.53
Citrus Aerial	3.0	January-15	CA citrus	6.44	0.97	0.42
Citrus Ground	3.0	January-15	CA citrus	4.46	0.69	0.31
Citrus ULV	3.0	January-15	CA citrus	17.97	2.58	1.03
Cotton Aerial	1.5	July-11	CA cotton irrig	3.44	0.65	0.29
Cotton Ground	1.5	July-11	CA cotton irrig	2.46	0.52	0.25
Cotton ULV	1.5	July-11	CA cotton irrig	9.87	1.52	0.60
Cucurbit Aerial	0.625	June-23	CA melons RLF	1.34	0.19	0.07
Cucurbit Ground	0.625	June-23	CA melons RLF	0.93	0.13	0.05
Cucurbit ULV	0.625	June-23	CA melons RLF	4.03	0.57	0.21
Grape Aerial	1.25	June-11	CA wine grape	2.69	0.39	0.15
Grape Ground	1.25	June-11	CA wine grape	1.86	0.27	0.10
Grape ULV	1.25	June-11	CA wine grape	8.06	1.15	0.44
Hops Aerial	1.165	May-31	OR hops	2.51	0.38	0.17
Hops Ground	1.165	May-31	OR hops	1.74	0.27	0.13
Hops ULV	1.165	May-31	OR hops	7.54	1.09	0.43
Mint Aerial	1.25	June-04	OR mint	2.69	0.39	0.16
Mint Ground	1.25	June-04	OR mint	1.86	0.27	0.11
Mint ULV	1.25	June-04	OR mint	8.05	1.15	0.44
Pepper Aerial	2.0	May-11	CA row crop RLF	1.61	0.23	0.09
Pepper Ground	2.0	May-11	CA row crop RLF	1.12	0.16	0.06
Pepper ULV	2.0	May-11	CA row crop RLF	4.83	0.69	0.26
Pome Fruit Aerial	3.0	June-05	CA fruit	6.44	0.91	0.34
Pome Fruit Ground	3.0	June-05	CA fruit	4.46	0.63	0.24

Crop/Application Represented	Application Rate (lbs a.i./acre)	Date of First Application	Scenario	Peak EEC	21-day average EEC	60-day average EEC
Pome Fruit ULV	3.0	June-05	CA fruit	17.97	2.55	0.96
Stone Fruit Aerial	1.5	May-08	CA fruit	3.24	0.46	0.18
Stone Fruit Ground	1.5	May-08	CA fruit	2.24	0.32	0.12
Stone Fruit ULV	1.5	May-08	CA fruit	9.05	1.29	0.48
Strawberry Aerial	2.0	January-15	CA strawberry (nonplastic) RLF	6.09	1.71	0.92
Strawberry Ground	2.0	January-15	CA strawberry (nonplastic) RLF	5.97	1.57	0.87
Strawberry ULV	2.0	January-15	CA strawberry (nonplastic) RLF	13.10	2.67	1.22
Tomato Aerial	0.75	June-07	CA tomato	1.61	0.23	0.09
Tomato Ground	0.75	June-07	CA tomato	1.12	0.16	0.06
Tomato ULV	0.75	June-07	CA tomato	4.83	0.69	0.26
Walnut/Pecan Aerial	2.0	June-08	CA almond	4.38	0.67	0.29
Walnut/Pecan Ground	2.0	June-08	CA almond	3.07	0.48	0.22
Walnut/Pecan ULV	2.0	June-08	CA almond	12.97	1.87	0.73
Bermuda grass Ground	0.4	January-15	CA turf RLF	0.60	0.10	0.04
Ornamentals Ground	0.5	January-15	CA nursery	1.77	0.39	0.18
Turf/Sod Farm Ground	0.5	January-15	CA turf RLF	0.75	0.13	0.05
Outside Buildings	0.5	January-15	CA impervious RLF & CA turf RLF	0.15	0.025	0.01

Table 13. Aquatic EECs (µg/L) for Dicofol, Parent and Degradate Uses in California.

Crop/Application Represented	Application Rate (lbs a.i./acre)	Date of First Application	Scenario	Peak EEC	21-day average EEC	60-day average EEC
Beans Aerial	1.5	May-01	CA row crop RLF	20.55	18.42	17.76
Beans Ground	1.5	May-01	CA row crop RLF	18.09	16.58	16.11
Beans ULV	1.5	May-01	CA row crop RLF	36.51	30.74	28.77
Citrus Aerial	3.0	January-15	CA citrus	21.64	17.89	16.61
Citrus Ground	3.0	January-15	CA citrus	16.49	13.93	13.13
Citrus ULV	3.0	January-15	CA citrus	55.15	44.58	40.99
Cotton Aerial	1.5	July-11	CA cotton irrig	22.86	21.17	20.52
Cotton Ground	1.5	July-11	CA cotton irrig	20.46	19.39	18.93
Cotton ULV	1.5	July-11	CA cotton irrig	38.84	33.25	31.31
Cucurbit Aerial	0.625	June-23	CA melons RLF	7.81	7.01	6.74
Cucurbit Ground	0.625	June-23	CA melons RLF	6.78	6.23	6.01
Cucurbit ULV	0.625	June-23	CA melons RLF	14.82	12.44	11.63
Grape Aerial	1.25	June-11	CA wine grape	15.39	13.81	13.26
Grape Ground	1.25	June-11	CA wine grape	13.33	12.22	11.84
Grape ULV	1.25	June-11	CA wine grape	29.15	24.37	22.74
Hops Aerial	1.165	May-31	OR hops	22.70	21.27	20.47
Hops Ground	1.165	May-31	OR hops	21.03	20.11	19.45
Hops ULV	1.165	May-31	OR hops	33.88	29.41	27.99
Mint Aerial	1.25	June-04	OR mint	18.81	17.62	16.81
Mint Ground	1.25	June-04	OR mint	17.12	16.05	15.52
Mint ULV	1.25	June-04	OR mint	32.57	27.83	26.26
Pepper Aerial	2.0	May-11	CA row crop RLF	10.29	9.23	8.90
Pepper Ground	2.0	May-11	CA row crop RLF	9.05	8.32	8.09

Crop/Application Represented	Application Rate (lbs a.i./acre)	Date of First Application	Scenario	Peak EEC	21-day average EEC	60-day average EEC
Pepper ULV	2.0	May-11	CA row crop RLF	18.21	15.34	14.37
Pome Fruit Aerial	3.0	June-05	CA fruit	24.32	20.57	19.26
Pome Fruit Ground	3.0	June-05	CA fruit	18.69	16.08	15.18
Pome Fruit ULV	3.0	June-05	CA fruit	57.34	46.74	43.13
Stone Fruit Aerial	1.5	May-08	CA fruit	12.06	10.17	9.50
Stone Fruit Ground	1.5	May-08	CA fruit	9.20	7.91	7.44
Stone Fruit ULV	1.5	May-08	CA fruit	28.73	23.40	21.57
Strawberry Aerial	2.0	January-15	CA strawberry (nonplastic) RLF	42.51	39.77	39.11
Strawberry Ground	2.0	January-15	CA strawberry (nonplastic) RLF	41.13	37.81	37.41
Strawberry ULV	2.0	January-15	CA strawberry (nonplastic) RLF	59.64	52.07	50.05
Tomato Aerial	0.75	June-07	CA tomato	7.72	6.77	6.44
Tomato Ground	0.75	June-07	CA tomato	6.38	5.72	5.49
Tomato ULV	0.75	June-07	CA tomato	16.54	13.70	12.73
Walnut/Pecan Aerial	2.0	June-08	CA almond	25.28	22.82	21.99
Walnut/Pecan Ground	2.0	June-08	CA almond	21.88	20.20	19.64
Walnut/Pecan ULV	2.0	June-08	CA almond	47.75	40.25	37.70
Bermuda grass Ground	0.4	January-15	CA turf RLF	2.66	2.31	2.21
Ornamentals Ground	0.5	January-15	CA nursery	7.16	6.48	6.29
Turf/Sod Farm Ground	0.5	January-15	CA turf RLF	3.31	2.87	2.74
Outside Buildings	0.5	January-15	CA impervious RLF & CA turf RLF	0.38	0.31	0.29

3.2.5. Available Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. Monitoring data for dicofol from the USGS NAWQA program (http://water.usgs.gov/nawqa) were not available. Surface water and sediment monitoring data from the California Department of Pesticide Regulation (CDPR) were available and are considered in this assessment. No air monitoring data were located.

Dicofol

A study was conducted in 1993 (Domagalski 1996) that assessed the levels of dicofol in the San Joaquin River and its tributaries during the irrigation season. Water samples were collected at 22 sites within the perennial reach of the San Joaquin River in the San Joaquin Valley. All sampling locations were selected downstream of the confluence of the San Joaquin River and the Salt Slough. All sites were sampled during two synoptic surveys that occurred during March and August 1993. A subset of these sites was sampled more frequently (twice-monthly or monthly) for the period of March through September 1993. The sampling sites with the greatest frequency were the Central California Irrigation District Canal, Orestimba Creek, the Spanish Grant Drain, and the Salt Slough. From the study, it appears that 79 samples were collected from March to September 1993. All samples collected between March and June of 1993 were below the level of detection (0.05 µg/L). From June to September, 33 samples had levels of dicofol above the detection limit, with the highest concentration of 2.5 µg/L from a sample collected at the Orestimba Creek site.

NAWQA monitoring data were not available for dicofol from California surface waters (USGS 2008).

CDPR maintains a database of monitoring data of pesticides in CA surface waters. The sampled water bodies include rivers, creeks, urban streams, agricultural drains, the San Francisco Bay delta region and storm water runoff from urban areas. The database contains data from 51 different studies by federal (including the USGS NAWQA program), state and local agencies as well as groups from private industry and environmental interests. Data are available from 1990-2006 for 46 counties for several pesticides and their degradates. Data for dicofol are included in this database (CDPR 2008).

From 1990-2006, 618 samples from surface waters were analyzed for dicofol in the CDPR database. Of these, dicofol was detected in 11 (1.8%) of the samples, with a maximum concentration of 0.27 µg/L. These samples included 131 different sites in 16 counties; including counties where CRLF core areas and critical habitat are located. Dicofol was not reported in the sediment samples that were collected over this timeframe. It should be noted that these results are not from targeted monitoring studies.

The *Pesticides in Ground Water Data Base* (U.S. EPA 1992) shows no detections of dicofol in limited sampling in several States, including California, (1634 wells sampled between 1979 and 1991).

Dicofol Degradates

NAWQA monitoring data were available for one degradate of dicofol, *p,p'*-DCBP. Twenty samples of *p,p'*-DCBP were collected from 2003 to 2005, with a maximum estimated concentration of 0.69 µg/L (detection limit unknown). It should be noted that the original source of the *p,p'*-DCBP detections (e.g., where the active ingredient came from) is unknown, as *p,p'*-DCBP is also a degradate of chlorobenzilate, chloropropylate, and DDT.

The CDPR database did not contain monitoring data of dicofol degradates in surface water or sediment.

3.3. Aquatic Bioaccumulation Assessment

Available data on the octanol-water partition coefficient $K_{ow} = 1.15 \times 10^6$, (MRID 00141580) and bioconcentration factors (BCFs) for dicofol indicate that this pesticide may accumulate in aquatic food webs. KABAM v.1.0 was used to estimate concentrations of dicofol in tissues of aquatic organisms resulting from bioaccumulation. Available empirical and modeling estimates of bioaccumulation of dicofol in aquatic organisms are described below.

3.3.1. Estimated BCF values

In order to estimate BCF values for aquatic organisms accumulating dicofol, KABAM was run, using a K_{ow} of 1.15 x 10^6 ($\log(K_{ow})$ = 6.06) to represent the partitioning of dicofol to aquatic organisms. It was assumed that the concentration of dissolved oxygen in water was 10 mg/L (near saturation) and the water temperature was 20°C. The body characteristics of organisms in the model trophic levels are depicted in Table 14. The resulting BCF values for these trophic levels are depicted in Table 15. Output files from KABAM are provided in **Appendix G**.

Table 14. Characteristics of model aquatic organisms used to derive BCF values.

Trophic Level	Wet Weight (kg)	% lipids	% Non-lipid organic matter	% Water
phytoplankton	N/A	2.0%	8.0%	90.0%
zooplankton	1.0E-07	3.0%	12.0%	85.0%
benthic invertebrates	1.0E-04	3.0%	21.0%	76.0%
filter feeders	1.0E-03	2.0%	13.0%	85.0%
small fish	1.0E-02	4.0%	23.0%	73.0%
medium fish	1.0E-01	4.0%	23.0%	73.0%
large fish	1.0E+00	4.0%	23.0%	73.0%

Table 15. Estimated BCF values for parent dicofol in aquatic organisms.

Trophic Level	Total BCF (µg/kg-ww)/(µg/L)
Phytoplankton	55,112
Zooplankton	39,268
Benthic Invertebrates	42,884
Filter Feeders	28,188
Small Fish	55,170
Medium Fish	55,170
Large Fish	55,170

3.3.2. Empirical BCF data

In a 28-day laboratory BCF study with bluegill sunfish (*Lepomis macrochirus*) exposed to *p,p'*-dicofol, a BCF of 10,000 was observed in whole fish. In this study, steady state was not reached. The estimated steady-state BCF for dicofol was 25,000, which is within a factor of 2.2 of the estimated BCF for fish (Table 15). In this study, parent dicofol represented >94% of the radioactivity measured after the 28-day exposure, suggesting that metabolism of dicofol was minimal. FW-152 and OH-DCBH were detected in tissue samples, each comprising as much as 4.7% of the overall radioactivity measured at the time (MRID 265330).

In an early life stage test with the aquatic invertebrate, *Hyalella azteca* and the fathead minnow (*Pimephales promelas*), mean 28-day BCF values of 10,000 (±3000) and 3,700

(±800), respectively, were observed (GS0021-017). As the duration of this study was insufficient to allow the test organisms to reach steady-state, it is expected that if the duration had been extended, observed BCF values would have increased.

In a full life cycle test with the fathead minnow, the highest observed BCF value was 43,000, which was observed in F_0 females after 296 days of exposure to dicofol (MRID 42628901). This value is within a factor of 1.3 of estimated BCF value for fish (*i.e.*, 55,000).

3.3.3. Bioaccumulation modeling

KABAM was run in default mode (see user's guide for full description), with a Log Kow = 6.06, a K_{OC} = 7060 L/kg-oc (see Table 10) and surface water and pore water EECs of 0.26 and 0.066 μg/L, respectively. These PRZM/EXAMS-generated EECs are based on the average of yearly average concentrations of dicofol parent from ULV dicofol applications to strawberries. These EECs were selected because they represent the highest annual EECs predicted for any use of dicofol and result in the highest predicted accumulation of dicofol in tissues of aquatic organisms. The average water temperature (13^{o}C) for this scenario was used to simulate the water temperature of the abiotic compartment of KABAM. It was assumed that metabolism of dicofol by aquatic organisms did not occur. This assumption is supported by the available BCF study with *p,p'*-dicofol, where parent dicofol represented >94% of the radioactivity measured after the 28-day exposure and metabolism was minimal (MRID 265330). The resulting concentrations of dicofol in tissues of aquatic organisms are provided in Table 16. Output files from KABAM are provided in **Appendix G**. These values are used to derive RQs based on dose-based and dietary-based exposures of aquatic-phase CRLF to dicofol through consumption of contaminated aquatic prey (See section 5.1).

Table 16. Concentrations of dicofol parent in tissues of aquatic organisms (estimated using KABAM).

Trophic level	Total concentration (μg/kg-ww)
Phytoplankton	10,559
Zooplankton	11,838
Benthic Invertebrates	15,191
Filter Feeders	10,301
Small Fish	39,027
Medium Fish	82,949
Large Fish	290,605

KABAM's predictions of bioaccumulation in aquatic systems are most sensitive to the K_{ow} value of the assessed pesticide, with accumulation increasing as the K_{ow} increases. No empirical data were available to define the K_{ow} values of dicofol's residues of concern, so EPISuite v.4.0 was used to estimate K_{ow} values for the 4 degradates of concern (Table 17). Review of the estimated K_{ow} values of dicofol's residues of concern indicates that dicofol transforms to residues that have lower K_{ow} values, and thus lower accumulation potential in aquatic organisms. KABAM was used to estimate the bioaccumulation of dicofol's total residues of concern, by considering PRZM/EXAMS generated aquatic EECs for total residues and the Log K_{ow} values of dicofol's degradates of concern. KABAM was run again in default mode (see user's guide for full description), with Log Kow = 3.96, 4.0, 4.44, 4.89, and 6.06 (measured), to represent the partitioning of OH-DCBP, DCBH, DCBP, FW-152 and dicofol, respectively in aquatic organisms. A K_{oc} = 7060 L/kg-oc (see Table 10) and surface water and pore water EECs of 41 and 17 μg/L, respectively. These EECs are based on the average of yearly average concentrations of dicofol parent derived from ULV applications of dicofol to strawberries, as modeled using PRZM/EXAMS. As discussed earlier, these EECs were selected because they represent the highest annual EECs predicted for any use of dicofol and result in the highest predicted accumulation of dicofol in tissues of aquatic organisms. The resulting concentrations of dicofol in tissues of aquatic organisms are provided in Table 18. Output files from KABAM are provided in **Appendix G**. In reality, dicofol and its residues of concern would be subject to uptake by aquatic organisms. Therefore, the overall bioaccumulation of dicofol's total residues would be a mixture of dicofol and its 4 residues and would therefore fall between the tissue residue concentrations estimated for OH-DCBP and dicofol that are provided in Table 18.

Table 17. Estimated Log Kow values of dicofol's residues of concern.

Chemical	Log K_{ow}*
Dicofol	5.81
DCBP	4.44
FW-152	4.89
DCBH	4.00
OH-DCBP	3.96

*Estimated using EPISuite v.4.0.

Table 18. Concentrations of dicofol total residues of concern in tissues of aquatic organisms (μg/kg-ww; estimated using KABAM). Concentrations were estimated using Log Kow values representative of the different dicofol residues of concern.

Trophic level	Log Kow = 3.96 (OH-DCBP)	Log Kow = 4.00 (DCBH)	Log Kow = 4.44 (DCBP)	Log Kow = 4.89 (FW-152)	Log Kow = 6.06 (dicofol)
Phytoplankton	1.7E+04	1.9E+04	5.2E+04	1.5E+05	1.7E+06
Zooplankton	1.3E+04	1.4E+04	3.9E+04	1.1E+05	1.9E+06
Benthic Invertebrates	1.4E+04	1.5E+04	4.2E+04	1.2E+05	2.4E+06
Filter Feeders	9.0E+03	9.9E+03	2.7E+04	7.9E+04	1.6E+06
Small Fish	1.8E+04	2.0E+04	5.5E+04	1.7E+05	6.2E+06
Medium Fish	1.8E+04	2.0E+04	5.8E+04	1.9E+05	1.3E+07
Large Fish	1.9E+04	2.1E+04	6.4E+04	2.4E+05	4.6E+07

3.4. Terrestrial Animal Exposure Assessment

3.4.1. Modeling Approach

T-REX (Version 1.4.1) is used to calculate dietary and dose-based EECs of dicofol 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.

Terrestrial EECs for dicofol were derived for the uses and corresponding application rates summarized in Table 19. According to dicofol labels, only 1 application of dicofol is allowed per year on any one field, so only 1 application per year was modeled for each use. One foliar dissipation half-life value specific to dicofol (6 days based on application to alfalfa in CA) is available in Willis and McDowell (1987). Because a single half-life value is insufficient to derive a foliar dissipation half-life specific to dicofol, the EFED default foliar dissipation half-life of 35 days is used based on the work of Willis and McDowell (1987). This value falls within the range of observed dissipation half-lives for dicofol measured in 3 studies (9-61 days, see section 3.4.1 below). The maximum application rate for each use is modeled in T-REX and upper bound EECs are used for RQ calculations. An example output from T-REX is available in **Appendix H**.

Table 19. Input parameters to T-REX used to generate dicofol EECs for terrestrial animals.

Use	Application Rate (lbs a.i./A)
Citrus,[1] Pome Fruits[2]	3
Strawberries, Walnuts (English/black), Pecans	2
Beans, cotton, Stone Fruits[3]	1.5
Grapes, mint[4]	1.25
Hops	1.165
Peppers, Tomatoes	0.75
Cucurbits[5]	0.625
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.5
Bermuda grass	0.4

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers

For modeling purposes, exposures of the CRLF, as well as other frog species serving as prey to the CRLF, to dicofol 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 20).

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

Table 21.

Table 20. Upper-bound Kenega Nomogram EECs for Dietary- and Dose-based Exposures of the CRLF and its Prey to Single Applications of dicofol for Current Uses in California.

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
Citrus,[1] Pome Fruits[2]	405	461	720	686
Strawberries, Walnuts (English/black), Pecans	270	308	480	458
Beans, cotton, Stone Fruits[3]	203	231	360	343
Grapes, mint[4]	168	192	300	286
Hops	157	179	281	267
Peppers, Tomatoes	101	115	180	172
Cucurbits[5]	84.4	96.1	150	143
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	67.5	76.9	120	114
Bermuda grass	54.0	61.5	96.0	91.5

1 grapefruit, lemons, oranges, tangelos, and tangerines
2 apples and pears
3 apricots, cherries, nectarines, peaches, plums, and prunes
4 mint, peppermint and spearmint
5 cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
6 nurseries and flowers

Table 21. Dicofol EECs (ppm) for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items.

Use	Small Insect EEC	Large Insect EEC
Citrus,[1] Pome Fruits[2]	405	45.0
Strawberries, Walnuts (English/black), Pecans	270	30.0
Beans, cotton, Stone Fruits[3]	203	22.5
Grapes, mint[4]	169	18.8
Hops	157	17.5
Peppers, Tomatoes	101	11.3
Cucurbits[5]	84.4	9.38
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	67.5	7.50
Bermuda grass	54.0	6.00

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers

3.4.1. Field Studies

Comprehensive ecological monitoring studies of dicofol residues were conducted for three years in California cotton fields (1990-92; MRIDs 41785102, 41857301, and 42285503), Florida citrus groves (1989-91; MRIDs 41785103, 41845605, 42091501, and 42437301), and New York apples orchards (1989-91; MRIDs 41845604, 42285501, and 42721301). Areas and crops selected had a previous history of heavy dicofol use and a high likelihood for exposure to non-target organisms. Application rates typified those most commonly used by the growers and not necessarily the maximum label rates.

Observed residue concentrations were variable and declined exponentially after application. The highest mean concentrations were typically found immediately following application on the treated area, usually on the treated crop foliage, except for the Florida citrus site. Residues of *p,p'*-dicofol on the non-crop area were typically 1 to 2 orders of magnitude below those found in the crop areas. In the crop areas, the highest mean concentration of *p,p'*-dicofol measured were 97 ppm for foliage (New York), 78 ppm on grass (Florida) and 0.56 ppm for soil (New York). The highest mean concentration of *p,p'*-dicofol measured in the abiotic matrices for the non-crop area were 9.7 ppm for grass (Florida), 5.9 ppm on foliage (Florida), and 0.1 ppm for soil (California and Florida). Foliage residues in the crop areas declined from 3-year means of 92, 97 and 74 ppm immediately after application, to 0.05, 16 and 24 ppm 90 days later for cotton, orchards, and citrus, respectively. Foliage residues in non-crop areas declined from 3-year means of 0.6, 5.2, and 5.9 ppm immediately after application to 0.09, 0.9, and 0.55 ppm after 90 days for cotton, orchards, and citrus, respectively. Mean grass residues declined from 0.47, 5.1, and 9.7 ppm immediately after application, to 0.04, 0.08, and 0.54 ppm 90 days later for cotton, orchards, and citrus, respectively.

Residues of *p,p'*-dicofol were detected in the foliage of crops and dissipated with a half-life ranging of 9, 41, and 61 days for cotton, orchard, and citrus foliage respectively. Grass residues declined from 3-year means of 48 and 78 ppm immediately after application, to 0.15 and 2.3 ppm 90 days later for orchards and citrus, respectively. Dissipation half-lives of *p,p'*-dicofol on orchard and citrus grass were 12 and 21 days, respectively. The observed foliar dissipation half-lives for dicofol are comparable to the 35-day default value used to represent the foliar dissipation half-life of dicofol in the T-REX model.

3.5. Accumulation of Dicofol Residues on Soil

Because dicofol and its degradates are moderately persistent in soil (aerobic soil half-lives greater than 104 days) and do not have a tendency to leach from soil, a screening analysis was conducted to characterize the levels of dicofol in the soil of a treated site after 30 years of applications.

Ground application to pome fruits was selected for the screening analysis, as it was expected to result in highest soil concentrations of dicofol compared to any other use (based on the highest application rate and application efficiency). Aerial application to strawberries was selected for the screening analysis, as this scenario produced the highest levels of EECs in the aquatic exposure assessment. PRZM/EXAMS runs were conducted and total soil concentrations were estimated for the upper 10 cm soil horizon. As with the aquatic exposure assessment, both the *o,p'*- and *p,p'* isomers of dicofol were run separately and the results combined in a postprocessor. The 1-in-10-year peak concentrations in the soil for total dicofol were 11,952 and 7,770 mg/m^3 for pome fruits and strawberries, respectively. The 1-in-10- year peak concentrations in the pore water for total dicofol were 176 and 115 mg/m^3 for pome fruits and strawberries, respectively. Annual average peak dicofol soil concentrations increased for the first fifteen years of the simulation, then reached a plateau at an average annual peak concentration in the soil at 10,170 and 6,600 mg/m^3 for pome fruits and strawberries, respectively, and in the pore water at 150 and 98 mg/m^3 for pome fruits and strawberries, respectively (Figure 9 and Figure 10).

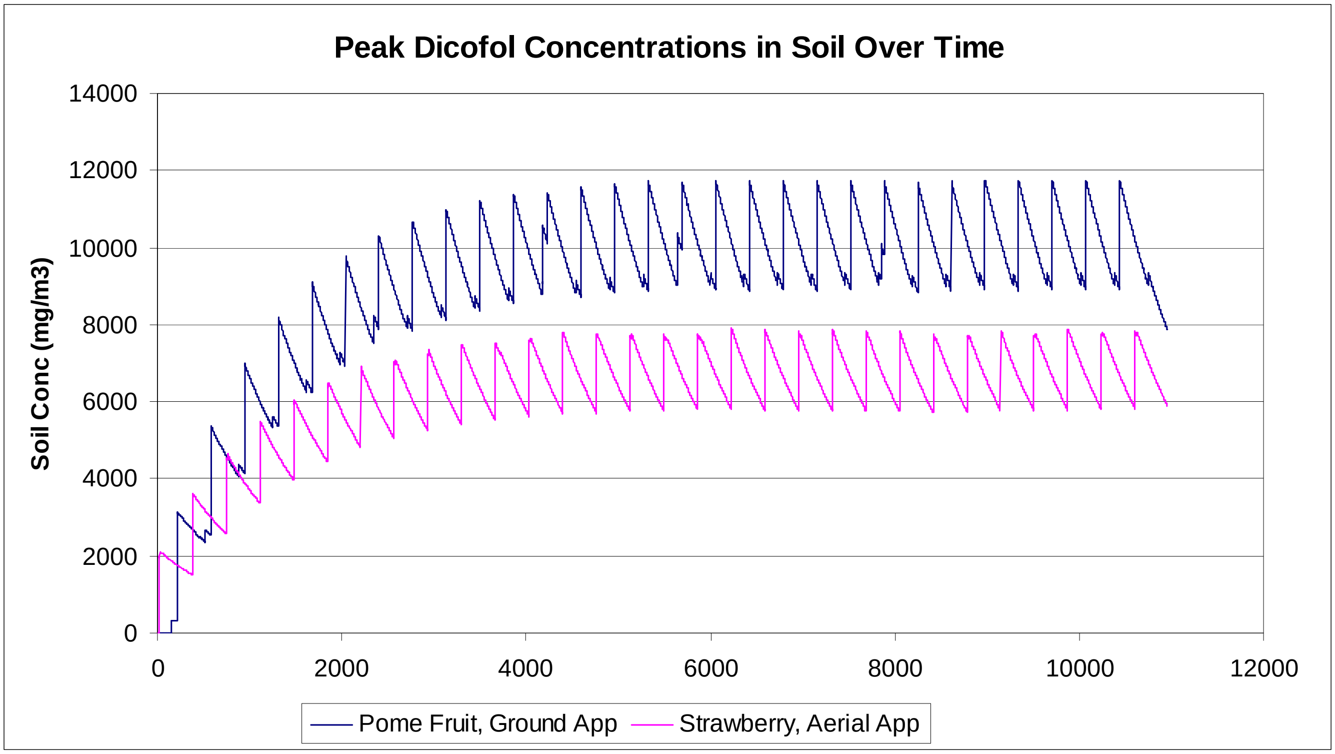


Figure 9. Concentration of total residues of dicofol in soil treated with dicofol for 30 years. X axis represents time in days. Soil modeled in PRZM using CA strawberries and CA fruit scenarios.

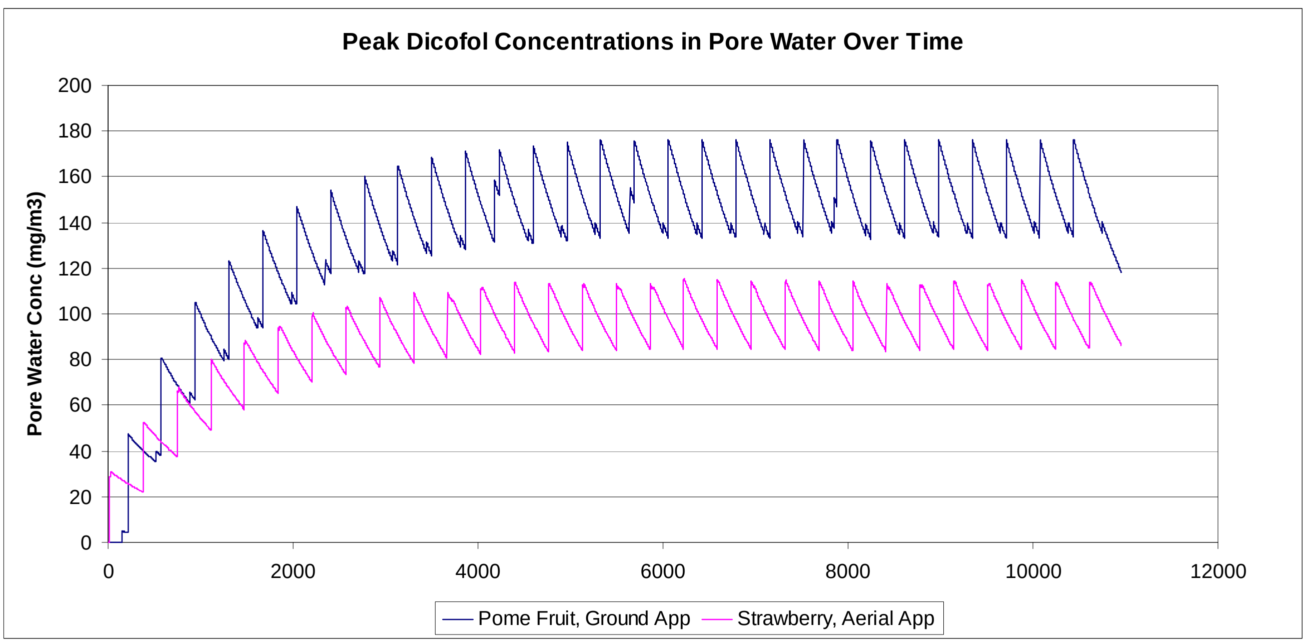


Figure 10. Concentration of total residues of dicofol in pore water of soil treated with dicofol for 30 years. X axis represents time in days. Soil modeled in PRZM using CA strawberries and CA fruit scenarios.

3.6. Terrestrial Bioaccumulation Assessment

The estimated octanol-air partition coefficient (K_{OA}) of 10^{10} (EPIsuite v.4.0) suggests that bioaccumulation of dicofol in air breathing organisms is possible (Kelly *et al*. 2007). At this time, modeling tools are unavailable to quantify the bioaccumulation of dicofol in terrestrial organisms. However, relevant monitoring studies involving dicofol have been conducted.

Comprehensive ecological monitoring studies of dicofol residues were conducted for three years in California cotton fields (1990-92; MRIDs 41785102, 41857301, and 42285503), Florida citrus groves (1989-91; (MRIDs 41785103, 41845605, 42091501, and 42437301), and New York apples orchards (1989-91; (MRIDs 41845604, 42285501, and 42721301). Areas and crops selected had a previous history of heavy dicofol use and a high likelihood for exposure to non-target organisms. Application rates typified those most commonly used by the growers and not necessarily the maximum label rates. Dicofol residues were monitored in soil, plant foliage, fish, mammals, reptiles, amphibians, earthworms, birds, and bird eggs.

In crop areas, the highest mean concentrations of *p,p'*-dicofol measured in the biotic matrices were 1.4 ppm for small mammals (Florida), 3.9 ppm for terrestrial invertebrates (California), and 3.8 ppm for reptiles/amphibians (Florida). In non-crop areas, highest mean concentrations were 0.3 ppm for small mammals (New York), 0.76 ppm for terrestrial invertebrates (Florida), 0.38 ppm for reptiles/amphibians (Florida), 0.9 ppm for birds (Florida), and 0.26 ppm for fish (Florida). Dicofol was found at a concentration of 1-2 ppm in earthworms in New York.

Eggs were collected from thirteen avian species and were analyzed for residues and eggshell thickness (MRIDs 41764801, 41764802, 41845601, 41845602, 41845603, 42285501, 42285505, and 42721302). These data were compared with the nesting success for these species. Yearly geometric mean *p,p'*-dicofol residues ranged from 0.0027 ppm (several species in California) to 0.46 ppm (American robin eggs in New York). Yearly means were highest in New York (0.01-0.46 ppm), and lowest in California (<LOD to 0.02 ppm). Yearly geometric means for *p,p'*-FW152 residues ranged from 0.002 ppm (mourning dove in California) to 0.218 ppm (eastern screech owl in Florida). Three year means exceeded 0.03 ppm only in eggs of the eastern screech owls in Florida and robins in New York (0.0947 ppm). Yearly geometric means for *p,p'*-DCBP residues ranged from 0.004 ppm (starling in California) to 0.1651 ppm (eastern screech owl in Florida). Three year means exceeded 0.03 ppm only in eggs of eastern screech owls in Florida and New York (0.1093 and 0.0648 ppm, respectively), New York robins (0.0374 ppm), and Florida mockingbirds (0.0431 ppm). Except for *p,p'*-FW152 concentrations in the eastern screech owl in Florida, geometric mean metabolite residue concentrations were generally lower than for *p,p'*-dicofol. None of the yearly geometric means for dicofol, *p,p'*-FW152, or *p,p'*-DCBP exceeded 0.5 ppm.

4.0 Effects Assessment

This assessment evaluates the potential for dicofol to directly or indirectly affect the CRLF or modify 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 effects to its habitat. In addition, potential effects to 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 dicofol.

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

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

- the toxic effects are related to single chemical exposure;[6]
- the toxic effects are on an aquatic or terrestrial plant or animal species;
- there is a biological effect on live, whole organisms;
- a concurrent environmental chemical concentration/dose or application rate is reported; and
- there is an explicit duration of exposure.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, maintenance of

[6] The studies that have information on mixtures are listed in the bibliography as rejected due to the presence of mixtures. These studies are evaluated by EFED when applicable to the assessment; however, the data is not used quantitatively in the assessment.

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 dicofol.

Toxicity data for dicofol available in the ECOTOX database on 10/31/08 were considered for this assessment. 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 I**. Appendix I 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 accepted ECOTOX open literature data, including the full suite of lethal and sublethal endpoints is presented in **Appendix J**. **Appendix K** includes a summary of the human health effects data for dicofol.

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 dicofol. A summary of the available incident information for dicofol is provided below.

It should be noted that where data were provided in study reports, sublethal effects observed during acute toxicity studies are described in this effects characterization. These sublethal effects raise concern about the effects of dicofol; however, it is not possible to quantitatively link these effects to the selected assessment endpoints for the listed CRLF (*i.e.*, survival, growth, and reproduction of individuals and maintenance of critical habitat PCEs). Therefore, potential sublethal effects on specific taxa are evaluated qualitatively. Definitive endpoints, such as LC_{50}s are used for quantifying RQs in this assessment.

4.1. Toxicity of dicofol to aquatic organisms

Table 22 summarizes the most sensitive aquatic toxicity endpoints for the CRLF, based on an evaluation of the available studies as previously discussed. Toxicity to aquatic fish and invertebrates is categorized using the system shown in Table 23 (U.S. EPA 2004).

Table 22. Freshwater toxicity profile for dicofol.

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Source (MRID)	Comment
Acute Direct Toxicity to Aquatic-Phase CRLF	*Oncorhynchus clarkii* (cutthroat trout)	LC_{50} = 53.0 µg/L	40098001	Slope not available
Chronic Direct Toxicity to Aquatic-Phase CRLF	*Oncorhynchus mykiss* (rainbow trout)	NOAEC = 4.4 µg a.i./L	42063001	LOAEC = 7.9 µg a.i./L based on decreased length
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Freshwater Invertebrates (*i.e.* prey items)	*Daphnia magna* (waterflea)	EC_{50} = 140 µg/L	40042057	Slope not available
Indirect Toxicity to Aquatic-Phase CRLF via Chronic Toxicity to Freshwater Invertebrates (*i.e.* prey items)	*Hyalella azteca* (amphipod)	NOAEC = 19 µg a.i./L	GS0021-016	28-day LOAEC = 33 µg a.i./L, based on decreased survival
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Non-vascular Aquatic Plants	*Scenedesmus acutus* (green alga)	EC_{50} > 5,000, <10,000 µg/L	Krishnakumari 1977	Effects to biomass and growth observed
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Vascular Aquatic Plants	No data are available to quantify an endpoint to represent effects of dicofol exposures to vascular plants.			

Table 23. Categories of acute toxicity for aquatic organisms.

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

4.1.1. Toxicity of Dicofol to Freshwater Fish

Given that dicofol toxicity data are not available for aquatic-phase amphibians, freshwater fish data are used as a surrogate to estimate direct acute and chronic risks to the CRLF. Freshwater fish toxicity data are also used to assess potential indirect effects of dicofol to the CRLF. Effects to freshwater fish resulting from exposure to dicofol 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).

Available acute toxicity data for freshwater fish exposed to dicofol include 96-h LC_{50} values ranging 53-603 µg /L (Table 24). Therefore, dicofol is classified (Table 23) as very highly to highly toxic to freshwater fish on an acute exposure basis. The most sensitive freshwater species tested is cutthroat trout, with a 96-hour LC_{50} value of 53 µg/L (MRID: 400980-01), is used for deriving risk quotients for the CRLF and fish serving as prey to the adult CRLF.

Table 24. Acute toxicity data (96-h LC_{50}) for freshwater fish exposed to dicofol.

Species (common name)	LC_{50} value (µg/L)	95% confidence interval (µg/L)	Slope	Source (MRID)
Oncorhynchus clarkii (cutthroat trout)	53.0	41-68	NA	40098001
O. clarkia (cutthroat trout)	158	100-250	NA	40098001
O. clarkii (cutthroat trout)	53.1	41.3-68.2	15.6	GS0021002
Salvelinus namaycush (lake trout)	86.9	53.1-142.0	NA	GS0021001
S. namaycush (lake trout)	87	53-142		40098001
O. mykiss (rainbow trout)	124.3	95.0-181.0	3.8	41695401
Ictalurus punctatus (channel catfish)	360	290-447	10.8	40098001
Micropterus salmoides (largemouth bass)	395	NA	NA	40098001
Pimephales promelas (fathead minnow)	509	492-533	12.2	GS0021018
Lepomis macrochirus (bluegill sunfish)	510	420-640	10.3	GS0021004
Lepomis macrochirus (bluegill sunfish)	520	421-642	NA	40098001
Pimephales promelas (fathead minnow)	603	577-631	NA	ECOTOX # 12859

NA = not available

Several chronic studies are available where freshwater fish were exposed to dicofol (Table 25). Available chronic studies for rainbow trout (*Oncorhynchus mykiss*) and fathead minnows (*Pimephales promelas*) are described below. From these studies, the most sensitive chronic endpoint, based on decreased growth, is a 95-day NOAEC value of 4.4 µg/L (MRID: 42063001). This value is used for deriving risk quotients for the CRLF and fish serving as prey to the adult CRLF.

Table 25. Chronic toxicity data for freshwater fish exposed to dicofol.

Species (common name)	Duration of Study (days)	NOAEC (µg/L)	LOAEC (µg /L)	Observed Effects	Source (MRID)
Oncorhynchus mykiss (rainbow trout)	95	4.4	7.9	Decreased length	42063001
Oncorhynchus mykiss (rainbow trout)	99	4.6	9.1	Decreased length	43383902
Pimephales promelas (fathead minnow)	296	4.52	8.82	Impacted reproduction	42628901
Pimephales promelas (fathead minnow)	28	19	39	Decreased survival and growth	GS0021-016

In an early life stage test with rainbow trout, growth (length) was significantly reduced (4.8% compared to controls) in fish (at 35-days post-hatch) exposed to concentrations of 7.9 (±1.0) µg a.i./L. The resulting NOAEC for this study was 4.4 µg a.i./L (MRIDs

42063001). In an additional early life stage test conducted with rainbow trout resulted in reduced growth (length was decreased 4.8% compared to controls) of fish (36-day old) exposed to 9.1 µg a.i./L dicofol. The resulting NOAEC for this study was 4.6 µg a.i./L (MRID 43383902).

In an early life stage test with fathead minnows, survival and growth were significantly decreased in fish exposed to concentrations of 39 (±6.3) µg a.i./L for 28 days. The resulting NOAEC for this study was 19 (±3.8) µg a.i./L (GS0021-016). In a full life cycle study (296 days) with the fathead minnow, mean hatching success of the F_1 generation was significantly decreased at 8.82 µg a.i./L treatment compared to controls (13% decrease). Also, significant effects to reproduction were observed in the F_0 generation exposed to 8.82 µg a.i./L, including decreased number of eggs/pair, decreased number of spawns per mating pair and decreased number of reproductive days per mating pair. The resulting NOAEC for this study was 4.52 µg a.i./L (MRID 42628901).

4.1.2. Toxicity of Dicofol to Freshwater Invertebrates

Dicofol is classified highly toxic to freshwater invertebrates, based on an acute toxicity study with *Daphnia magna* (MRID 40042057), where an EC_{50} of 140 µg/L was observed.

Chronic toxicity data are available for the amphipod, *Hyalella azteca*. The NOAEC for this study was 19 (±2.2) µg a.i./L, based on a decrease in survival (70% mortality, compared to 0% in controls) in animals exposed to 33 (±2.2) µg a.i./L for 28 days (GS0021-016).

4.1.3. Toxicity of Dicofol to Aquatic Plants

Data are available from the scientific literature involving exposures of dicofol to the green alga, *Scenedesmus acutus*. Based on observed decreases in biomass and growth rates, the EC_{50} is estimated to lie between 5,000 and 10,000 µg/L (Krishnakumari 1977).

No data are available involving exposures of aquatic vascular plants to dicofol.

4.2. Toxicity of Dicofol's Degradates to Aquatic Organisms

4.2.1. Toxicity of Dicofol's Degradates to Aquatic Animals

Empirical data are not available for exposure of aquatic animals to dicofol's major degradates (DCBP, FW-152, DCBH, OH-DCBP and CBA). In order to characterize the relative toxicity of dicofol and its major degradates, ECOSAR v. 1.0 (USEPA 2009) was run to estimate acute LC_{50} and chronic toxicity values for fish and aquatic invertebrates. ECOSAR predicted acute and chronic values for the parent and degradates are not used quantitatively in this risk assessment (*i.e.*, to derive RQ values for the degradates), but rather to compare the relative toxicitites of dicofol and its major environmental degradates. ECOSAR estimates of acute and chronic toxicity for fish and daphnids indicate that DCBP, FW-152, DCBH and OH-DCBP are similar (*i.e.*, estimated LC_{50} and chronic values are within an order of magnitude) to that of dicofol. ECOSAR estimates indicate that CBA may be of lesser toxicity than dicofol, with estimated LC_{50} and chronic values for CBA being several orders of magnitude greater than dicofol (Table 26).

Table 26. Estimated acute and chronic toxicity values (µg/L) for fish and daphnids exposed to dicofol and its degradates (as calculated by ECOSAR).

Chemical	Fish 96-h LC_{50}	Fish chronic value	Daphnid 48-h LC_{50}	Daphnid chronic value
Dicofol[1]	274	9	8	21
DCBP[2]	1391	171	1124	192
FW-152[1]	1027	40	50	79
DCBH[1]	3037	139	242	231
OH-DCBP[3]	1472	8	1088	206
CBA[2]	844098	88987	488560	58244

[1]Benzyl alcohol class
[2]Neutral organic class
[3]Phenols class

Ninety-six hour LC_{50} values for fish exposed to dicofol range 53-603 µg/L. The ECOSAR estimated value of 274 µg/L falls within this range. The ECOSAR estimated chronic value of 9 µg /L also falls within the range of available NOAECs 4.4-19 µg/L for fish exposed to dicofol. For aquatic invertebrates, the ECOSAR estimated acute value is 2 orders of magnitude lower than the available empirical EC_{50} value (48-h EC_{50} = 140 µg/L).

In this risk assessment, the total residues of concern for aquatic environments are defined as: dicofol, DCBP, FW-152, DCBH and OH-DCBP. Because the estimated acute and chronic toxicity of CBA is several orders of magnitude less than that of dicofol and the other degradates, CBA is not considered to be a degradate of concern. It is assumed in this assessment that for aquatic animals, total residues are of equal toxicity compared to the parent. The acute toxicity data used to represent the toxicity of the total residues of dicofol to aquatic animals are selected based on the most sensitive values available for dicofol exposures. Chronic toxicity data available for exposures of freshwater fish and invertebrates exposed to dicofol are also used to represent the chronic toxicity of the total residues to these organisms.

4.2.2. Toxicity of Dicofol's Degradates to Aquatic Plants

Data are available from the scientific literature involving separate exposures of DCBP and DCBH to the green alga, *Chlorella vulgaris*. At concentrations of 1000 µg/L, decreases in chlorophyll a and biomass were not observed compared to controls. At 10,000 µg/L, decreases in chlorophyll a and biomass were observed (Subba-Rao and Alexander 1980).

No data are available involving exposures of aquatic vascular plants to dicofol's major degradates.

4.3. Toxicity of dicofol to terrestrial organisms

Table 27 summarizes the most sensitive terrestrial toxicity endpoints for the CRLF, based on an evaluation of registrant submitted studies and the scientific literature. Acute toxicity to terrestrial animals is categorized using the classification system shown in Table 28 (U.S. EPA 2004). Toxicity categories for terrestrial plants have not been defined.

Table 27. Terrestrial toxicity profile for dicofol.

Endpoint	Species	Toxicity Value Used in Risk Assessment	Source (MRID)	Comment
Acute Direct Toxicity to Terrestrial-Phase CRLF	Ring-necked pheasant (*Phasianus colchicus*)	LD_{50} = 265 mg a.i./kg bw	160000	Average body weight of 1135 g for this species from Dunning 1984 used in T-REX. Slope data are not available.
Subacute Direct Toxicity to Terrestrial-Phase CRLF	Japanese quail (*Coturnix japonica*)	LC_{50} = 905 ppm	ECOTOX# 35240	Available slope is 5.92
Chronic Direct Toxicity to Terrestrial-Phase CRLF	American kestrel (*Falco sparverius*)	NOAEC = 1 ppm	41934001	LOAEC = 3 ppm based on 8% decrease in egg shell thickness. Body weight for this species is 0.100 kg from Dunning 1984.
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to mammalian prey items)	Laboratory rat (*Rattus norvegicus*)	LD_{50} = 587 mg/kg-bw	40731204	No slope is available.
Indirect Toxicity to Terrestrial-Phase CRLF (via chronic toxicity to mammalian prey items)	Laboratory rat	NOAEC = 5 ppm (0.4 mg/kg/day)	41606601	LOAEC = 25 ppm; based on parental systemic and reproductive effects.
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to terrestrial invertebrate prey items)	Honey bee (*Apis mellifera*)	LD_{50}>50 µg a.i./bee	05001991	LD_{50} is equivalent to >391 µg a.i./g of bee
Indirect Toxicity to Terrestrial- and Aquatic-Phase CRLF (via toxicity to terrestrial plants)	No data are available to quantify this endpoint			

Table 28. Categories of acute toxicity for avian and mammalian studies.

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

4.3.1. Toxicity of Dicofol to Birds

An acute oral toxicity study with ring-necked pheasant (*Phasianus colchicus*) established an LD_{50} of 265 (211-334) mg ai/kg bw (MRID 160000). This indicates that dicofol is moderately toxic to avian species on an acute oral exposure basis.

Available subacute dietary toxicity data for birds exposed to dicofol include 8-day LC_{50} values ranging 905-3010 ppm (Table 29). Therefore, dicofol is classified (Table 28) as moderately to slightly toxic to birds on a subacute dietary exposure basis. Data are available for 4 species of birds exposed to dicofol. The most sensitive species is the Japanese quail (*Coturnix japonica*), with an LC_{50} value of 905 ppm (ECOTOX # 35240). This value is used for deriving risk quotients for the CRLF and frogs serving as prey to the adult CRLF.

Table 29. Subacute dietary toxicity data (LC_{50}) for birds exposed to dicofol.

Species (common name)	LC_{50} value (ppm)	95% confidence interval (µppm)	Initial age of test birds (days)	Slope	Source
Coturnix japonica (Japanese quail)	905	723-1140	1	5.92	ECOTOX# 35240
C. japonica (Japanese quail)	1237	979-1578	7	4.89	GS0021010
C. japonica (Japanese quail)	1418	1232-1628	12	4.13	00022923
C. japonica (Japanese quail)	1545	1360-1739	14	7.95	GS0021011
Anas platyrhynchos (mallard duck)	1651	1356-2029	10	5.64	00022923
C. japonica (Japanese quail)	1746	1377-2255	21	5.37	GS0021012
Phasianus colchicus (ring-necked pheasant)	2126	1892-2387	16	7.38	00022923
Colinus virginianus (bobwhite quail)	3010	2635-3424	15	4.31	00022923

Several chronic studies are available where birds were exposed to dicofol (Table 30). Available chronic studies included data on American kestrel (*Falco sparverius*), eastern screech owls (*Otus asio*), ring doves (*Streptopelia risoria)*, mallard ducks (*Anas platyrhynchos*) and northern bobwhite quail (*Colinus virginianus*). From these studies, the most sensitive chronic toxicity endpoint is a NOAEC of 1 ppm based on reproductive effects to the American kestrel. This value is based on a LOAEC where effects to egg shells were observed. There is some uncertainty in relying upon observed effects to egg shells to represent effects to reproduction of the CRLF, since the CRLF does not produce eggs with hardened shells. However, observed effects in bird eggs caused by parental exposures to dicofol could result in other effects to amphibian eggs that are unrelated to egg shell thickness but do affect the composition of the egg coatings that regulate osmotic balance in eggs. In addition, effects to other endpoints that directly relate to amphibians, including decreased numbers of eggs laid and feminization of male chicks were observed at 40 ppm. In the two studies where these effects were observed in birds, a NOAEC was not established, *i.e*., effects were measured at all levels tested. Therefore the available 1 ppm NOAEC is used for deriving risk quotients for the CRLF and terrestrial frogs (*e.g.*, the Pacific tree frog) serving as prey to the adult CRLF. Another consideration is that dicofol produces similar effects in birds as DDT/DDE. This endpoint has clear population level effects as demonstrated with bald eagles exposed to DDT.

Table 30. Chronic toxicity data for birds exposed to dicofol.

Species (common name)	NOAEC (ppm)	LOAEC (ppm)	Observed Effects	Source
Falco sparverius (American kestrel)	1	3	Decreased egg shell thickness (8%)	MRID 41934001
Otus asio (eastern screech owls)	none	7.2	Decreased shell weight (11.7-13.5%) and thickness (7.6-11%) of eggs	Wienmeyer *et al.* 1989
Anas platyrhynchos (mallard duck)	10	40	Increased number of cracked eggs (12%)	MRID 41231301
Streptopelia risoria (ring dove)	none	40	Decreased egg-shell thickness and egg production, increased number of cracked eggs (11.2%)	Schwarzbach *et al.* 1988
Falco sparverius (American kestrel)	None	40	Decreased number of eggs laid, increase in eggs lost, potential feminization of male chicks	MacLellan et al. 1996
Anas platyrhynchos (mallard duck)	10	none	none	GS0021-014
Colinus virginianus (northern bobwhite quail)	120	none	none	MRID 40042055

In a reproduction study with the American kestrel, eggshells were thinned by 8% in parent birds fed 3 ppm technical dicofol for up to 175 days. Shell weight was also reduced by 9% at concentrations as low as 10 ppm. The resulting NOAEC for the study was 1 ppm (MRID 41934001). In a second study with captive American kestrels, paired females were given daily oral doses of 0, 5 and 20 mg/kg-bw of dicofol. This study was conducted over 2 generations. Female birds in the first generation treated with 20 mg/kg-bw produced eggs with significantly reduced shell thickness (10.98%) compared to controls. Female birds in the second generation treated with 5 mg/kg-bw had an increase in number of eggs lost and a decrease in total number of eggs laid compared to controls. Female birds of the first and second generation treated with 5 mg/kg-bw produced male offspring with abnormal gonads. Histological examination of male gonads indicated a thickened cortex and a significant increase in primordial germ cells present in male offspring of females treated with 5 mg/kg-bw. The authors suggested that this histological evidence indicated feminization of male offspring (MacLellan *et al.* 1996). As 5 mg/kg-bw was the lowest treatment level, a NOAEL could be established for this study. On a dietary exposure basis, a dose of 5 mg/kg-bw/day is approximately equivalent to 40 mg/kg-diet/day[7].

In a reproduction study with eastern screech owls, birds were exposed to 7.2 ppm dicofol in feed. At this concentration, shell weight was reduced on average by 12-14% compared to controls. Also, egg shell thickness was reduced by 8-11% on average, compared to controls. Since only one treatment group was involved in this study, a NOAEC could not be determined (Wienmeyer *et al.* 1989).

Ring doves were exposed to 40 ppm dicofol in a reproductive study. Observed effects at this level included significant reductions in egg shell thickness (9% less than to controls), increased numbers of cracked eggs (14.3 more than controls), and decreased egg production (13% less than controls). In addition, 14.3% of clutches produced by the treated group contained only single eggs, as compared to 1.8% of clutches produced by the control group (Schwartzbach *et al.* 1988).

In a reproduction study with mallard ducks exposed to technical grade dicofol, egg shell strength was significantly reduced (12% increase in number of cracked eggs compared to controls) at 40 ppm, resulting in a NOAEC of 10 ppm. No other effects were observed during this study (MRID 41231301). In another reproductive study with mallard ducks, birds treated with 5 ppm and 10 ppm showed no significant effects to reproduction compared to controls. Effects considered in this study included number of eggs laid, eggs cracked, eggs embryonated, survival of embryos and hatchling survival. Egg shell thickness data were not reported (GS0021-014).

In a reproduction study with northern bobwhite quail exposed to technical grade dicofol, no significant effects to reproduction were observed relative to controls. Effects considered in this study included eggs laid, eggs cracked, egg shell thickness, eggs set, viable embryos, survival of embryos and hatchling survival. The highest treatment level of this study was 120 ppm (MRID 40042055).

[7] The available dose-based value (5 mg/kg-bw) is multiplied by the body weight (BW) of the bird (0.111 kg, from Dunning 1984) and then divided by the food intake rate. The food intake rate (FI, in kg/day), is calculated according to: $FI = 0.0582 * BW^{0.651}$ $(USEPA\ 1993)$.

4.3.2. Toxicity of Dicofol to Mammals

Available acute toxicity data for the laboratory rat indicates that dicofol is slightly toxic to mammals on an acute oral exposure basis (LD_{50}=587 mg/kg, MRID 40731204).

In a two-generation reproduction study, groups of laboratory rats (25/sex/group) were fed diets containing dicofol (93.3%) at dose levels of 0, 5, 25, 125 or 250 ppm (equivalent to 0.4, 1.9, 9.5, or 18.9 mg/kg-bw/day for males and 0.4, 2.1, 10.5, or 20.5 mg/kg-bw/day for females, respectively). For parental systemic toxicity, the NOAEC was 5 ppm (0.4 mg/kg-bw/day) and the LOAEC was 25 ppm (1.9/2.1 mg/kg-bw/day for M/F) based upon histopathological changes in P and F_1 livers (hypertrophy of centrilobular hepatocytes with associated vacuolation) and F_1 ovaries (increased vacuolation). For reproductive toxicity, the NOAEC was 5 ppm (0.4 mg/kg-bw/day) and the LOAEC was 25 ppm (1.9/2.1 mg/kg-bw/day in M/F), based on the ovarian vacuolation in the F_1 females, which was judged to be an effect on reproductive physiology. For offspring toxicity, the NOAEC could be defined at 25 ppm (1.9/2.1 mg/kg-bw/day for M/F) and the LOAEC at 125 ppm (9.5/10.5 mg/kg-bw/day for M/F), based on decreased F_2 pup viability (increased numbers of stillborn pups, postnatal day 0-4 pup deaths, and total litter loss) (MRID 41606601).

Additional chronic toxicity data for mammals (rats and mice) exposed to dicofol were available in ECOTOX. However, all reported data corresponded to higher NOAEC values than that used in this assessment (*i.e.*, NOAEC = 5 ppm (0.4 mg/kg/day); MRID 41606601). Therefore, these data were not considered further for this assessment.

4.3.3. Toxicity of Dicofol to Terrestrial Invertebrates

Dicofol is classified as practically nontoxic to honey bees (*Apis mellifera*) on an acute contact exposure basis (LD_{50}>50 µg a.i./bee; MRID 05001991). An acute oral LD_{50} for bees has also been reported as >10 µg a.i./bee (MRID 05001991). In a study where a 1% solution of a formulated product containing 18.5% dicofol was applied directly to honey bee hives through saw cuts in the frame, no abnormal mortality was observed in worker bees (MRID 05009244).

For the purpose of this assessment, the acute contact honey bee endpoint is used to represent effects to terrestrial invertebrates. This toxicity value is converted to units of µg a.i./g (of bee) by multiplying by 1 bee/0.128 g resulting in an LD_{50} >391 µg a.i./g.

4.3.4. Toxicity of Dicofol to Terrestrial Plants

There are no data are available to quantify an endpoint to represent effects of dicofol exposures to vascular plants. However, there are several studies available in the scientific literature to qualitatively describe effects of dicofol on vascular plants.

In a study involving 15 types of ornamental plants, dicofol applied as a spray resulted in phytotoxicity to begonias. No effects were observed to the other 14 ornamental plants included in the test, including antirrhinum, asters, carnation, chrysanthemum, cineraria, coleus, cyclamen, dahlia, geranium, petunia, polyanthus, ,saintpaulia, violets and zinnia (Dennis and Edwards 1963).

When neanthe bella palm (*Chamaedorea elegans*) was exposed to dicofol, phytotoxicity was observed. Dicofol applied to 6 other species of plants did not cause phytotoxicity (Knauss 1971).

In a study involving the papaya (*Carica papaya*), 0.125% of a formulation including dicofol affected plant growth and resulted in leaf burn (Sherman and Sanchez 1968).

4.4. Toxicity of dicofol degradates to terrestrial organisms

There are no data available from registrant-submitted studies or in the scientific literature to evaluate the potential toxicity of dicofol degradates to terrestrial organisms. In addition, there are no models or tools available to estimate the toxicity of dicofol or its degradates to terrestrial organisms.

4.5. Incident Database Review for Dicofol

A search of the EIIS (Environmental Incident Information System) database for ecological incidents (run on February 24, 2009) identified 1 incident associated with the use of dicofol. This incident involved plant damage to 10 acres of oranges treated directly with dicofol and chlorpyrifos. The incident occurred in June of 2000 in Tulare County of California. The certainty (likelihood) that the observed plant damage was associated with exposure to dicofol was considered possible. The legality of the use was undetermined (Incident # I013563-010).

In 1980, a wastewater pond maintained by the Tower Chemical Company (TCC) overflowed into an onsite drainage ditch which flowed downstream into the Gourd Neck of Lake Apopka. Lake Apopka is the fourth largest freshwater lake (12,500 ha) in the state of Florida and has been designated as one of Florida's most polluted. From 1957 to 1981, TCC manufactured and stored various pesticides, used primarily in the citrus industry, and discharged process wastewater into the unlined wastewater pond. This discharge included dicofol, as much as 15% of DDT and its metabolites (DDD, DDE, and chloro-DDT), and sulfuric acid. Studies subsequent to the upset showed a dramatic decline in the American alligator population during the 1980s that continued into the mid to late 1990s (Guillette *et al.* 1994).

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 dicofol in CA. The risk characterization provides an estimation (Section 5.1) and a description (Section 5.2) of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of adverse effects to the CRLF or its designated critical habitat (*i.e.*, 'no effect,' 'likely to adversely affect,' or 'may affect, but not likely to adversely affect').

5.1. Risk Estimation

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

Risks to the aquatic-phase CRLF and its prey are estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended dicofol usage scenarios summarized in Section 2.4.4 and the appropriate aquatic toxicity endpoint from Section 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 dicofol (Table 20 and

Table 21) and the appropriate toxicity endpoint from Section 4.4.

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 of total dicofol residues 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 of total dicofol residues (including dicofol, DCBP, FW-152, DCBH, and OH-DCBP) and the lowest chronic toxicity value for freshwater fish are used.

Acute and chronic RQs for the aquatic-phase CRLF resulting from aerial, ground and ULV applications of dicofol are provided in Table 31, Table 32, and Table 33 respectively. For exposures involving dicofol and its degradates of concern, RQs for all uses of dicofol exceed the acute listed species LOC (0.05), with the exception of dicofol use on Bermuda grass and outside buildings. RQs for chronic exposures to the CRLF resulting from all uses exceed the LOC (1.0) for all uses, except Bermuda grass, turf and outside buildings. Although RQs for aerial applications are higher than those for ground applications, for all uses of dicofol that have both ground and aerial applications, both sets of RQs exceed levels of concern for the aquatic-phase CRLF.

Table 31. Acute and chronic RQs for aquatic-phase CRLF resulting from AERIAL applications of dicofol. EECs are based on parent and degradates of concern.

Use	Peak EEC (µg/L)	60-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	17.77	15.47	**0.34**[3]	**3.5**[4]
Citrus	17.50	13.29	**0.33**[3]	**3.0**[4]
Cotton	18.02	16.27	**0.34**[3]	**3.7**[4]
Cucurbit	6.32	5.37	**0.12**[3]	**1.2**[4]
Grape	13.15	11.17	**0.25**[3]	**2.5**[4]
Hops	19.67	17.50	**0.37**[3]	**4.0**[4]
Mint	16.47	14.56	**0.31**[3]	**3.3**[4]
Pepper	8.91	7.74	**0.17**[3]	**1.8**[4]
Pome Fruit	20.73	16.26	**0.39**[3]	**3.7**[4]
Stone Fruit	9.97	7.76	**0.19**[3]	**1.8**[4]
Strawberry	37.39	33.41	**0.71**[3]	**7.6**[4]
Tomato	6.30	5.16	**0.12**[3]	**1.2**[4]
Walnut/Pecan	20.77	18.06	**0.39**[3]	**4.1**[4]

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
[2]Based on NOAEC = 4.4 µg/L for rainbow trout
[3] Exceeds acute risk to endangered species level of concern (RQ>0.05)
[4] Exceeds chronic risk level of concern (RQ>1.0)

Table 32. Acute and chronic RQs for aquatic-phase CRLF resulting from GROUND applications of dicofol. EECs are based on parent and degradates of concern.

Use	Peak EEC (µg/L)	60-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	15.87	14.27	**0.30**[3]	**3.2**[4]
Citrus	12.99	10.53	**0.25**[3]	**2.4**[4]
Cotton	16.01	14.99	**0.30**[3]	**3.4**[4]
Cucurbit	5.52	4.77	**0.10**[3]	**1.1**[4]
Grape	11.31	10.07	**0.21**[3]	**2.3**[4]
Hops	18.35	16.69	**0.35**[3]	**3.8**[4]
Mint	15.14	13.50	**0.29**[3]	**3.1**[4]
Pepper	8.23	7.43	**0.16**[3]	**1.7**[4]
Pome Fruit	15.40	12.25	**0.29**[3]	**2.8**[4]
Stone Fruit	7.60	6.05	**0.14**[3]	**1.4**[4]
Strawberry	36.36	32.15	**0.69**[3]	**7.3**[4]
Tomato	5.22	4.41	**0.10**[3]	**1.0**[4]
Walnut/Pecan	17.94	16.02	**0.34**[3]	**3.6**[4]
Bermuda grass	2.31	1.93	0.044	0.44
Ornamentals	6.09	5.25	**0.11**[3]	**1.2**[4]
Turf/Sod Farm	2.88	2.40	**0.054**[3]	0.55
Outside Buildings	0.354	0.248	0.0067	0.056

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
[2]Based on NOAEC = 4.4 µg/L for rainbow trout
[3] Exceeds acute risk to endangered species level of concern (RQ>0.05)
[4] Exceeds chronic risk level of concern (RQ>1.0)

Table 33. Acute and chronic RQs for aquatic-phase CRLF resulting from ULV applications of dicofol. EECs are based on parent and degradates of concern.

Use	Peak EEC (µg/L)	60-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	31.80	25.26	**0.60**[3]	**5.7**[4]
Citrus	45.13	33.29	**0.85**[3]	**7.6**[4]
Cotton	31.57	25.23	**0.60**[3]	**5.7**[4]
Cucurbit	12.14	9.41	**0.23**[3]	**2.1**[4]
Grape	25.28	19.80	**0.48**[3]	**4.5**[4]
Hops	29.66	24.58	**0.56**[3]	**5.6**[4]
Mint	28.76	23.28	**0.54**[3]	**5.3**[4]
Pepper	15.88	12.61	**0.30**[3]	**2.9**[4]
Pome Fruit	48.90	36.56	**0.92**[3]	**8.3**[4]
Stone Fruit	23.78	17.68	**0.45**[3]	**4.0**[4]
Strawberry	51.32	43.81	**0.97**[3]	**10**[4]
Tomato	13.70	10.35	**0.26**[3]	**2.4**[4]
Walnut/Pecan	40.15	31.59	**0.76**[3]	**7.2**[4]

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
[2]Based on NOAEC = 4.4 µg/L for rainbow trout
[3] Exceeds acute risk to endangered species level of concern (RQ>0.05)
[4] Exceeds chronic risk level of concern (RQ>1.0)

As discussed above in section 3.3, dicofol has the potential to accumulate in tissues of aquatic organisms. Since aquatic-phase CRLF consume algae, aquatic invertebrates and fish, CRLF could be exposed to dicofol accumulated in the tissues of these prey. In order to define the risks of aquatic-phase CRLF consuming phytoplankton (algae), benthic invertebrates and fish, KABAM was used to derive RQ values for small (1.4 g), medium (37 g) and large (238 g) aquatic-phase CRLF. Body weight assumptions are consistent with those incorporated into T-HERPS. Diet assumptions assigned to each of these size classes are provided in Table 34. The resulting RQ values for the CRLF are provided in Table 35. RQ values for all size classes exceed the LOC for acute-dose based and chronic, dietary-based exposures to the CRLF ingesting dicofol through consumption of contaminated aquatic prey (that have accumulated dicofol).

Table 34. Diet assumptions of small, medium and large aquatic-phase CRLF used in KABAM.

Trophic level in diet	Diet for:					
	small CRLF 1	small CRLF 2	med CRLF 1	med CRLF 2	large CRLF 1	large CRLF 2
phytoplankton	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
zooplankton	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
benthic invertebrates	0.0%	100.0%	100.0%	0.0%	100.0%	0.0%
filter feeders	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
small fish	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
medium fish	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
large fish	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 35. Acute and chronic RQs for aquatic-phase CRLF exposed to dicofol (parent) through consumption of aquatic organisms which have accumulated dicofol.

Size Classes of CRLF	Acute, Dose Based RQ[1]	Acute, Dietary Based RQ[2]	Chronic, Dietary Based RQ[3]
small CRLF 1	**0.63**[4]	0.012	**11**[5]
small CRLF 2	**0.38**[4]	0.017	**15**[5]
med CRLF 1	0.073	0.017	**15**[5]
med CRLF 2	**0.17**[4]	0.043	**39**[5]
large CRLF 1	0.029	0.017	**15**[5]
large CRLF 2	**0.14**[4]	**0.092**[4]	**83**[5]

[1] Based on LD_{50} = 265 mg/kg-bw (for ring-necked pheasant)
[2] Based on LC_{50} = 903 ppm (for Japanese quail)
[3] Based on NOAEC = 1 ppm (for American kestrel)
[4] Exceeds acute risk to endangered species level of concern (RQ>0.1)
[5] Exceeds chronic risk level of concern (RQ>1.0)

5.1.1.2. Indirect Effects to Aquatic-Phase CRLF through effects to prey

Indirect effects of dicofol 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. RQ values generated using EECs representing total residues of dicofol (Table 12) are less than 0.01 for all uses, which is below the LOC (1.0) for non-vascular aquatic plants.

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on peak EECs of total dicofol residues in the standard pond and the lowest acute toxicity value for freshwater invertebrates. For chronic risks, 21-day EECs of total dicofol residues and the lowest chronic toxicity value for invertebrates are used to derive RQs.

Acute and chronic RQs for the aquatic invertebrates resulting from aerial, ground and ULV applications of dicofol are provided in Table 36, Table 37, and Table 38 respectively. RQs for all uses of dicofol exceed the acute listed species LOC (0.05) for aquatic invertebrates, with the exception of dicofol use on Bermuda grass, ornamentals, turf and outside buildings. RQs for chronic exposures to the CRLF from all uses of dicofol exceed LOC (1.0), except cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings.

Table 36. Acute and chronic RQs for aquatic invertebrates resulting from AERIAL applications of dicofol. EECs are based on parent and degradates of concern.

Use	Peak EEC (µg/L)	21-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	17.77	16.16	**0.13**[3]	0.85
Citrus	17.50	14.40	**0.12**[3]	0.76
Cotton	18.02	16.81	**0.13**[3]	0.88
Cucurbit	6.32	5.63	0.045	0.30
Grape	13.15	11.78	**0.09**[3]	0.62
Hops	19.67	18.51	**0.14**[3]	0.97
Mint	16.47	15.58	**0.12**[3]	0.82
Pepper	8.91	8.09	**0.064**[3]	0.43
Pome Fruit	20.73	17.51	**0.15**[3]	0.92
Stone Fruit	9.97	8.37	**0.071**[3]	0.44
Strawberry	37.39	34.68	**0.27**[3]	**1.8**[4]
Tomato	6.30	5.49	0.045	0.29
Walnut/Pecan	20.77	18.80	**0.15**[3]	0.99

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid
[2]Based on NOAEC = 19 µg/L for amphipod
[3] Exceeds acute risk to endangered species level of concern (RQ>0.05)
[4] Exceeds chronic risk level of concern (RQ>1.0)

Table 37. Acute and chronic RQs for aquatic invertebrates resulting from GROUND applications of dicofol. EECs are based on parent and degradates of concern.

Use	Peak EEC (µg/L)	21-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	15.87	14.69	**0.11**[3]	0.77
Citrus	12.99	10.87	**0.093**[3]	0.57
Cotton	16.01	15.36	**0.11**[3]	0.81
Cucurbit	5.52	4.98	0.04	0.26
Grape	11.31	10.39	**0.081**[3]	0.55
Hops	18.35	17.45	**0.13**[3]	0.92
Mint	15.14	14.22	**0.11**[3]	0.75
Pepper	8.23	7.66	**0.059**[3]	0.40
Pome Fruit	15.40	13.13	**0.11**[3]	0.69
Stone Fruit	7.60	6.48	**0.054**[3]	0.34
Strawberry	36.36	33.38	**0.26**[3]	**1.8**[4]
Tomato	5.22	4.65	0.037	0.24
Walnut/Pecan	17.94	16.52	**0.13**[3]	0.87
Bermuda grass	2.31	2.02	0.016	0.11
Ornamentals	6.09	5.51	0.044	0.29
Turf/Sod Farm	2.88	2.52	0.021	0.13
Outside Buildings	0.354	0.281	0.0025	0.015

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid
[2]Based on NOAEC = 19 µg/L for amphipod.
[3] Exceeds acute risk to endangered species level of concern (RQ>0.05)
[4] Exceeds chronic risk level of concern (RQ>1.0)

Table 38. Acute and chronic RQs for aquatic invertebrates resulting from ULV applications of dicofol. EECs are based on parent and degradates of concern.

Use	Peak EEC (µg/L)	21-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	31.80	27.04	**0.23**[3]	**1.4**[4]
Citrus	45.13	36.41	**0.32**[3]	**1.9**[4]
Cotton	31.57	27.01	**0.23**[3]	**1.4**[4]
Cucurbit	12.14	10.18	**0.087**[3]	0.54
Grape	25.28	21.29	**0.18**[3]	**1.1**[4]
Hops	29.66	25.90	**0.21**[3]	**1.4**[4]
Mint	28.76	24.71	**0.21**[3]	**1.3**[4]
Pepper	15.88	13.49	**0.11**[3]	0.71
Pome Fruit	48.90	39.92	**0.35**[3]	**2.1**[4]
Stone Fruit	23.78	19.38	**0.17**[3]	**1.0**[4]
Strawberry	51.32	45.31	**0.37**[3]	**2.4**[4]
Tomato	13.70	11.27	**0.10**[3]	0.59
Walnut/Pecan	40.15	33.92	**0.29**[3]	**1.8**[4]

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid
[2]Based on NOAEC = 19 µg/L for amphipod
[3] Exceeds acute risk to endangered species level of concern (RQ>0.05)
[4] Exceeds chronic risk level of concern (RQ>1.0)

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 31 and Table 32) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. As noted above, exposures involving dicofol and its degradates of concern (DCBP, FW-152, DCBH, and OH-DCBP), RQs for all uses of dicofol exceed the acute listed species LOC (0.05), with the exception of dicofol use on Bermuda grass and outside buildings. RQs for chronic exposures to the CRLF resulting from all uses exceed the LOC (1.0) for all uses, except Bermuda grass, turf and outside buildings.

5.1.1.3. Indirect Effects to Aquatic-Phase CRLF through effects to habitat

Indirect effects to the CRLF via direct toxicity to aquatic plants are estimated using the most sensitive non-vascular and vascular plant toxicity endpoints. RQ values generated for non-vascular plants using EECs representing total residues of dicofol (Table 12) are less than 0.01 for all uses, which is below the LOC of 1.0 for non-vascular aquatic plants. Since no data are available to quantify the effects of dicofol to vascular aquatic plants, RQ values for vascular aquatic plants cannot be derived.

5.1.2. Exposures in the Terrestrial Habitat

5.1.2.1. Direct Effects to Terrestrial-Phase CRLF

Potential direct acute risks 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 20) and acute oral and subacute dietary toxicity endpoints for avian species. Potential direct chronic risks of dicofol to the terrestrial-phase CRLF are derived by considering dietary-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates and the lowest available chronic toxicity data for birds. EECs are divided by toxicity values to estimate chronic dietary-based RQs. Acute dose-based RQs (Table 39) exceed the LOC (0.1) for all uses of dicofol, with RQs exceeding the LOC by factors ranging between 4.3 to 32X. Acute dietary-based RQs exceed the LOC (0.1) for most uses, with the exception of use on cucurbits, ornamentals, turf and Bermuda grass. Chronic dietary-based RQs exceed the LOC (1.0) for all uses of dicofol, by factors ranging 54 to 405X (Table 39).

Table 39. Acute and chronic, dietary-based RQs and dose-based RQs for direct effects of dicofol to the terrestrial-phase CRLF. RQs calculated using T-REX.

Use	**Acute, Dose-based**[7]	**Acute, Dietary-based**[8]	**Chronic, Dietary-based**[9]
Citrus,[1] Pome Fruits[2]	**3.2**[10]	**0.45**[10]	**405**[11]
Strawberries, Walnuts (English/black), Pecans	**2.13**[10]	**0.30**[10]	**270**[11]
Beans, cotton, Stone Fruits[3]	**1.59**[10]	**0.22**[10]	**203**[11]
Grapes, mint[4]	**1.33**[10]	**0.19**[10]	**169**[11]
Hops	**1.24**[10]	**0.17**[10]	**157**[11]
Peppers, Tomatoes	**0.80**[10]	**0.11**[10]	**101**[11]
Cucurbits[5]	**0.66**[10]	0.09	**84**[11]
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	**0.53**[10]	0.07	**67**[11]
Bermuda grass	**0.43**[10]	0.06	**54**[11]

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on LD_{50} = 265 mg/kg-bw (for ring-necked pheasant)
[8] Based on LC_{50} = 903 ppm (for Japanese quail)
[9] Based on NOAEC = 1 ppm (for American kestrel)
[10] Exceeds acute risk to endangered species level of concern (RQ>0.1)
[11] Exceeds chronic risk level of concern (RQ>1.0)

5.1.2.2. Indirect Effects to Terrestrial-Phase CRLF through Effects to Prey

In order to assess the risks of dicofol applications to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the honey bee is used as a surrogate for terrestrial invertebrates. EECs (µg a.i./g of bee) calculated by T-REX for small and large insects are divided by the calculated toxicity value (LD_{50}) for terrestrial invertebrates, which is >391 µg a.i./g of bee. The resulting RQ values for large insect and small insect exposures bound the potential range of exposures for terrestrial insects to dicofol. Since the acute contact toxicity estimate is indeterminate, *i.e.*, the LD_{50} value exceeds the highest dose tested (LD_{50}>50µg/bee) the resulting toxicity value for terrestrial invertebrate is also indeterminate (LD_{50}>391 µg a.i./g of bee). As such, RQ values based on these indeterminate values are expressed as less than (<) values. For small insect exposures, RQ values range <1.04 to <0.138. For large insect exposures, RQ values range <0.115 to <0.0153. For all uses of dicofol, RQ values potentially exceed the acute risk LOC (RQ≥0.05) for terrestrial insects.

As described above, to assess risks of dicofol to prey (small mammals) of larger terrestrial-phase CRLF, dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass are used. Acute and chronic effects are estimated using the most sensitive acute (rat LD_{50}=587 mg/kg-bw) and chronic (rate NOAEC 5 mg/kg diet; 0.4 mg/kg-bw/day) mammalian toxicity data. EECs are divided by the toxicity values to estimate acute and chronic dietary-based RQs as well as acute dose-based RQs. Acute dose-based RQ values exceed the listed species acute risk LOC (RQ>0.1) for the majority of dicofol uses. Across all uses, chronic dose-based and dietary-based RQs exceed the chronic risk LOC (RQ>1.0) (Table 40).

An additional prey item of the adult 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. These are the same EECs, toxicity values and RQs used to assess direct effects to the CRLF. Acute dose-based RQs exceed the LOC (0.1) for all uses of dicofol, with RQs exceeding the LOC by factors ranging between 4.3 to 32X. Acute dietary-based RQs exceeded the LOC (0.1) for most uses, with the exception of use on cucurbits, ornamentals, turf and Bermuda grass. Chronic dietary-based RQs exceed the LOC (1.0) for all uses of dicofol, by factors ranging 54 to 405X (Table 39).

Table 40. RQs for determining indirect effects to the terrestrial-phase CRLF through effects to potential prey items, specifically small terrestrial mammals consuming short grass.

Use	Acute, dose-based[7]	Chronic, dose-based[8]	Chronic, dietary-based[9]
Citrus,[1] Pome Fruits[2]	**0.53[10]**	**781[11]**	**144[11]**
Strawberries, Walnuts (English/black), Pecans	**0.35[10]**	**521[11]**	**96[11]**
Beans, cotton, Stone Fruits[3]	**0.27[10]**	**390[11]**	**72[11]**
Grapes, mint[4]	**0.22[10]**	**325[11]**	**60[11]**
Hops	**0.21[10]**	**303[11]**	**55[11]**
Peppers, Tomatoes	**0.13[10]**	**195[11]**	**36[11]**
Cucurbits[5]	**0.11[10]**	**163[11]**	**30[11]**
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.09	**130[11]**	**24[11]**
Bermuda grass	0.07	**104[11]**	**19[11]**

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on LD_{50} for laboratory rat = 587 mg/kg.
[8] Based on chronic NOAEL for laboratory rat = 0.4 mg/kg-bw.
[9] Based on chronic NOAEC for laboratory rat = 5 ppm.
[10] Exceeds acute risk to endangered species level of concern (RQ>0.1)
[11] Exceeds chronic risk level of concern (RQ>1.0)

5.1.2.3. Indirect Effects to Terrestrial-Phase CRLF through Effects to Habitat (plants)

Indirect effects to the CRLF via direct toxicity to terrestrial plants are estimated using the most sensitive plant toxicity endpoints. Since no data are available to quantify the effects of dicofol to terrestrial plants, these RQ values cannot be derived and risk is presumed.

5.1.3. Primary Constituent Elements of Designated Critical Habitat

For dicofol use, the assessment endpoints for designated critical habitat PCEs involve a reduction and/or modification of food sources necessary for normal growth and viability of aquatic-phase CRLFs, and/or a reduction and/or modification of food sources for terrestrial-phase juveniles and adults. Because these endpoints are also being assessed relative to the potential for indirect effects to aquatic- and terrestrial-phase CRLF, the effects determinations for indirect effects from the potential loss of food items are used as the basis of the effects determination for potential effects to designated critical habitat.

5.1.3.1. Aquatic-Phase

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 a lack of data to quantify potential effects of dicofol to aquatic and terrestrial plants, it is assumed that dicofol may affect aquatic-phase PCEs of designated habitat related to effects on aquatic and/or terrestrial plants. This assumption will be refined later in the risk description of this assessment.

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 dicofol on this PCE (*i.e.*, alteration of food sources), acute and chronic freshwater fish and invertebrate toxicity endpoints, as well endpoints for aquatic non-vascular plants, are used as measures of effects. RQs for these endpoints were calculated in Section 5.1.1. Based on LOC exceedances for acute and chronic exposures of fish and aquatic invertebrates to total residues of dicofol, use of dicofol 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

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

Based on a lack of data to quantify potential effects of dicofol to terrestrial plants, it is assumed that dicofol may affect terrestrial-phase PCEs of designated habitat related to effects on terrestrial plants. This assumption will be refined later in the risk description of this assessment.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of dicofol 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. Based on LOC exceedances for acute and chronic exposures of frogs and mammals to dicofol, use of dicofol may affect terrestrial-phase PCEs of designated habitat related to "reduction and/or modification of food sources for terrestrial phase juveniles and adults."

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. Based on LOC exceedances for acute and chronic exposures of frogs to dicofol, use of dicofol may affect terrestrial-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.

5.2. 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.

The direct and indirect effect LOCs are exceeded and dicofol may affect the PCEs of the CRLF's critical habitat. Therefore, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding dicofol. A summary of the risk estimation results are provided in Table 41 for direct and indirect effects to the CRLF and in Table 42 for the PCEs of designated critical habitat for the CRLF.

Table 41. Risk estimation summary for dicofol - direct and indirect effects to the CRLF.

Assessment Endpoint	LOC Exceedances?	Description of Results of Risk Estimation
Aquatic-Phase CRLF (eggs, larvae, tadpoles, juveniles, and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	Yes	Acute RQs exceed the LOC for exposures of aquatic-phase CRLF resulting from all uses of dicofol, except applications to outside buildings. Chronic RQs exceed the LOC for exposures of aquatic-phase CRLF resulting from all uses of dicofol, except use on Bermuda grass, turf and outside buildings. Acute and chronic RQs for aquatic-phase CRLF consuming aquatic organisms contaminated with dicofol (resulting from accumulation) exceed LOCs.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants)	yes	RQ values for algae are below the LOC for all uses. Acute RQs exceed the LOC for exposures of aquatic invertebrates resulting from the majority of dicofol uses, except Bermuda grass, ornamentals, turf and applications to outside buildings. Chronic RQs exceed the LOC for exposures of aquatic invertebrates resulting from the majority of dicofol uses, except cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and applications to outside buildings. Acute RQs for all uses of dicofol modeled, except applications to outside buildings exceed the LOC for exposures of fish and aquatic-phase amphibians resulting. Chronic RQs exceed the LOC for exposures of fish and aquatic-phase amphibians resulting from all uses of dicofol, except use on Bermuda grass, turf and outside buildings.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	Undetermined	RQ values for algae are below the LOC for all uses. No data are available to derive RQs representative of the effects of dicofol on vascular plants.
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	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular plants.

Assessment Endpoint	LOC Exceedances?	Description of Results of Risk Estimation
range.		
Terrestrial-Phase CRLF (Juveniles and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Yes	Acute and chronic RQs exceed the LOC for terrestrial-phase CRLF for all uses of dicofol.
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	For terrestrial invertebrates, RQs for all uses potentially exceed the LOC. Acute RQs for small terrestrial mammals exposed to dicofol exceed the LOC for all uses of dicofol, except ornamentals, turf, outside building surfaces and Bermuda grass. Chronic RQs for small terrestrial mammals exposed to dicofol exceed the LOC for all uses of dicofol. Acute and chronic RQs exceed the LOC for terrestrial-phase amphibians for all uses of dicofol.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat (*i.e.*, riparian vegetation)	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular plants.

Table 42. Risk estimation summary for dicofol – PCEs of designated critical habitat for the CRLF.

Assessment Endpoint	Habitat Effects?	Description of Results of Risk Estimation
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.	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular plants.
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.	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular plants.

Assessment Endpoint	Habitat Effects?	Description of Results of Risk Estimation
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Yes	Acute and chronic RQs for aquatic-phase CRLF consuming aquatic organisms contaminated with dicofol (resulting from accumulation) exceed LOCs. Acute RQs exceed the LOC for exposures of aquatic invertebrates resulting from the majority of dicofol uses, except Bermuda grass, ornamentals, turf and applications to outside buildings. Chronic RQs exceed the LOC for exposures of aquatic invertebrates resulting from the majority of dicofol uses, except cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and applications to outside buildings. Acute RQs exceed the LOC for exposures of fish and aquatic-phase amphibians resulting from all uses of dicofol, except applications to outside buildings. Chronic RQs exceed the LOC for exposures of fish and aquatic-phase amphibians resulting from all uses of dicofol, except use on Bermuda grass, turf and outside buildings.
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (e.g., algae)	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular plants.
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	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular 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	Undetermined	No data are available to derive RQs representative of the effects of dicofol on vascular plants.
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Yes	For terrestrial invertebrates, RQs for all uses potentially exceed the LOC. Acute RQs for small terrestrial mammals exposed to dicofol exceed the LOC for all uses of dicofol, except ornamentals, turf, outside building surfaces

Assessment Endpoint	Habitat Effects?	Description of Results of Risk Estimation
		and Bermuda grass. Chronic RQs for small terrestrial mammals exposed to dicofol exceed the LOC for all uses of dicofol. Acute and chronic RQs exceed the LOC for terrestrial-phase amphibians for all uses of dicofol.
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Yes	Acute and chronic RQs exceed the LOC for terrestrial-phase CRLF for all uses of dicofol. For terrestrial invertebrates, RQs for all uses potentially exceed the LOC. Acute RQs for small terrestrial mammals exposed to dicofol exceed the LOC for all uses of dicofol, except ornamentals, turf, outside building surfaces and Bermuda grass. Chronic RQs for small terrestrial mammals exposed to dicofol exceed the LOC for all uses of dicofol. Acute and chronic RQs exceed the LOC for terrestrial-phase amphibians for all uses of dicofol.

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 below.

5.2.1. Direct Effects

5.2.1.1. Aquatic-Phase CRLF

As discussed in the risk estimation section, RQs for all uses of dicofol, except Bermuda grass and outside buildings exceed LOCs for aquatic-phase CRLFs exposed to total residues of dicofol. Therefore, the determination for use of dicofol on Bermuda grass and outside buildings is ‘no effect’ for direct effects of total residues of dicofol to the aquatic-phase CRLF. The determination for all other uses of dicofol is ‘may effect’ for direct effects of total residues of dicofol to the aquatic-phase CRLF.

Based on an analysis of the likelihood of individual mortality considering the range of acute RQs exceeding the LOC for aquatic-phase CRLFs (0.054-0.97), and using the probit dose-response of 4.5 (default assumption), the chance of mortality to CRLF range from 1 in $1.7x10^{8}$ individuals to 1 in 2 individuals (Table 43). This indicates that aquatic-phase CRLF could potentially be affected by acute exposures to dicofol. An example output calculating the analysis of the likelihood of individual mortality is provided in **Appendix M**.

Table 43. Acute RQs and for aquatic-phase CRLF resulting from applications of dicofol. EECs are based on parent and degradates of concern.

Use	ULV application		Aerial application		Ground application	
	Acute RQ[1]	Chance of individual mortality (1 in…)	Acute RQ[1]	Chance of individual mortality (1 in…)	Acute RQ[1]	Chance of individual mortality (1 in…)
Beans	0.60	6	0.34	57	0.30	107
Citrus	0.85	3	0.33	66	0.25	297
Cotton	0.60	6	0.34	57	0.30	107
Cucurbit	0.23	491	0.12	58,519	0.10	294,319
Grape	0.48	13	0.25	297	0.21	84
Hops	0.56	8	0.37	38	0.35	50
Mint	0.54	9	0.31	91	0.29	129
Pepper	0.30	107	0.17	3,744	0.16	5853
Pome Fruit	0.92	2	0.39	30	0.29	129
Stone Fruit	0.45	17	0.19	1,706	0.14	16,417
Strawberry	0.97	2	0.71	4	0.69	4
Tomato	0.26	236	0.12	58,519	0.10	294,319
Walnut/Pecan	0.76	3	0.39	30	0.34	57
Bermuda grass	NA	NA	NA	NA	0.044	1.94×10^{9}
Ornamentals	NA	NA	NA	NA	0.11	124,594
Turf/Sod Farm	NA	NA	NA	NA	0.054	1.71×10^{8}
Outside Buildings	NA	NA	NA	NA	0.0067	1.52×10^{22}

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
NA = not applicable

Chronic RQs for the majority of dicofol uses (all except Bermuda grass, turf and outside buildings) exceed the LOC (1.0) by factors of 1.1X to 10X, depending upon the use and application method (Table 31-Table 33). EECs are sufficient to exceed the LOAEC (7.9 µg/L, based on growth effects) for the majority of dicofol uses, with the exception of Bermuda grass, ornamentals, turf and outside buildings.

Exposures of aquatic-phase CRLF are to dicofol are quantified in terms of total residues of dicofol. RQs are derived using the most sensitive toxicity data available for fish exposed to dicofol. It is assumed that dicofol's degradates of concern (*i.e.*, DCBP, FW-152, DCBH and OH-DCBP) are equivalent to dicofol in toxicity to the aquatic-phase CRLF. This assumption adds uncertainty to the risk assessment as the actual toxicity of dicofol's degradates to the CRLF is unknown. If exposures involving parent dicofol alone are considered, resulting acute RQs for the aquatic-phase CRLF exceed the listed species LOC (0.05) for all uses of dicofol, except Bermuda grass ornamentals, turf and outside buildings (Table 44 - Table 46). Therefore, acute exposures to parent dicofol alone are sufficient to be of concern for mortality to the aquatic-phase CRLF. RQs for chronic exposures of the CRLF to parent dicofol alone do not exceed the LOC (1.0).

Table 44. Acute and chronic RQs for aquatic-phase CRLF resulting from AERIAL applications of dicofol. EECs are based on parent dicofol only.

Crop	Peak EEC (µg/L)	60-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	3.25	0.18	**0.061[3]**	0.040
Citrus	6.46	0.42	**0.12[3]**	0.095
Cotton	3.48	0.29	**0.066[3]**	0.066
Cucurbit	1.34	0.07	0.025	0.016
Grape	2.70	0.15	**0.051[3]**	0.033
Hops	2.52	0.16	0.048	0.037
Mint	2.70	0.15	**0.051[3]**	0.035
Pepper	1.61	0.09	0.030	0.020
Pome Fruit	6.46	0.34	**0.12[3]**	0.077
Stone Fruit	3.25	0.17	**0.061[3]**	0.040
Strawberry	6.41	0.93	**0.12[3]**	0.21
Tomato	1.61	0.09	0.030	0.020
Walnut/Pecan Aerial	4.41	0.29	**0.083[3]**	0.065

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
[2]Based on NOAEC = 4.4 µg/L for rainbow trout
[3] Exceeds acute risk to endangered species LOC (RQ>0.05)

Table 45. Acute and chronic RQs for aquatic-phase CRLF resulting from GROUND applications of dicofol. EECs are based on dicofol only.

Crop	Peak EEC (µg/L)	60-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	2.26	0.12	0.043	0.028
Citrus	4.47	0.32	**0.084[3]**	0.072
Cotton	2.49	0.25	0.047	0.056
Cucurbit	0.93	0.05	0.018	0.011
Grape	1.87	0.10	0.035	0.023
Hops	1.74	0.12	0.033	0.028
Mint	1.87	0.11	0.035	0.025
Pepper	1.12	0.06	0.021	0.014
Pome Fruit	4.47	0.24	**0.084[3]**	0.053
Stone Fruit	2.25	0.12	0.042	0.028
Strawberry	6.34	0.89	**0.12[3]**	0.20
Tomato	1.12	0.06	0.021	0.014
Walnut/Pecan	3.09	0.22	**0.058[3]**	0.050
Bermudagrass	0.60	0.04	0.011	0.0095
Ornamentals	1.78	0.18	0.034	0.041
Turf/Sod Farm	0.75	0.05	0.014	0.012
Outside Buidlings	0.152	0.010	0.0029	0.0023

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
[2]Based on NOAEC = 4.4 µg/L for rainbow trout
[3] Exceeds acute risk to endangered species LOC (RQ>0.05)

Table 46. Acute and chronic RQs for aquatic-phase CRLF resulting from ULV applications of dicofol. EECs are based on parent dicofol only.

Crop	Peak EEC (µg/L)	60-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	9.75	0.52	**0.18**[3]	0.12
Citrus	18.02	1.03	**0.34**[3]	0.23
Cotton	9.92	0.60	**0.19**[3]	0.14
Cucurbit	4.04	0.21	**0.076**[3]	0.048
Grape	8.08	0.43	**0.15**[3]	0.10
Hops	7.56	0.43	**0.14**[3]	0.10
Mint	8.07	0.44	**0.15**[3]	0.10
Pepper	4.85	0.26	**0.091**[3]	0.059
Pome Fruit	18.02	0.94	**0.34**[3]	0.21
Stone Fruit	9.08	0.48	**0.17**[3]	0.11
Strawberry	13.17	1.23	**0.25**[3]	0.28
Tomato	4.85	0.25	**0.091**[3]	0.058
Walnut/Pecan	13.02	0.72	**0.25**[3]	0.16

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
[2]Based on NOAEC = 4.4 µg/L for rainbow trout
[3] Exceeds acute risk to endangered species LOC (RQ>0.05)

Aquatic EECs account for direct toxicity to the CRLF through contact with dicofol present in the water column. Given the high Log Kow of dicofol (>6) and its degradates of concern (>4), dicofol and its residues of concern are expected to partition to aquatic organisms. Therefore, the aquatic-phase CRLF can also be exposed to dicofol and its residues through consumption of contaminated prey items. Acute and chronic RQ values generated using KABAM (Table 35) are above LOCs, indicating that exposure of aquatic-phase CRLF to dicofol through consumption of aquatic organisms which have accumulated dicofol is of concern for the CRLF.

Based on the above information, for all uses of dicofol, except Bermuda grass and outside buildings, the effects determination for direct effects to the aquatic-phase CRLF is "LAA" based on potential acute mortality and chronic growth effects. The determination for use of dicofol on Bermuda grass and outside buildings is "no effect" for direct effects of total residues of dicofol to the aquatic-phase CRLF.

5.2.1.2. Terrestrial-Phase CRLF

T-REX calculated acute dose-based RQs, acute dietary-based RQs and chronic dietary-based RQs exceed their respective LOCs, resulting in a "may affect" determination for all uses. In order to explore influences of amphibian-specific food intake equations on potential dose-based and dietary-based exposures of the terrestrial-phase CRLF to dicofol, T-HERPS is used. Modeling with T-HERPS incorporates the same application rates, intervals and number of applications for each use as defined for modeling using T-REX (Table 19). Since applications of dicofol for all uses result in exposures sufficient to exceed the LOC for direct effects to the terrestrial-phase CRLF, the T-HERPS model was used to estimate EECs and subsequent risks to the terrestrial-phase CRLF based on amphibian-specific equations. These refined EECs and RQs were used to distinguish

"NLAA" and "LAA" determinations. An example output from T-HERPS is available in **Appendix N**.

RQs are calculated for the terrestrial-phase CRLF on the basis of dose and diet. It should be noted that although dietary-based RQ values are considerably lower than dose-based RQ values, the former do not take into account that different-sized animals consume differing amounts of food and that depending on the forage item, an animal has to consume varying amounts due to differing nutrition levels in the food item. If dietary-based RQ values are adjusted to account for differential food consumption, the adjusted RQ value would likely approximate the dose-based RQ value.

Acute exposures

Refined dose-based RQs for small sized (1.4 g) CRLF consuming insects do not exceed the acute listed species LOC (0.1) for dicofol (Table 47).

Table 47. Refined dose-based RQs[7] for 1.4 g CRLF consuming different food items. EECs calculated using T-HERPS.

Use	Small Insects	Large Insects
Citrus,[1] Pome Fruits[2]	0.06	0.01
Strawberries, Walnuts (English/black), Pecans	0.04	<0.01
Beans, cotton, Stone Fruits[3]	0.03	<0.01
Grapes, mint[4]	0.02	<0.01
Hops	0.02	<0.01
Peppers, Tomatoes	0.01	<0.01
Cucurbits[5]	0.01	<0.01
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.01	<0.01
Bermuda grass	0.01	<0.01

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on LD_{50} = 265 mg/kg-bw (for ring-necked pheasant)

Refined dose-based RQs for medium-sized (37 g) CRLF consuming small herbivorous mammals exceed the acute listed species LOC (0.1) for all uses of dicofol. RQs exceed the LOC by factors of 2.3 to 16.9x. Based on an analysis of the likelihood of individual mortality considering the range of acute dose-based RQs for medium terrestrial-phase CRLFs consuming small herbivore mammals (0.23-1.69), and using the default probit dose-response of 4.5, the chance of mortality to these CRLF range from 1 out of 491 individuals to 100%. RQs for medium-sized CRLF consuming insects and terrestrial-phase amphibians do not exceed the acute listed species LOC (Table 48). This indicates that medium-sized CRLF could potentially be affected by acute exposures to dicofol.

Table 48. Revised dose-based RQs[7] for 37 g CRLF consuming different food items. EECs calculated using T-HERPS.

Use	Small Insects	Large Insects	Small Herbivore Mammals	Small Insectivore Mammals	Small Terrestrial-phase Amphibians
Citrus,[1] Pome Fruits[2]	0.06	0.01	**1.69**[8]	**0.11**[8]	<0.01
Strawberries, Walnuts (English/black), Pecans	0.04	<0.01	**1.13**[8]	0.07	<0.01
Beans, cotton, Stone Fruits[3]	0.03	<0.01	**0.85**[8]	0.05	<0.01
Grapes, mint[4]	0.02	<0.01	**0.71**[8]	0.04	<0.01
Hops	0.02	<0.01	**0.66**[8]	0.04	<0.01
Peppers, Tomatoes	0.01	<0.01	**0.42**[8]	0.03	<0.01
Cucurbits[5]	0.01	<0.01	**0.35**[8]	0.02	<0.01
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.01	<0.01	**0.28**[8]	0.02	<0.01
Bermuda grass	0.01	<0.01	**0.23**[8]	0.01	<0.01

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on LD_{50} = 265 mg/kg-bw (for ring-necked pheasant)
[8] Exceeds acute endangered species LOC (RQ>0.1)

Refined dose-based RQs for large-sized (238 g) CRLF consuming small, herbivore mammals are exceeded for some uses of dicofol (Table 49). Based on an analysis of the likelihood of individual mortality considering the range of acute dose-based RQs exceeding the LOC for large terrestrial-phase CRLFs consuming small herbivore mammals (0.10-0.26), and using the default probit dose-response of 4.5, the chance of mortality to these CRLF range from 1 in 294,319 individuals to 1 in 236 individuals. RQs for large-sized CRLF consuming insects and terrestrial-phase amphibians do not exceed the acute listed species LOC (Table 49). This indicates that large-sized terrestrial-phase CRLF could potentially be affected by acute exposures to dicofol resulting from several uses.

Table 49. Revised dose-based RQs[7] for 238 g CRLF consuming different food items. EECs calculated using T-HERPS.

Use	Small Insects	Large Insects	Small Herbivore Mammals	Small Insectivore Mammals	Small Terrestrial-phase Amphibians
Citrus,[1] Pome Fruits[2]	0.04	<0.01	**0.26[8]**	0.02	<0.01
Strawberries, Walnuts (English/black), Pecans	0.03	<0.01	**0.18[8]**	0.01	<0.01
Beans, cotton, Stone Fruits[3]	0.02	<0.01	**0.13[8]**	0.01	<0.01
Grapes, mint[4]	0.02	<0.01	**0.11[8]**	0.01	<0.01
Hops	0.01	<0.01	**0.10[8]**	0.01	<0.01
Peppers, Tomatoes	0.01	<0.01	0.07	<0.01	<0.01
Cucurbits[5]	0.01	<0.01	0.05	<0.01	<0.01
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.01	<0.01	0.04	<0.01	<0.01
Bermuda grass	0.01	<0.01	0.04	<0.01	<0.01

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on LD_{50} = 265 mg/kg-bw (for ring-necked pheasant)
[8] Exceeds acute endangered species LOC (RQ>0.1)

Refined acute dietary-based RQs for CRLFs consuming small insects and herbivorous mammals exceed the acute listed species LOC (0.1) for most uses of dicofol (the exceptions include ornamentals, turf and Bermuda grass). Based on an analysis of the likelihood of individual mortality considering the range of acute dietary-based RQs exceeding the LOC for terrestrial-phase CRLFs consuming small herbivore mammals (0.11-0.53), and using the probit dose-response of 5.92 (Table 27), the chance of mortality to these CRLF range from 1 in $1.4x10^8$ individuals to 1 in 19 individuals. For CRLFs consuming large insects, terrestrial-phase amphibians and small insectivorous mammals, the acute LOC is not exceeded for any use (Table 50). This indicates that CRLF could potentially be affected by acute exposures to dicofol.

Table 50. Revised acute dietary-based RQs[7] for CRLF consuming different food items. EECs calculated using T-HERPS.

Use	Small Insects	Large Insects	Small Herbivore Mammals	Small Insectivore Mammals	Small Terrestrial-phase Amphibians
Citrus,[1] Pome Fruits[2]	**0.45**[8]	0.05	**0.52**[8]	0.03	0.02
Strawberries, Walnuts (English/black), Pecans	**0.30**[8]	0.03	**0.35**[8]	0.02	0.01
Beans, cotton, Stone Fruits[3]	**0.22**[8]	0.02	**0.26**[8]	0.02	0.01
Grapes, mint[4]	**0.19**[8]	0.02	**0.22**[8]	0.01	0.01
Hops	**0.17**[8]	0.02	**0.20**[8]	0.01	0.01
Peppers, Tomatoes	**0.11**[8]	0.01	**0.13**[8]	0.01	<0.01
Cucurbits[5]	0.09	0.01	**0.11**[8]	0.01	<0.01
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.07	0.01	0.09	0.01	<0.01
Bermuda grass	0.06	0.01	0.07	<0.01	<0.01

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on LC_{50} = 905 ppm (for Japanese quail)
[8] Exceeds acute endangered species LOC (RQ>0.1)

Chronic exposures

Refined chronic dietary-based RQs for CRLFs exceed the chronic listed species LOC (1.0) for all uses of dicofol and for all food items potentially consumed by the CRLF (Table 51). In the available chronic study where American kestrel were exposed to dicofol, the NOAEC was 1 ppm, and the LOAEC was 3 ppm, based on decreased eggshell thickness. Comparison of the LOAEC directly to chronic dietary-based EECs for CRLF consuming all food items indicate that EECs for *all* uses are sufficient to exceed the concentration where reproductive effects were observed in the laboratory. There is some uncertainty in relying upon observed effects to egg shells to represent effects to reproduction of the CRLF, since the CRLF does not produce eggs with shells. In other chronic studies with birds, decreased number of eggs laid was observed in ring doves and American kestrel feed 40 ppm dicofol. EECs from all uses of dicofol for CLRF consuming small insects and small herbivore mammals are still sufficient to exceed this level where decreased number of offspring was observed in birds.

Based on the above information, for all uses of dicofol, the effects determination for chronic effects to the terrestrial-phase CRLF is "LAA" based on potential reproductive effects.

Table 51. Revised chronic dietary-based RQs[7] for CRLF consuming different food items. EECs calculated using T-HERPS.

Use	Small Insects	Large Insects	Small Herbivore Mammals	Small Insectivore Mammals	Small Terrestrial-phase Amphibians
Citrus,[1] Pome Fruits[2]	**405[8]**	**45.0[8]**	**474[8]**	**30.0v**	**14.1[8]**
Strawberries, Walnuts (English/black), Pecans	**270v**	**30.0[8]**	**316[8]**	**1938[8]**	**9.37[8]**
Beans, cotton, Stone Fruits[3]	**203[8]**	**22.5[8]**	**237[8]**	**14.8[8]**	**7.03[8]**
Grapes, mint[4]	**169[8]**	**18.8[8]**	**198[8]**	**12.4[8]**	**5.86[8]**
Hops	**157[8]**	**17.5[8]**	**184[8]**	**11.5[8]**	**5.46[8]**
Peppers, Tomatoes	**101[8]**	**11.2[8]**	**119[8]**	**7.41[8]**	**3.51[8]**
Cucurbits[5]	**84.4[8]**	**9.38[8]**	**98.8[8]**	**6.18[8]**	**2.93[8]**
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	**67.5[8]**	**7.50[8]**	**79.1[8]**	**4.94[8]**	**2.34[8]**
Bermuda grass	**54.0[8]**	**6.00[8]**	**63.3[8]**	**3.95[8]**	**1.87[8]**

[1] grapefruit, lemons, oranges, tangelos, and tangerines
[2] apples and pears
[3] apricots, cherries, nectarines, peaches, plums, and prunes
[4] mint, peppermint and spearmint
[5] cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
[6] nurseries and flowers
[7] Based on NOAEC = 1 ppm (for American kestrel)
[8] Exceeds chronic risk LOC (RQ>1.0)

5.2.2. Indirect Effects (through effects to prey)

As discussed in Section 2.5.3, the diet of tadpole CRLF is composed primarily of unicellular nonvascular aquatic plants and detritus. Juvenile CRLF consume primarily aquatic and terrestrial invertebrates. The diet of adult CRLF is composed of aquatic and terrestrial invertebrates, fish, frogs and mice. These prey groups are considered in determining indirect effects to the CRLF caused by direct effects to its prey.

5.2.2.1. Algae (non-vascular plants)

RQ values for algae are below the LOC for all uses of dicofol. This results in a “no effect” determination for indirect effects to the CRLF due to exposures of algae to dicofol.

5.2.2.2. Aquatic Invertebrates

Based on an analysis of the likelihood of individual mortality using acute RQs for aquatic invertebrates and a probit dose-response of 4.5 (default), the likelihood of individual mortality for each use is available in Table 52**.** Based on this analysis, all uses of dicofol result in less than or equal to a 3% chance of effects to an individual aquatic invertebrates representing prey of the CRLF.

Table 52. Acute RQs and associated likelihood of individual effects for aquatic invertebrates resulting from applications of dicofol. EECs are based on parent and degradates of concern.

Use	ULV application		Aerial application		Ground application	
	Acute RQ[1]	Likelihood of individual acute effect (%)	Acute RQ[1]	Likelihood of individual acute effect (%)	Acute RQ[1]	Likelihood of individual acute effect (%)
Beans	0.23[3]	0.2	0.13[3]	<0.1	0.11[3]	<0.1
Citrus	0.32[3]	1.3	0.12[3]	<0.1	0.093[3]	<0.1
Cotton	0.23[3]	0.2	0.13[3]	<0.1	0.11[3]	<0.1
Cucurbit	0.087[3]	<0.1	0.045	<0.1	0.039	<0.1
Grape	0.18[3]	<0.1	0.094[3]	<0.1	0.081[3]	<0.1
Hops	0.21[3]	0.1	0.14[3]	<0.1	0.13[3]	<0.1
Mint	0.21[3]	0.1	0.12[3]	<0.1	0.11[3]	<0.1
Pepper	0.11[3]	<0.1	0.064[3]	<0.1	0.059[3]	<0.1
Pome Fruit	0.35[3]	2.0	0.15[3]	<0.1	0.11[3]	<0.1
Stone Fruit	0.17[3]	<0.1	0.071[3]	<0.1	0.054[3]	<0.1
Strawberry	0.37[3]	2.6	0.27[3]	0.5	0.26[3]	0.4
Tomato	0.10[3]	<0.1	0.045	<0.1	0.037	<0.1
Walnut/Pecan	0.29[3]	0.8	0.15[3]	<0.1	0.13[3]	<0.1
Bermuda grass	NA	NA	NA	NA	0.016	<0.1
Ornamentals	NA	NA	NA	NA	0.044	<0.1
Turf/Sod Farm	NA	NA	NA	NA	0.021	<0.1
Outside Buildings	NA	NA	NA	NA	0.0025	<0.1

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid.
[2]Based on NOAEC = 19 µg/L for amphipod.
[3] Exceeds acute risk to endangered species LOC (RQ>0.05)
NA = not applicable

Exposures of aquatic invertebrates to dicofol are quantified in terms of total residues of dicofol. RQs are derived using the most sensitive toxicity data available for aquatic invertebrates exposed to dicofol. It is assumed that dicofol's degradates of concern *(i.e.*, DCBP, FW-152, DCBH and OH-DCBP) are equivalent to dicofol in toxicity to aquatic invertebrates. This assumption adds uncertainty to the risk assessment, the toxicity of dicofol's degradates to aquatic invertebrates is unknown. If exposures involving dicofol only are considered, acute RQs for the aquatic invertebrates CRLF exceed the listed species LOCs (0.05) for all dicofol uses, except cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings (Table 53 - Table 55). Chronic exposures of dicofol parent are insufficient to exceed the LOC (1.0).

Table 53. Acute and chronic RQs for aquatic invertebrates resulting from AERIAL applications of dicofol. EECs are based on dicofol only.

Crop	Peak EEC (µg/L)	21-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	3.25	0.46	0.023	0.024
Citrus	6.46	0.97	0.046	0.051
Cotton	3.48	0.64	0.025	0.034
Cucurbit	1.34	0.19	0.010	0.010
Grape	2.70	0.38	0.019	0.020
Hops	2.52	0.38	0.018	0.020
Mint	2.70	0.39	0.019	0.020
Pepper	1.61	0.23	0.012	0.012
Pome Fruit	6.46	0.90	0.046	0.048
Stone Fruit	3.25	0.46	0.023	0.024
Strawberry	6.41	1.76	0.046	0.092
Tomato	1.61	0.23	0.012	0.012
Walnut/Pecan Aerial	4.41	0.66	0.031	0.035

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid.
[2]Based on NOAEC = 19 µg/L for amphipod.

Table 54. Acute and chronic RQs for aquatic invertebrates resulting from GROUND applications of dicofol. EECs are based on dicofol only.

Crop	Peak EEC (µg/L)	21-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	2.26	0.32	0.016	0.017
Citrus	4.47	0.69	0.032	0.036
Cotton	2.49	0.51	0.018	0.027
Cucurbit	0.93	0.13	0.0067	0.0069
Grape	1.87	0.27	0.013	0.014
Hops	1.74	0.27	0.012	0.014
Mint	1.87	0.27	0.013	0.014
Pepper	1.12	0.16	0.0080	0.0084
Pome Fruit	4.47	0.63	0.032	0.033
Stone Fruit	2.25	0.32	0.016	0.017
Strawberry	6.34	1.62	0.045	0.085
Tomato	1.12	0.16	0.0080	0.0083
Walnut/Pecan	3.09	0.48	0.022	0.025
Bermuda grass	0.60	0.10	0.0043	0.0054
Ornamentals	1.78	0.39	0.013	0.020
Turf/Sod Farm	0.75	0.13	0.0053	0.0067
Outside Buildings	0.152	0.025	0.0011	0.0013

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid.
[2]Based on NOAEC = 19 µg/L for amphipod.

Table 55. Acute and chronic RQs for aquatic invertebrates resulting from ULV applications of dicofol. EECs are based on dicofol only.

Crop	Peak EEC (µg/L)	21-day (µg/L)	Acute RQ[1]	Chronic RQ[2]
Beans	9.75	1.38	**0.070**[3]	0.073
Citrus	18.02	2.58	**0.13**[3]	0.14
Cotton	9.92	1.49	**0.071**[3]	0.079
Cucurbit	4.04	0.56	0.029	0.030
Grape	8.08	1.14	**0.058**[3]	0.060
Hops	7.56	1.08	**0.054**[3]	0.057
Mint	8.07	1.15	**0.058**[3]	0.060
Pepper	4.85	0.69	0.035	0.036
Pome Fruit	18.02	2.52	**0.13**[3]	0.13
Stone Fruit	9.08	1.28	**0.065**[3]	0.067
Strawberry	13.17	2.70	**0.094**[3]	0.14
Tomato	4.85	0.68	0.035	0.036
Walnut/Pecan	13.02	1.85	**0.093**[3]	0.097

[1]Based on 48-h EC_{50} = 140 µg/L for daphnid.
[2]Based on NOAEC = 19 µg/L for amphipod.
[3] Exceeds acute risk to endangered species LOC (RQ>0.05)

Chronic RQs based on total residues of dicofol for the majority of dicofol uses (all but cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings) are sufficient to exceed the LOC (1.0). For ULV applications of dicofol to cotton, pome fruit, strawberries, and walnuts/pecans, EECs are sufficient to exceed the LOAEC (33 µg/L) for chronic effects to aquatic invertebrates.

Based on the above information, the impact of the indirect effects to aquatic-phase CRLFs via acute effects on aquatic invertebrates is discountable for all uses of dicofol. The majority of dicofol uses (all but cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings) have the potential to result in chronic exposures that may result in effects to aquatic invertebrates, especially when dicofol is applied via ULV methods.

5.2.2.3. Fish and Aquatic-Phase Amphibians

Based on an analysis of the likelihood of individual mortality considering the range of acute RQs exceeding the LOC for fish and aquatic-phase amphibians (0.05-0.71), and using the probit dose-response of 4.5 (default assumption), likelihood of individual mortality for each use is available in Table 56**.** Based on this analysis, use of dicofol on beans, citrus, cotton, hops, mint, pome fruit, strawberries and walnuts/pecans results in greater than a 10% likelihood of individual mortality. All other uses of dicofol result in less than a 10% chance of effects to an individual fish and aquatic-phase amphibians representing prey of the CRLF.

Table 56. Acute RQs and likelihood of individual mortality for fish and aquatic-phase amphibians resulting from applications of dicofol. EECs are based on parent and degradates of concern.

Use	ULV application		Aerial application		Ground application	
	Acute RQ[1]	Likelihood of individual mortality (%)	Acute RQ[1]	Likelihood of individual mortality (%)	Acute RQ[1]	Likelihood of individual mortality (%)
Beans	0.60	16	0.34	1.8	0.30	0.9
Citrus	0.85	38	0.33	1.5	0.25	0.3
Cotton	0.60	16	0.34	1.8	0.30	0.9
Cucurbit	0.23	0.2	0.12	<0.1	0.10	<0.1
Grape	0.48	7.6	0.25	0.3	0.21	0.1
Hops	0.56	13	0.37	2.6	0.35	2.0
Mint	0.54	11	0.31	1.1	0.29	0.8
Pepper	0.30	0.9	0.17	<0.1	0.16	<0.1
Pome Fruit	0.92	44	0.39	3.3	0.29	0.8
Stone Fruit	0.45	5.9	0.19	0.1	0.14	<0.1
Strawberry	0.97	48	0.71	25.2	0.69	23
Tomato	0.26	0.4	0.12	<0.1	0.10	<0.1
Walnut/Pecan	0.76	30	0.39	3.3	0.34	1.8
Bermuda grass	NA	NA	NA	NA	0.044	<0.1
Ornamentals	NA	NA	NA	NA	0.11	<0.1
Turf/Sod Farm	NA	NA	NA	NA	0.054	<0.1
Outside Buildings	NA	NA	NA	NA	0.0067	<0.1

[1]Based on 96-h LC_{50} = 53 µg/L for cutthroat trout
NA = not applicable

Chronic RQs for fish and aquatic-phase amphibians for the majority of dicofol uses (all except Bermuda grass, turf and outside buildings) exceed the LOC (1.0) by factors of 1.1X to 10X, depending upon the use (Table 31 - Table 33). EECs are sufficient to exceed the LOAEC (7.9 µg/L, based on growth effects) for the majority of dicofol uses, with the exception of Bermuda grass, ornamentals, turf and outside buildings.

5.2.2.4. Terrestrial Invertebrates

As noted above, for small insect exposures, RQ values range <1.04 to <0.138. For large insect exposures, RQ values range <0.115 to <0.0153. For all uses of dicofol, RQ values potentially exceed the acute risk LOC (RQ≥0.05) for terrestrial insects. Because the LD_{50} used in deriving RQs for terrestrial invertebrates is not quantified, RQs for acute exposures of small and large terrestrial invertebrates to dicofol *potentially* exceed the LOC of 0.05 for all uses.

Based on an analysis of the likelihood of individual mortality considering the range of acute RQs potentially exceeding the LOC (0.05 to <1.04), and using the default probit dose-response of 4.5, the chance of mortality to terrestrial invertebrates range from less than 0.1% to 53% (Table 57). For use of dicofol on grapes, mint, hops, peppers, tomatoes, cucurbits, ornamentals, turf and Bermuda grass, dicofol exposures result in a chance of individual mortality to less than 10% of terrestrial insects. Therefore, indirect effects to the CRLF through potential effects to terrestrial invertebrates resulting from these dicofol uses are considered discountable. Use of dicofol on citrus, pome fruits, strawberries, walnuts, pecans, beans, cotton and stone fruits could potentially result in indirect effects to greater than 10% of small invertebrates. Although there is uncertainty in the actual effects of these exposures to terrestrial invertebrates, given that no LD_{50} was established, mortality to small insects resulting from dicofol applied to these crops has the potential to result in indirect effects to the CRLF, especially considering that dicofol is intended for control of insects.

Table 57. RQs[7] and associated likelihood of individual effects to terrestrial invertebrates due to dicofol exposures.

Use	Small Insect		Large Insect	
	RQ	Likelihood of individual acute effect (%)	RQ	Likelihood of individual acute effect (%)
Citrus,[1] Pome Fruits[2]	<1.04	<53.10	<0.12	<0.1
Strawberries, Walnuts (English/black), Pecans	<0.69	<23.40	<0.08	<0.1
Beans, cotton, Stone Fruits[3]	<0.52	<10.10	<0.06	<0.1
Grapes, mint[4]	<0.43	<4.95	<0.05	<0.1
Hops	<0.40	<3.67	<0.04	<0.1
Peppers, Tomatoes	<0.26	<0.42	<0.03	<0.1
Cucurbits[5]	<0.22	<0.15	<0.02	<0.1
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	<0.17	<0.1	<0.02	<0.1
Bermuda grass	<0.14	<0.1	<0.02	<0.1

1 grapefruit, lemons, oranges, tangelos, and tangerines
2 apples and pears
3 apricots, cherries, nectarines, peaches, plums, and prunes
4 mint, peppermint and spearmint
5 cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
6 nurseries and flowers
7 Based on LD_{50} >391 μg a.i./g for honey bee

5.2.2.5. Mammals

RQ values representing acute exposures to terrestrial mammals exceed the LOC (0.1) for all uses of dicofol except: ornamentals, turf, outside buildings and Bermuda grass (Table 58). Therefore, there is potential for acute effects of dicofol to terrestrial mammals.

Based on an analysis of the likelihood of individual mortality using acute dose-based RQs for terrestrial mammals and a probit dose-response of 4.5 (default value), the likelihood of individual mortality for each use is available in Table 58**.** Based on this analysis, the majority of dicofol uses result in less than a 10% chance of effects to an individual terrestrial mammal representing prey of the CRLF. Only the highest RQ (from citrus and pome fruits) result in estimations of likelihood of individual effects which represents a significant indirect effect to the CRLF (10.7%). Therefore, the impact of the indirect effects to terrestrial-phase CRLFs via acute effects on small mammals is discountable for all uses of dicofol, except citrus and pome fruits.

Table 58. Acute dose-based RQs and associated likelihood of individual effects to small terrestrial mammals (consuming short grass) due to dicofol exposures.

Use	**Acute, dose-based[7]**	**Likelihood of individual acute effect (%)**
Citrus,[1] Pome Fruits[2]	**0.53**	**10.7**
Strawberries, Walnuts (English/black), Pecans	**0.35**	**2.0**
Beans, cotton, Stone Fruits[3]	**0.27**	**0.5**
Grapes, mint[4]	**0.22**	**0.2**
Hops	**0.21**	**0.1**
Peppers, Tomatoes	**0.13**	**<0.1**
Cucurbits[5]	**0.11**	**<0.1**
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.09	**<0.1**
Bermuda grass	0.07	**<0.1**

1 grapefruit, lemons, oranges, tangelos, and tangerines
2 apples and pears
3 apricots, cherries, nectarines, peaches, plums, and prunes
4 mint, peppermint and spearmint
5 cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
6 nurseries and flowers
[7]Based on LD_{50} for laboratory rat = 587 mg/kg.

Dose-based and dietary-based chronic RQs for terrestrial mammals exceed the LOC (1.0) by factors of 19X to 781X, depending upon the use (Table 40). EECs are sufficient to exceed the LOAEC (25 ppm, based on reproductive effects) for all uses by factors of 4X or greater. Based on this information, chronic exposures of dicofol from all uses have the potential to indirectly affect the CRLF via impacts to terrestrial mammals serving as potential prey items.

The T-REX model is useful for assessing exposures of terrestrial animals to pesticides through consumption of foliar surfaces of crops and insects on the treated site. The model cannot be used to assess pesticide exposures to terrestrial animals resulting from consumption of soil dwelling invertebrates which have accumulated the pesticide in their tissues. In order to explore the potential exposures of mammals to total residues of dicofol that have accumulated in earthworms inhabiting dicofol treatment sites, a simple fugacity approach was employed to estimate dicofol concentrations in earthworms and subsequent exposures to mammals consuming earthworms. This approach is explained in detail in **Appendix O**.

Based on PRZM estimated dicofol concentrations of 10 and 0.16 g/m3 in soil and soil pore water, respectively (Figure 9 and Figure 10), the estimated concentration of dicofol in earthworms is 2914 ppm. This translates to a dose-based EEC of 2778 mg/kg-bw, which exceeds the LD_{50} for rats of 587 mg/kg-bw. If it is assumed that a 20g mammal consumes only earthworms, its chronic dietary based and dose-based exposures would be approximately 100X and 1000X, respectively, above levels where reproductive effects were observed in rats (25 ppm, MRID 41606601). Therefore, acute and chronic exposures of small mammals to dicofol through consumption of contaminated earthworms from fields treated with dicofol have the potential to result in effects to mammals.

5.2.2.6. Terrestrial-Phase Amphibians

In order to explore influences of amphibian-specific food intake equations on potential dose-based and dietary-based exposures of amphibians (prey of CRLF) to dicofol, the T-HERPS model is used. The Pacific tree frog (*Hyla regilla*) is used to represent the amphibian prey species. The weight of the animal is assumed to be 2.3 g, and its diet is assumed to be composed of small and large insects. For frogs consuming small and large insects, the acute LOC (0.1) is not exceeded for dicofol (Table 59).

Table 59. Acute dose-based RQs[7] for terrestrial-phase frogs (prey) exposed to dicofol.

Use	Frogs consuming Small Insects	Frogs consuming Large Insects
Citrus,[1] Pome Fruits[2]	0.04	<0.01
Strawberries, Walnuts (English/black), Pecans	0.04	<0.01
Beans, cotton, Stone Fruits[3]	0.03	<0.01
Grapes, mint[4]	0.02	<0.01
Hops	0.02	<0.01
Peppers, Tomatoes	0.01	<0.01
Cucurbits[5]	0.01	<0.01
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.01	<0.01
Bermuda grass	0.01	<0.01

1 grapefruit, lemons, oranges, tangelos, and tangerines
2 apples and pears
3 apricots, cherries, nectarines, peaches, plums, and prunes
4 mint, peppermint and spearmint
5 cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
6 nurseries and flowers
7 Based on LD_{50} = 265 mg/kg-bw (for ring-necked pheasant)

Acute dietary-based RQs for the CRLF, which do not account for the weight of the animal being assessed, can also be used to assess risks to the terrestrial frog prey (Table 50). For frogs which consume small insects, RQs exceed the acute LOC (0.1) for the majority of dicofol uses, with the exception of use on cucurbits, ornamentals, turf, outside buildings and Bermuda grass. For frogs which consume large insects, the acute LOC is not exceeded for dicofol.

Based on an analysis of the likelihood of individual mortality using acute dietary-based RQs for terrestrial amphibians and a probit dose-response of 5.92, the likelihood of individual mortality for each use is available in Table 60**.** Based on this analysis, all uses of dicofol result in ≤2% chance of effects to an individual terrestrial amphibian representing prey of the CRLF. Therefore, the impact of the indirect effects to terrestrial-phase CRLFs via acute effects on terrestrial amphibians is discountable for all uses of dicofol.

Table 60. Acute dietary-based RQs for terrestrial-phase frogs (prey) consuming small insects and likelihood of individual effects chance resulting from dicofol exposures. RQs calculated using T-HERPS.

Use	Acute, dietary-based RQ[7]	Likelihood of individual acute effect (%)
Citrus,[1] Pome Fruits[2]	**0.45**	**2.0**
Strawberries, Walnuts (English/black), Pecans	**0.30**	**0.1**
Beans, cotton, Stone Fruits[3]	**0.22**	**<0.1**
Grapes, mint[4]	**0.19**	**<0.1**
Hops	**0.17**	**<0.1**
Peppers, Tomatoes	**0.11**	**<0.1**
Cucurbits[5]	0.09	**<0.1**
Ornamentals,[6] Turf grasses, Sod farms, Outside building surfaces	0.07	**<0.1**
Bermuda grass	0.06	**<0.1**

1 grapefruit, lemons, oranges, tangelos, and tangerines
2 apples and pears
3 apricots, cherries, nectarines, peaches, plums, and prunes
4 mint, peppermint and spearmint
5 cantaloupes, cucumbers, melons, pumpkins, watermelons, and winter and summer squash
6 nurseries and flowers
7 Based on LC_{50} = 903 ppm (for Japanese quail)

Chronic dietary-based RQs for the CRLF, which do not account for the weight of the animal being assessed, can also be used to assess risks to the terrestrial frog prey (Table 51). Chronic RQs for the frog exceed the LOC (1.0) by factors ranging from 2X to 474X. Therefore, for all dicofol uses, there is potential for indirect effects to the CRLF resulting from chronic effects to terrestrial amphibians.

5.2.3. Indirect Effects (through effects to habitat)

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.

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.

Due to a lack of effects data, potential risk of dicofol to plants cannot be quantified. Qualitative effects data suggest that applications of dicofol may result in phytotoxicity, however, due to a lack of detail provided in the available studies, the relationship between effects observed and application rates of dicofol cannot be defined. In addition, there is one reported incident involving effects of dicofol to plants. Although effects of dicofol on plants cannot be quantified, effects of dicofol on plants cannot be discounted.

5.2.4. Primary Constituent Elements of Designated Critical Habitat

As discussed above, effects of dicofol to plants comprising the aquatic and terrestrial habitats of the CRLF cannot be discounted. Also, exposures of dicofol to the CRLF and its prey have the potential to affect the CRLF. Therefore, dicofol is likely to result in effects to the CRLF's aquatic and terrestrial habitats based on potential impacts to all 8 PCEs.

5.2.5. Area of Effects

The initial area of concern for dicofol was previously discussed in Section 2.7 and depicted in Figure 5 of the problem formulation. A map depicting the overlap of this initial area of concern and CRLF habitat is depicted in Figure 11. Because of the lack of a NOAEC in several chronic toxicity studies with birds (described in Section 4.3.1), the action area for dicofol is established as the entire state of California.

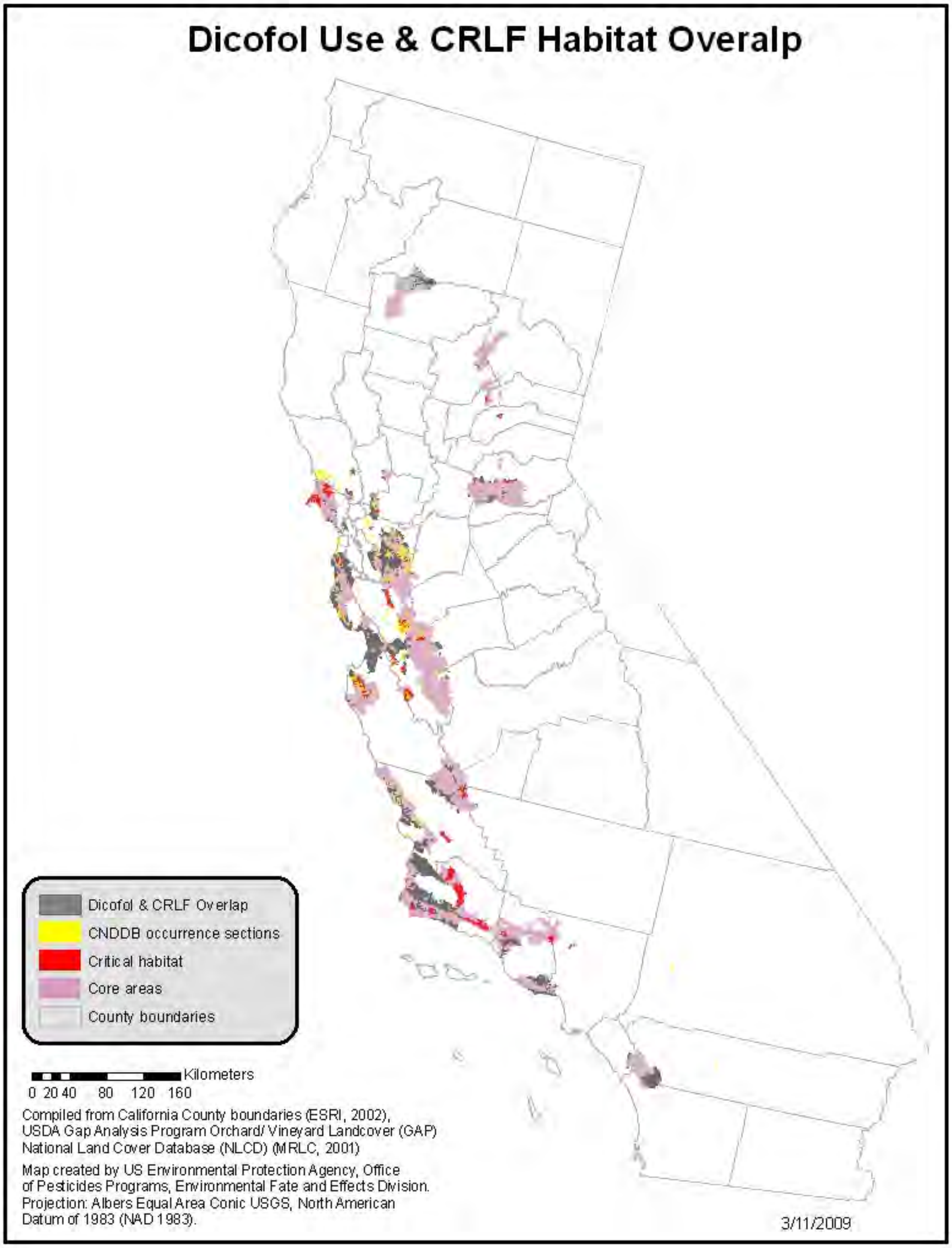


Figure 11. Intersection between dicofol use areas and CRLF habitat.

Available pesticide use data from California indicate that dicofol has been used in counties which contain CRLF habitat. Out of 58 counties in California, 33 contain some portion of CRLF critical habitat or core areas. According to use data for 1999-2006, all of the 33 counties containing CRLF areas have reported past uses of dicofol. From 1999-2006, 8 of these counties had >1000 pounds of dicofol applied annually (Table 61).

Table 61. Summary of CDPR pesticide use reporting by county for dicofol (annual pounds of dicofol applied from 1999 to 2006).

County	Are CRLF habitat/core areas present?	1999	2000	2001	2002	2003	2004	2005	2006
FRESNO	yes	123,090	100,221	75,201	51,563	49,215	63,344	60,967	27,191
TULARE	no	53,026	62,227	39,640	35,513	42,234	43,507	35,060	10,155
KINGS	yes	35,692	44,112	18,674	25,114	27,709	31,010	29,124	7,807
MERCED	yes	23,932	25,490	19,746	17,070	18,552	27,707	19,666	22,032
KERN	yes	32,442	22,994	9,345	10,338	8,726	5,966	12,774	5,828
STANISLAUS	yes	17,860	23,376	14,536	13,815	11,925	13,822	7,120	5,330
SAN JOAQUIN	yes	22,647	15,153	3,379	4,895	3,527	5,582	4,839	5,924
MADERA	no	12,042	6,208	4,369	3,019	2,037	2,454	5,358	4,938
MONTEREY	yes	7,057	4,058	4,504	1,523	802	1,824	3,767	1,825
IMPERIAL	no	8,439	2,916	3,103	2,271	2,371	2,965	2,138	472
SUTTER	no	2,514	3,590	3,071	4,067	2,500	1,846	1,580	2,905
RIVERSIDE	yes	5,996	2,466	1,913	2,046	3,140	2,694	586	1,212
BUTTE	yes	829	1,545	4,846	1,278	4,196	2,255	3,797	1,102
YOLO	no	4,652	2,585	1,511	2,466	1,771	403	431	341
GLENN	no	2,016	645	1,066	1,273	980	618	1,226	1,170
TEHAMA	yes	1,219	1,529	1,128	2,356	2,159	42	277	29
SOLANO	yes	2,353	496	1,210	1,294	833	368	663	184
COLUSA	no	1,766	224	233	770	403	1,775	756	479
SANTA BARBARA	yes	487	1,670	797	349	162	636	1,311	571
SACRAMENTO	yes	3,537	1,270	133	376	211	3	8	0
CONTRA COSTA	yes	1,432	1,107	1,282	33	301	334	0	10
SAN LUIS OBISPO	yes	1,881	1,495	198	56	4	149	3	324
SAN DIEGO	yes	449	269	385	290	496	288	235	86
SONOMA	yes	1,363	780	103	8	18	0	0	2
SANTA CLARA	yes	76	12	7	26	179	395	840	543
ALAMEDA	yes	1,667	72	35	0	0	2	0	0
VENTURA	yes	27	84	189	23	441	693	251	27
LOS ANGELES	yes	527	731	273	135	29	2	2	7
SAN BENITO	yes	813	416	55	0	0	50	0	195
SISKIYOU	no	0	0	0	0	8	494	874	149
YUBA	yes	177	11	638	47	263	7	0	0
ORANGE	yes	860	60	18	31	13	8	3	0
MENDOCINO	no	604	161	0	2	0	0	6	0
AMADOR	yes	92	16	30	0	629	0	0	0
SAN BERNARDINO	no	211	149	86	45	29	5	5	5
SHASTA	yes	173	218	11	0	26	31	34	2
MODOC	no	0	0	0	0	0	441	20	0
SANTA CRUZ	yes	222	4	9	179	8	0	0	0

County	Are CRLF habitat/core areas present?	1999	2000	2001	2002	2003	2004	2005	2006
CALAVERAS	no	63	8	173	123	0	0	0	0
NAPA	yes	154	0	53	0	8	0	65	0
SAN MATEO	yes	103	19	40	8	10	13	20	12
PLACER	no	42	125	1	0	1	0	1	0
LAKE	no	47	7	38	12	20	6	3	3
EL DORADO	yes	65	0	6	14	42	2	2	0
NEVADA	yes	42	7	0	4	0	0	0	0
PLUMAS	yes	12	0	0	0	0	0	0	0
MARIPOSA	no	0	6	0	0	0	0	0	0
SIERRA	no	6	0	0	0	0	0	0	0
MARIN	yes	2	0	0	0	0	0	0	0
SAN FRANCISCO	no	2	0	0	0	0	0	0	0
HUMBOLDT	no	0	1	0	0	0	0	0	0
Total		**372,704**	**328,533**	**212,033**	**182,430**	**185,981**	**211,738**	**193,809**	**100,862**

In order to determine the extent of the lotic (flowing) aquatic habitat directly affected in aquatic, the greatest ratio of the RQ to the LOC for any endpoint for aquatic organisms is used to determine the distance downstream for concentrations to be diluted below levels that would be of concern (*i.e*. result in RQs less than the LOC). For this assessment, this applies to RQs for acute exposures of total residues of dicofol to the aquatic-phase CRLF (and fish and aquatic-phase amphibians). The highest RQ (0.71) divided by the acute LOC (0.05) results in a ratio of 14.2. The maximum downstream distance from areas where dicofol are applied and dicofol is at concentrations that are of concern to the aquatic-phase CRLF is 155 km.

EECs and relevant RQs calculated by T-HERPS and T-REX apply to sites where dicofol is directly applied. Since dicofol can be transported through spray drift to non-target areas beyond the treatment site, the CLRF and its prey located outside of direct treatment areas can still be exposed to dicofol in non-target areas. Exposure and associated risks to the CRLF are expected to decrease with increasing distance away from the treated field or site of application.

Based on acute effects data for the terrestrial-phase CRLF, spray drift deposition of dicofol as low as 0.18 lbs a.i./A would be sufficient to exceed the acute listed species LOC for the CRLF. This is based on the highest acute RQ for terrestrial phase CRLF and its prey, which is 1.69 based on risks to medium sized CRLF receiving dicofol through consumption of small herbivore mammals. For aerial applications of dicofol to citrus and pome fruits, at the maximum application rate (3 lb a.i./A), spray drift is sufficient to exceed the LOC for as far as 161 feet from the edge of the treatment field (Table 62). Since 3 lb a.i./A represents the highest application rate of dicofol, for all other uses of dicofol, the distance from the edge of the field where the LOC is exceeded is expected to be less than 161 feet for aerial applications and 43 feet for ground applications.

Table 62. Single application rate not exceeding acute LOC for dietary- and dose-based exposures of the CRLF to dicofol.

CRLF size[1]	Based on dose or diet?	Feeding Category	Highest application rate not exceeding LOC (lbs a.i./A)	Distance from edge of field where LOC is not exceeded (in feet) for single application of 3 lb a.i./A[2, 3]	
				Ground	Aerial
medium	Dose	small herbivore mammals	0.18	43	161
all	Diet	Small herbivore mammals	0.55	16	43
all	Diet	Small insects	0.64	13	30
large	Dose	small herbivore mammals	1.1	10	10
medium	Dose	small insectivore mammals	2.9	3	0
small	Dose	small insects	>3	0	0
medium	Dose	small insects	>3	0	0
large	Dose	small insects	>3	0	0
large	Dose	small insectivore mammals	>3	0	0
Small	Dose	large insects	>3	0	0
medium	Dose	large insects	>3	0	0
large	Dose	large insects	>3	0	0
all	Diet	large insects	>3	0	0
medium	Dose	terrestrial-phase amphibians	>3	0	0
all	Diet	Small insectivore mammals	>3	0	0
all	Diet	Terrestrial-phase amphibians	>3	0	0
large	Dose	terrestrial-phase amphibians	>3	0	0

1. Small is defined as 1.4 g. Medium is defined as 37 g. Large is defined as 238 g.
2. Estimated using the terrestrial assessment of the Tier 1 version of AgDRIFT. Modeling assumed that applications were done using ground and aerial methods, and assuming that the droplet size distribution was “ASAE very fine to fine” for ground applications (high boom) and "ASAE fine to medium" for aerial applications.
3. 3 lb a.i./A is the highest application of dicofol. This corresponds to applications to citrus and pome fruits.

5.2.6. Description of Assumptions, Limitations and Uncertainties

5.2.6.1. Exposure Assessment

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.

Use Characterization Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. 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. 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.

Aquatic Exposure Modeling of Dicofol

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 m3) 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 (U.S. FWS/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.

The temporal and spatial distribution of pesticides with persistent and bioaccumulative characteristics in aquatic ecosystems is expected to be influenced substantially by processes governing sediment particle delivery to (and transport within) water bodies (i.e., sediment dynamics). For these compounds, soil erosion is usually a major source of pesticide loading into aquatic ecosystems. Once in an aquatic ecosystem, processes such as settling, resuspension, and burial of sediment particles can affect the distribution of pesticides in the water column-, pore water-, and suspended- and benthic-sediment compartments. Sediment dynamics can also influence pesticide bioavailability within these compartments, due to pesticide sorption on particulate organic carbon and complexation with dissolved organic carbon. Currently, OPP’s aquatic exposure modeling framework incorporates pesticide delivery to a standard pond from soil erosion and runoff using the Pesticide Root Zone Model (PRZM). In this modeling framework, only the pesticide mass delivered from soil erosion and runoff is considered for delivery to an aquatic ecosystem (i.e., the mass of soil and volume of runoff predicted by PRZM are not considered). Pesticide transport between the water column and the benthic region within the standard pond is modeled using the Exposure Analysis Modeling System (EXAMS) based on a set of lumped parameters that are designed to reflect the combined effect of multiple transport processes (e.g., diffusion, setting and resuspension). The current modeling framework does not consider pesticide burial in the benthic area, a process by which pesticide is rendered permanently unavailable for biological interaction due to accumulating sediment. Without consideration of burial processes, the current modeling framework likely represents an effective screen for pesticide exposure assessment in both lentic (static) and lotic (flowing water) systems.

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.

Terrestrial Exposure Modeling of Dicofol

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. EPA 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.

Long Range Transport

Based on dicofol's vapor pressure ($3.9x10^{-7}$ torr), low levels of volatility can potentially occur, but are not expected. However, once in the air dicofol can be expected to partition between the gas and particle phases in the atmosphere, existing largely in the particle phase, potentially contributing to the long-range transport of dicofol. Partioning in the air would most likely occur when the pesticide is applied via an aerial or ground spray, particularly when ultra-low volume sprays. Data on volatilization from foliar surfaces were not available. However, three dislodgeable foliar residue studies indicate that the half-life for dicofol on cotton, cucumbers, and oranges was 3.2, 5.52, and 15.6 days, respectively. For comparative purposes, DDT has a range of half-lives on clover from 1.6 to 18.8 days (Willis and McDowell 1987).

Although OPP is not able to quantify the extent to which dicofol and its degradates will undergo long-range atmospheric transport once it has been released from a treatment site, this mechanism of transport will constitute a route of exposure for nontarget animals distant from use sites. Based on its vapor pressure ($3.9x10^{-7}$ torr @ 20^{o}C) and persistence in the air (half life =3.1 days), the United Nations Economic Commission for Europe's (UNECE) Convention on Long-range Transboundary Air Pollution has indicated that dicofol has the potential for long-range transport (Rasenberg *et al.* 2003). According to the report, "dicofol is expected to partition between the gas and particle phases in the atmosphere and is likely to exist largely in the particle phase."

Atmospheric Monitoring Data

In 2000, CDPR monitored ambient air in Lompoc (Santa Barbara County) for 31 pesticides and breakdown products, including dicofol (CDPR 2003). Lompoc County is one of the largest producers of flower seeds in the United States. CDPR monitored the pesticides during the peak use period for most of the pesticides, between May 31 and August 3, 2000. During this 10-week period, DPR collected 24-hour samples, four consecutive days per week at each of the four monitoring locations, located in the northwest, west, southwest, and central parts of the county. The University of California, Davis performed the primary laboratory analysis, using a new method developed specifically to analyze the pesticides used in Lompoc. For dicofol, the highest one-day air concentration was listed as trace, meaning the concentration was halfway between the method detection limit and the estimated quantitation limit of 4 ng/m^3. Additionally, the highest 14-day and 10-week air concentrations measured for dicofol were also listed as trace (*i.e.*., the concentration was halfway between the method detection limit and the estimated quantitation limit of 1.37 ng/m^3 and 0.91 ng/m^3, respectively). Collocated samples were collected during the last week of sampling to determine if any percentage of the chemical concentrations were being missed in the analysis of the primary samples as particulates. In all of the samples analyzed, levels of dicofol were below detection levels.

In 2006, as part of the California Environmental Protection Agency's Environmental Justice Action Plan, CDPR conducted a pilot project focusing on pesticide air concentrations in the low-income, predominantly Hispanic, Fresno County farming community of Parlier, located in the San Joaquin Valley (CDPR 2006). Fruit orchards and grape vineyards were the predominant crops in the area. CDPR and the Air Resources Board (ARB) collected samples of ambient air at three primary schools throughout the 2006 calendar year. During the sampling period, approximately 6 applications totaling 150 lbs of dicofol occurred within five miles of Parlier in 2006. Four hundred and sixty-eight ambient air samples were collected and analyzed for dicofol. Dicofol was not detected in any of the 468, one-day concentration samples collected (quantitation limit = 46.3 ng/m^3). It does not appear that particulate matter, collected during this study, was analyzed for dicofol concentrations; given that dicofol is expected to be associated with particulate matter suspended in the air, the absence of detections may not accurately reflect the potential movement of dicofol.

The USGS publication, *Pesticides in the Atmosphere* (Majewski *et al.* 1995) reports an observed concentration for kelthane (dicofol) in the air of 9.5 ng/m^3. Additionally, a cited study in this reference reports one detected residential outdoor ambient air concentration of 6 ng/m^3 out of 53 samples collected (Yeary *et al.* 1993). It is not clear whether the detection occurred in California.

Modeling of Long-Range Transport Potential

The "OECD Pov and LRTP Screening Tool" (version 2.0) was utilized in evaluating the overall environmental persistence (Pov), the long range transport potential (LRTP) and transfer efficiency (TE). The OECD Tool requires estimated degradation half lives in soil, water and air, and partition coefficients between air and water and between octanol and water as chemical-specific input parameters to calculate metrics of Pov and LRTP. Pov is derived from the degradation rate constants in soil, water and air to provide overall degradation. The resulted Pov value represents the characteristic time for disappearance of a chemical after releases in various media have been stopped and the overall degradation rate is determined by the disappearance of chemical from a medium (Scheringer *et al.*, 2006). The characteristic travel distance (CTD) represents the potential of a chemical to be transported over long distances in air or water. In the OECD Tool, the CTD is the distance at which the concentration of chemical decrease to 37% due to transport of chemical by a constant flow of air (wind speed of 0.02 m/s) or water (ocean water circulation speed of 0.02m/s (Scheringer *et al.* 2006).

Transfer efficiency is a dimensionless metric of potential for atmospheric transport and deposition of parent compound in terrestrial and aquatic environments of a remote region (Wegmann *et al.* 2007). It is a ratio between the depositional flux (mol/day) in remote region and emission flux from the source area. A high TE value indicates an "optimal" transport condition from the source region to remote depositional region.

The OECD Tool was used in evaluating the Pov and LRTP for 3 known PBT chemicals (DDT, aldrin and endrin) and the dicofol isomers (both as the parent and parent plus degradates) using chemical-specific degradation half-lives in soil, water, and air as well as two partition constants, the Kow and K_{AW}. Table 63 provides input parameters used in the OECD Tool.

Table 63. Physicochemical and environmental fate properties used as input for estimating overall persistence and long-range transport potential using the OECD Tool.

Name of Chemical	Molecular Weight (g/mole)	Log K_{ow} [a]	Log K_{Aw} [a]	Half life in Air (hrs)	Half life in Water (hrs)	Half life in Soil (hrs)
p.p' DDT [b]	345.5	6.39	-3.34	170	5500	17000
Aldrin [b]	364.9	4.94	-3.38	2.86	2670	3830
Endrin [b]	380.9	5.44	-3.11	12.72	78840	29070
*o,p'*dicofol	370.5	6.06	-7.641	74.4[c]	408[d]	612 [d]
p,p'-dicofol	370.5	6.06	-5.005	74.4[c]	1536 [d]	2304 [d]
DCBP	251	4.44[e]	-4.359[e]	103[e]	1440[e]	2880[e]
FW-152	336	4.89[e]	-7.187[e]	57.1[e]	4320[e]	8640[e]
DCBH	253	4.0[e]	-6.404[e]	25.1[e]	900[e]	1800[e]
3- and 4- OH-DCBP	267	3.96[e]	-8.343[e]	46.8[e]	1440[e]	2880[e]
2 OH-DCBP	267	4.73[e]	-5.242[e]	11.3[e]	1440[e]	2880[e]

a Maximum reported value
b Input parameters for these chemical are based on the Reference chemicals data in the OECD Tool.
c Half-life in air based on value reported in Rasenberg et al. 2003
d The half-life in water based on PRZM/EXAM inputs
e Maximum value derived in EPISuite for dicofol degradates.

Although there are considerable uncertainties in the environmental fate properties of the selected chemicals under consideration, the results (Table 64) indicate that dicofol and its degradates have Pov and LRTP properties similar to those of several known POPs (*p,p'* DDT, aldrin and endrin).

Table 64. Overall persistence and characteristic travel distances generated using the OECD Tool.

Chemical	Overall Persistence (Pov) (Days)	Characteristic Travel Distance km (Miles)	Transfer Efficiency (%)
p.p' DDT	1010	2530 (1572)	5.17
Aldrin	225	206 (128)	0.003
Endrin	1556	515 (320)	0.04
o,p'-dicofol	37	2142 (1331)	9.45
p,p'-dicofol	138	1467 (912)	3.39
DCBP	172	1381 (858)	2.24
FW-152	516	504 (313)	2.15
DCBH	108	238 (148)	0.66
3- and 4- OH-DCBP	171	149 (93)	0.31
2 OH-DCBP	173	228 (142)	0.10

Results from the OECD Tool do not indicate absolute loading of pesticides in the environment but help to compare model estimates for dicofol residues relative to known POP pesticides according to their Pov, TE, and CTD.

Annual Emission Amounts

There are two potential mechanisms that can result in transport of dicofol from an application area to the atmosphere with subsequent wet or dry deposition of the compound to areas distant from the initial site of application. These mechanisms include 1) drift of dicofol during spray treatments of fields and 2) wind erosion of soil containing sorbed dicofol.

From the CA PUR data, the average annual rate of dicofol applied between 1999 and 2006 was 223,511 lbs. From the AGDRIFT analysis, between 0.94% and 8.7% of the amount applied during aerial and ULV application, respectively, is lost due to airborne drift, or 2,101 to 19,450 lbs/year. Wet and dry deposition would result in removal of this airborne drift from the atmosphere; however, estimates of these removal processes require estimates for scavenging coefficients, particle size distributions, and settling velocities, and are beyond the level of this analysis. As such, a conservative estimate would result in all of the aerial drift, or 2,101 to 19,450 lbs/year, remaining for long-range transport.

As dicofol has an affinity to partition to particulate matter, a potentially significant source of dicofol emissions from a field would be particulate matter from windblown soil erosion. The California Air Resources Board developed non-pasture agriculture particulate matter emission estimates for a number of counties in California (CARB 1997). These emission estimates were divided by the total number of acres harvested in each county (USDA 2009) and then multiplied by the average annual acres of dicofol applied in each county (from the CA PUR data), in order to estimate the annual particulate matter per county where dicofol was used. The average annual amount of particulate matter from nonpasture windblown agricultural emissions in counties where dicofol was applied was 2,677 tons/year. If 90% of the dicofol applied is integrated into the top 1 cm of the soil, then the concentration of dicofol in the soil is 2.59×10^{-8} lbs dicofol/cm^3 (0.9 x 223,511 lbs / [192,120 acres x 4.05×10^7 cm^2/acre x 1 cm]). Assuming an average soil bulk density of 1.3 g/cm3, this equates to 9.03×10^{-6} lbs dicofol/lb soil. Multiplying this concentration by the average amount of particulate matter from nonpasture windblown agricultural emissions results in 48 lbs/year of dicofol emitted via wind erosion.

The average total annual amount of dicofol, not including that which might volatilize from the soil or wate surface, that is available for long range transport is between 2,149 and 19,500 lbs/year, or between 1 and 9% of the dicofol applied. It is worth noting that despite these estimates, air monitoring reported earlier showed only trace amounts of dicofol in the atmospheric samples collected.

DDT, DDD, DDE

In assessing the impacts of dicofol on the red-legged frog, it was assumed that the impacts of DDT, DDD, and DDE would be additive to those seen for dicofol's total residues of concern.

5.2.6.2. Effects Assessment

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.

Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on dicofol are not available for frogs or any other aquatic-phase amphibian; therefore, freshwater fish are used as surrogate species for aquatic-phase amphibians. 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.

In order to characterize the conservatism, of the endpoint selected to represent direct effects to aquatic-phase CRLF (*i.e.*, the 96-h LC_{50} for the cutthroat trout = 53 µg/L), a genus sensitivity distribution was derived using the available acute toxicity data for freshwater fish (Table 24). Data were considered useful for the distribution if they are classified acceptable or supplemental. Data for this distribution were collected from registrant-submitted studies as well as the open literature (as identified using ECOTOX). Once the data set was assembled, the average of the Log10 values of the LC_{50} values for a species was calculated. Then, the average of the Log10 values of the genera was calculated. A student's t distribution was used to derive a genus sensitivity distribution for with the mean and standard deviations of log-transformed acute toxicity data for all of the available genera of fish. The degrees of freedom were equal to n-1, where n is the number of genera for which there are data available for the distribution. In this case, data were available for 6 genera, so the distribution was established with 5 degrees of freedom. The t-statistic was calculated for probabilities ranging 0.05-0.95 at intervals of 0.05. The log LC_{50} value for a specific proportion (p) of genera is calculated by Equation 1. The genus sensitivity distribution for 96-h LC_{50} values for fish exposed to dicofol is displayed in Figure 12. Additional information relevant to this sensitivity distribution is provided in **Appendix L**. The endpoint selected to represent direct effects to aquatic-phase CRLF (LC_{50} = 53 µg/L) is comparable to the lower 5% of the genus sensitivity distribution (LC_{50} = 49 µg/L), indicating that this endpoint is protective of the lower 5th percentile of freshwater fish species.

Equation 1. $Log\ LC_{50_p} = Mean\ Log\ LC_{50} + \left(t_p * STDEV\right)$

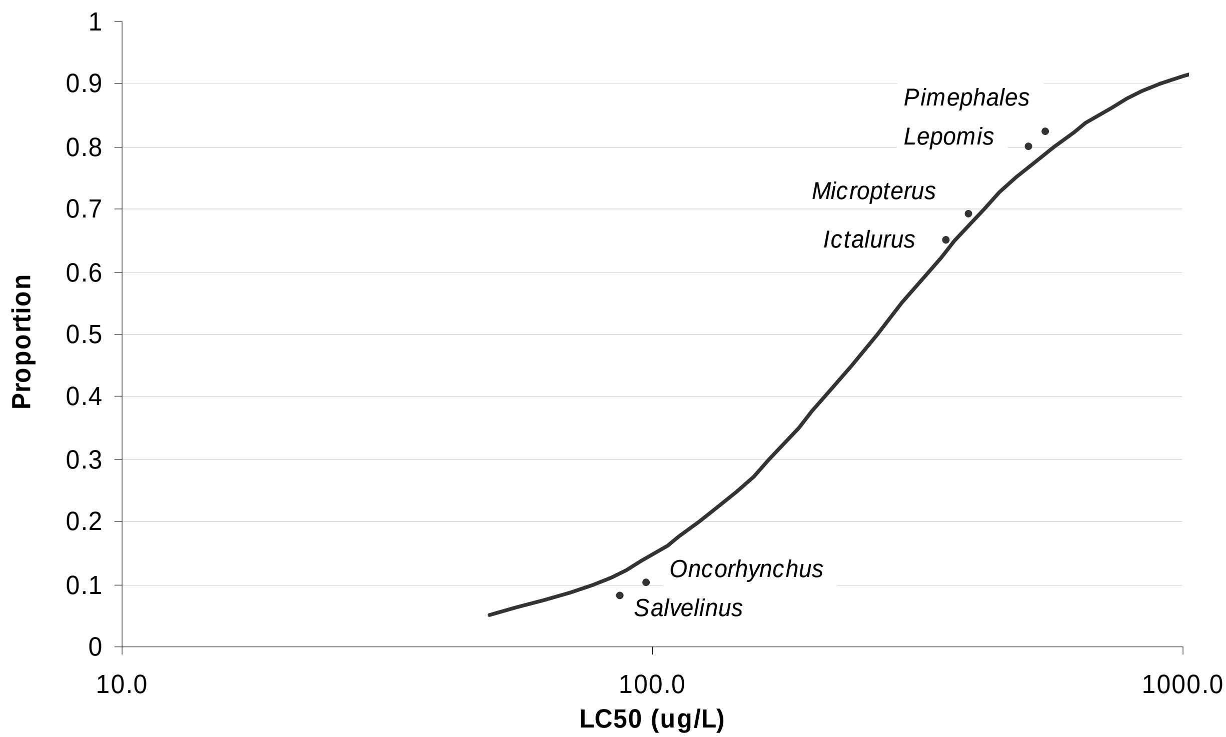


Figure 12. Genus sensitivity distribution for acute (96-h) exposures of fish to dicofol.

In order to characterize the conservatism of the endpoint selected to represent direct effects to terrestrial-phase CRLF (*i.e.*, the subacute dietary toxicity endpoint for birds, LC_{50} for the Japanese quail = 903 ppm), a species sensitivity distribution was derived using the available subacute dietary toxicity data for birds (Table 29). Data were considered useful for the distribution if they are classified acceptable or supplemental.

Data for this distribution were collected from registrant-submitted studies as well as the open literature (as identified using ECOTOX). Once the data set was assembled, the average of the log-transformed LC_{50} values for a species was calculated. Unlike with the fish data, avian data were not averaged based on genera because no data were available for multiple species within the same genera. A student's t distribution was used to derive a species sensitivity distribution for with the mean and standard deviations of log-transformed subacute toxicity data for all of the available species within taxa. The degrees of freedom were equal to n-1, where n is the number of species for which there are data available for the distribution. In this case, data were available for 4 species, so the distribution was established with 3 degrees of freedom. The t-statistic was calculated for probabilities ranging 0.05-0.95 at intervals of 0.05. The log LC_{50} value for a specific proportion (p) of genera is calculated by Equation 1. The species sensitivity distribution for LC_{50} values for birds exposed to dicofol is displayed in Figure 13. Additional information relevant to this sensitivity distribution is provided in **Appendix L**. The Japanese quail toxicity endpoint selected to represent direct effects to terrestrial-phase CRLF is comparable to the lower 10% of the species sensitivity distribution.

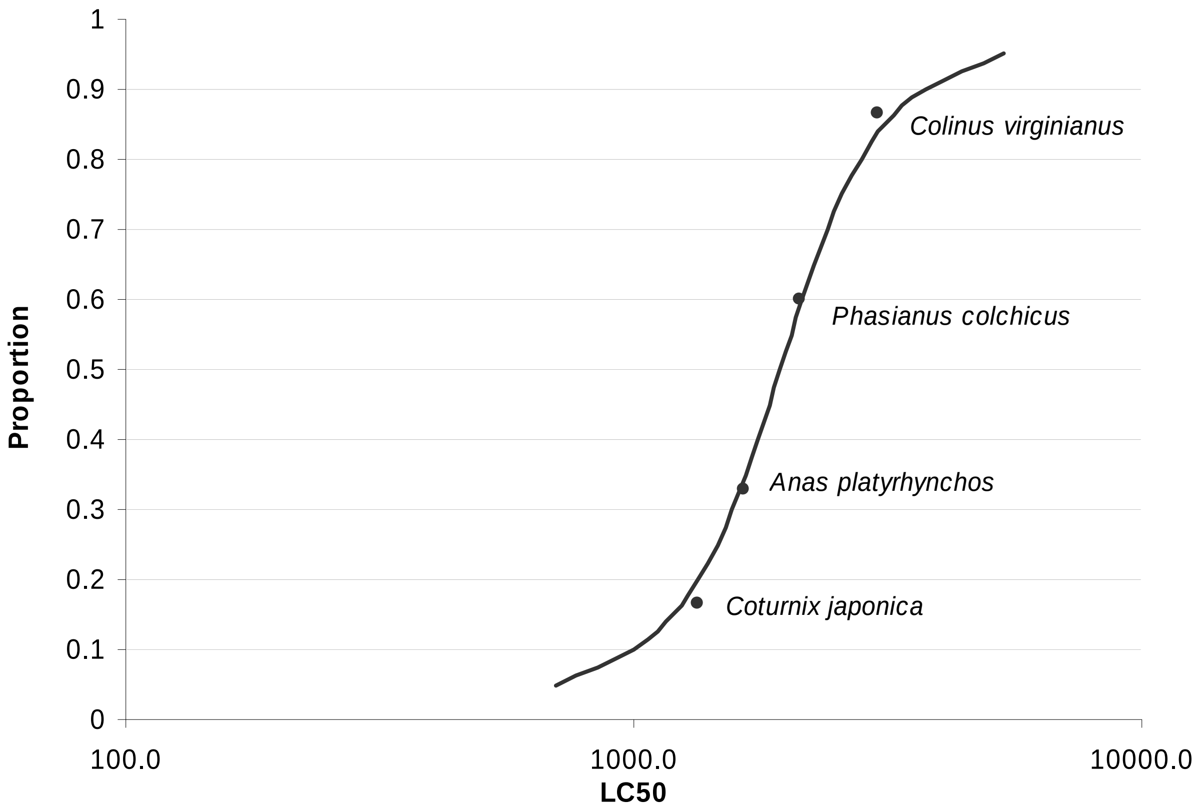


Figure 13. Species sensitivity distribution for subacute exposures of birds to dicofol.

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.

Potential for Endocrine Disruption

The extent to which dicofol may act on endocrine-mediated processes of non-target organisms, including CRLF is uncertain. EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) *"may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen, or other such endocrine effects as the Administrator may designate."* Following the recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there were scientific bases for including, as part of the program, androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. When the appropriate screening and/or testing protocols being considered under the Agency's Endocrine Disrupter Screening Program (EDSP) have been developed and vetted, dicofol may be subjected to additional screening and/or testing to better characterize effects related to endocrine disruption.

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.

5.2.7. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in section 2.9.1. Based on the conclusions of this assessment, none of the hypotheses can be rejected, meaning that the stated hypotheses represent concerns in terms of direct and indirect effects of dicofol on the CRLF and its designated critical habitat.

6.0 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 dicofol to the CRLF and its designated critical habitat.

Based on the best available information, the Agency makes a May Affect, and Likely to Adversely Affect (LAA) determination for the CRLF from the use of dicofol. Additionally, the Agency has determined that there is the potential for effects to CRLF designated critical habitat from the use of dicofol. Summaries of the risk conclusions and effects determinations for the CRLF and its critical habitat are presented in Table 65 and in Table 66, respectively. Analysis related to the intersection of the dicofol action area and CRLF habitat used in determining use patterns that result in LAA determinations are described in **Appendix B**. The LAA determination for the CRLF and potential effects to designated critical habitat is described in the baseline status and cumulative effects for the CRLF and is provided in **Attachment 2**.

Table 65. Description of evidence supporting effects determination for dicofol use in California. Assessment endpoint is survival, growth and reproduction of CRLF individuals.

Assessment Endpoint	Effects Determination	Basis for Determination
Direct effects to CRLF	LAA	-Acute RQs for aquatic-phase CRLF exceed the LOC for all uses of dicofol, except Bermuda grass and outside buildings. - Analysis of individual effects indicates that up to 1 in 2 individual CRLF could experience mortality after acute exposures to dicofol in the aquatic habitat. - Chronic RQs for aquatic-phase CRLF exceed the LOC for all uses of dicofol, except Bermuda grass, turf and outside buildings. - Chronic EECs in the aquatic environment are above levels where growth effects were observed in fish. - Acute and chronic RQs for aquatic-phase CRLF consuming aquatic organisms contaminated with dicofol (resulting from accumulation) exceed LOCs. - Refined acute, dose-based RQs (derived using T-HERPS) for medium sized CRLF consuming small herbivore mammals exceed LOCs for all uses of dicofol. - Refined acute, dietary-based RQs (derived using T-HERPS) for CRLF consuming small insects and small herbivore mammals exceed LOCs for several uses of dicofol. - Chronic dietary-based RQs for CRLF exceed LOCs for all uses of dicofol, for CRLF consuming any terrestrial food item (i.e., insects, mammals and terrestrial-phase amphibians). - Chronic, dietary-based EECs are above levels where reduced number of eggs laid was observed in birds (i.e., EECs are >40 ppm).
Indirect effects to tadpole CRLF via reduction of prey (*i.e.*, algae)		RQ values for algae are below the LOC for all uses of dicofol.
Indirect effects to juvenile CRLF via reduction of prey (*i.e.*, invertebrates)		- Acute RQs for aquatic invertebrates exceed the LOC the majority of dicofol uses. - The likelihood of individual acute effects to aquatic invertebrates is ≤3%. Based on this, indirect effects to the CRLF through acute effects to aquatic invertebrates is discountable. - Chronic RQs for aquatic invertebrates do not exceed the LOC for dicofol use on cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings. - Chronic RQs for aquatic invertebrates exceed the LOC for dicofol use on beans, citrus, cotton, grapes, hops, mint, pome fruit, stone fruit, strawberry, and walnuts/pecans.
Indirect effects to adult CRLF via reduction of prey (*i.e.*, invertebrates, fish, frogs, mice)		- Acute RQs for aquatic invertebrates exceed the LOC the majority of dicofol uses. - The likelihood of individual acute effects to aquatic invertebrates is ≤3%. Based on this, indirect effects to the CRLF through acute effects to aquatic invertebrates is discountable. - Chronic RQs for aquatic invertebrates do not exceed the LOC for dicofol use on cucurbits, peppers, tomatoes, Bermuda grass, ornamentals, turf and outside buildings. - Chronic RQs for aquatic invertebrates exceed the LOC for dicofol use on beans, citrus, cotton, grapes, hops, mint, pome fruit, stone fruit, strawberry, and walnuts/pecans. -Acute RQs for aquatic-phase amphibians and fish exceed the LOC for all uses of dicofol, except Bermuda grass and outside buildings.

Assessment Endpoint	Effects Determination	Basis for Determination
		- Use of dicofol on beans, citrus, cotton, hops, mint, pome fruit, strawberries and walnuts/pecans results in >10% likelihood of individual mortality (from acute exposures) to fish and aquatic-phase amphibians. -Use of dicofol on cucurbits, grapes, pepper, stone fruit, tomatoes, Bermuda grass, ornamentals, turf and outside buildings result in <10% chance of effects to an individual fish and aquatic-phase amphibians representing prey of the CRLF. - Chronic RQs for fish and aquatic-phase amphibians exceed the LOC for all uses of dicofol, except Bermuda grass, turf and outside buildings. - Because the LD_{50} used in deriving RQs for terrestrial invertebrates is not quantified, RQs for acute exposures of small and large terrestrial invertebrates to dicofol potentially exceed the LOC of 0.05 for all uses. - Given that dicofol is intended for control of insects, it has the potential to impact non-target insects (other than honey bees). -For use of dicofol on grapes, mint, hops, peppers, tomatoes, cucurbits, ornamentals, turf and Bermuda grass, dicofol exposures result in a chance of individual mortality to <10% of terrestrial insects. Therefore, indirect effects to the CRLF through potential effects to terrestrial invertebrates resulting from these dicofol uses are considered discountable. - Use of dicofol on citrus, pome fruits, strawberries, walnuts, pecans, beans, cotton and stone fruits could potentially result in ≥10% of mortality to small invertebrates. Although there is uncertainty in the actual effects of these exposures to terrestrial invertebrates, given that no LD50 was established, mortality to small insects resulting from dicofol applied to these crops has the potential to result in indirect effects to the CRLF. - RQ values representing acute exposures to terrestrial mammals exceed the LOC (0.1) for all uses of dicofol except: ornamentals, turf, outside buildings and Bermuda grass - Use of dicofol on citrus and pome fruits could potential result in 10.7% mortality to individual terrestrial mammals. Therefore, dicofol use on citrus and pome fruits could potentially result in indirect effects to the CRLF due to acute effects to terrestrial mammals. All other uses of dicofol result in ≤2.0% mortality to small mammals resulting from acute exposures to dicofol. Therefore, indirect effects to the CRLF through potential effects to terrestrial mammals resulting from all dicofol uses, except citrus and pome fruits, are considered discountable. - Chronic RQs exceed the LOC for terrestrial mammals for all uses of dicofol. Chronic EECs are sufficient to exceed the LOAEC for mammals where reproductive effects were observed. Therefore, chronic exposures of dicofol from all uses have the potential to indirectly affect the CRLF via impacts to terrestrial mammals serving as potential prey items. - Acute and chronic exposures of small mammals to dicofol through consumption of contaminated earthworms from fields treated with dicofol have the potential to result in effects to mammals. - Acute, dose-based RQs for terrestrial-phase amphibians serving as prey to the CRLF do not exceed the LOC. - Acute, dietary-based RQs for terrestrial-phase amphibians exceed the LOC for several uses. - Analysis of the likelihood of individual mortality using acute dietary-based RQs for terrestrial amphibians indicates that all uses of dicofol result in ≤2% chance of effects to an individual terrestrial amphibian representing prey of the CRLF. Therefore, the impact of the indirect effects to terrestrial-phase CRLFs via acute effects on terrestrial amphibians is discountable for all uses of dicofol. - Chronic, dietary-based RQs exceed the LOC by factors ranging 2x to 474x. Therefore, for all dicofol uses, there is potential for indirect effects to the CRLF resulting from chronic effects to terrestrial frogs.
Indirect effects to CRLF via		-Due to a lack of quantitative effects data for non-target plants exposed to dicofol, potential risk of dicofol to the aquatic and terrestrial habitats of the CRLF cannot be quantified and effects of dicofol to plants cannot be discounted.

Assessment Endpoint	Effects Determination	Basis for Determination
reduction of habitat and/or primary productivity (*i.e.*, plants)		-Qualitative data suggest that dicofol may result in phytotoxicity. -There is one reported incident involving effects of dicofol to plants. -Dicofol exposures to plants have the potential to cause indirect effects to aquatic phase CLRF through reduction of habitat.

Table 66. Summary of effects determination for CRLF critical habitat based on uses of dicofol in California.

Assessment Endpoint	Effects Determination	Basis for Determination
Modification of aquatic-phase primary constituent elements	**Habitat Effects**	Dicofol has the potential to modify habitat based on the aquatic-phase PCEs. - Dicofol has the potential to directly affect the aquatic-phase CRLF (See Table 59). - Dicofol has the potential to indirectly affect the aquatic-phase CRLF through effects to its prey (see Table 59). -Effects of dicofol to plants making up the aquatic habitat of the CRLF cannot be discounted.
Modification of terrestrial-phase primary constituent elements		Dicofol has the potential to modify habitat based on the terrestrial-phase PCEs. - Dicofol has the potential to directly affect the terrestrial-phase CRLF (See Table 59). - Dicofol has the potential to indirectly affect the terrestrial-phase CRLF through effects to its prey (see Table 59). -Effects of dicofol to plants making up the terrestrial habitat of the CRLF cannot be discounted.

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

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

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