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

Pesticide Effects Determination

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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 paraquat dichloride 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.

Paraquat dichloride is a contact herbicide that causes desiccation to the plants. It is applied as a flowable solution from an emulsifiable concentrate. As a result, paraquat dichloride is already dissociated into its cation, paraquat, when it is applied. Therefore, this assessment will focus on the paraquat cation. Currently, labeled uses of paraquat include various agricultural uses such as apricots, loganberries, corn, peanuts, coffee, and lettuce, as well as multiple non-agricultural uses such as airport landing fields, and commercial, industrial and institutional premises. The uses considered as part of the federal action evaluated in this assessment are listed in Table 2-2.

There are a total of three PC codes associated with paraquat; the PC code for paraquat dichloride is 061601, 061602 for paraquat bis (methyl sulfate), and 061603 for paraquat. Paraquat bis (methyl sulfate) is no longer a registered product of paraquat, but data from ECOTOX and past assessments including all three PC codes were incorporated into the paraquat cation.

Paraquat is dissipated by rapid adsorption to biological materials and clay particles. Due to the apparent adsorption strength of paraquat, these bound residues do not appear to be environmentally available. Paraquat was shown to be very immobile in soil with batch equilibrium studies conducted on four soils in the laboratory. Adsorption Kds ranged from 68-50,000. There was no desorption of paraquat from any of these soils (MRID 40762701). Due to high biological toxicity to plants and animals prior to adsorption, paraquat is subject to spray drift concerns. However, paraquat has such extremely high adsorption coefficients, it is not expected to volatilize once applied to the soil. In addition, since it is not expected to volatilize, is not a concern for atmospheric transport.

Paraquat does not hydrolyze, does not photodegrade in aqueous solutions, and is resistant to biotic degradation. Essentially no aerobic or anaerobic microbial degradation of paraquat occurred during the laboratory studies. In short and long-term field dissipation

studies, paraquat residues were shown to be persistent and to accumulate slightly with repeated applications.

Adsorbed paraquat could potentially be found in surface water systems associated with soil particles carried by erosion. Paraquat is not expected to be a contaminant of groundwater.

The only monitoring data available for paraquat was from the California Department of Pesticide Regulation (CPR) database. Out of 399 samples taken from July 2005 to October 2006, only one sample contained paraquat. The detection, at 0.24 ppb, was below the quantification limit of 1 ppb.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey and its habitats to paraquat are assessed separately for the two habitats. A Tier-I aquatic exposure model, GENEEC2, was used to estimate high-end exposures of paraquat in aquatic habitats resulting from spray drift from different uses. Peak model-estimated environmental concentrations resulting from different paraquat uses ranged from 1.6 to 33 µg/L. These estimates are supplemented with analysis of available California surface water monitoring data from U. S. Geological Survey's National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation. NAWQA did not have any available monitoring data for paraquat in California surface waters or ground water. The maximum concentration of paraquat reported by the California Department of Pesticide Regulation surface water database (0.24 µg/L) is roughly 3,717 times *lower* than the highest peak model-estimated environmental concentration.

To estimate paraquat exposures to the terrestrial-phase CRLF, and its potential prey resulting from uses involving paraquat applications, the T-REX model is used for spray treatment. The AgDRIFT model is also used to estimate deposition of paraquat on terrestrial and aquatic habitats from spray drift. The T-HERPS model is used as a refinement tool to explore amphibian-specific food intake on potential exposures to the terrestrial phase CRLF.

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 and aquatic plants, toxicity information for these taxonomic groups is also discussed. In the terrestrial habitat, indirect effects due to depletion of prey are assessed by considering effects to terrestrial insects, small terrestrial mammals, and frogs. Indirect effects due to effects to the terrestrial habitat are characterized by available data for terrestrial monocots and dicots.

QINA (4-carboxyl-1-methylpyridinium) is a degradate formed by paraquat. However, in the photodegradation in water study the quantity of degradate present was only 6% of the radioactivity of paraquat after 85 weeks of natural sunlight irradiation. Due to paraquat degrading very slowly, the minor degradate, QINA, does not pose an important environmental concern and will not be evaluated in this assessment.

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

Based on the best available information, the Agency makes a **May Affect, and Likely to Adversely Affect determination for the CRLF based on the direct effects to the terrestrial-phase CRLF, and indirect effects to the aquatic- and terrestrial-phase CRLF.** Additionally, the Agency has determined that there is the potential for effects to CRLF designated critical habitat from the use of paraquat. A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat is presented in Table 1-1 and Table 1-2. Use-specific determinations for direct and indirect effects to the CRLF are provided in Table 1-3 and Table 1-4. The non-agricultural and agricultural uses with the maximum application rates, along with the agricultural use with the median application rate, and the agricultural use with the three lowest application rates were used to bound the potential exposures from all registered uses. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2. Given the LAA determination for the CRLF and potential effects to designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment II**.

**Table 1-1 Effects Determination Summary for Paraquat Use and the CRLF**

| Assessment Endpoint | Effects Determination [1] | Basis for Determination |
|---|---|---|
| Survival, growth, and/or reproduction of CRLF individuals | **NE[1]** | **Potential for Direct Effects**<br>***Aquatic-phase (Eggs, Larvae, and Adults)***:<br><br>The aquatic phase amphibian acute LOCs for listed species (0.05) are not exceeded for any uses of paraquat in California. The chronic EECs are all less than the estimated chronic value derived from the ACR. Therefore, there are no exceedances of chronic LOCs. |
| | **LAA[1]** | ***Terrestrial-phase (Juveniles and Adults)***:<br><br>Refined acute dietary-based RQs for CRLFs consuming small insects exceed the acute listed species LOC (0.1) for all uses of paraquat except melons, RQs ranged from 1.28 (Airport/public health use/guava) to 0.06 (melons). The Refined acute dietary-based RQs for CRLFs consuming large insects and 15g small insectivore mammals resulted in paraquat use on airports/public health use/guava exceeding the listed species LOC (0.1), with an RQ of 0.14 for both. The refined acute dietary-based RQs for CRLFs consuming small herbivore mammals (15g) resulted in all uses exceeding the listed species LOC, RQs ranged from 2.17 (Airport/public health use/guava) to 0.10 (melons) and for 35g small mammals all uses except melons exceed the listed species LOC, RQs ranged from 1.50 (Airport/public health use/guava) to 0.77 (melons). There are no exceedances for CRLFs consuming small terrestrial-phase amphibians.<br><br>Refined dose-based RQs for CRLF of varying weights (1.4g, 37g and 238g) consuming small insects exceed the acute endangered species LOC (0.1) for only the Airport/public health and Guava uses of paraquat for all weights of CRLF). There are no exceedances for small sized (1.4g) CRLF consuming large insects and CRLF this size are too small to consume small mammals or small terrestrial-phase amphibians. The RQs for small sized (1.4g) CRLF are 0.27 suggesting that small CRLF consuming small insects are potentially affected by acute exposures to paraquat.<br><br>Refined dose-based RQs for medium sized (37g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat. There were also exceedances in the acute listed species LOC (0.1) for medium sized CRLF consuming small insectivore (15g) mammals for the airports/public health, guava, and ginger uses of paraquat. For medium sized CRLF consuming small insectivore (35g) mammals there were exceedances in the acute listed species LOC (0.1) for all uses of paraquat except carrots and melons. There are no exceedances for medium sized (37g) CRLF consuming large insects or small terrestrial-phase amphibians. Due to exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses, and exceedances of LOCs for CRLF consuming small insectivore mammals (either 15g or 35g) for a majority of paraquat uses indicate that the medium sized CRLF could potentially be affected by acute exposures to paraquat.<br><br>Refined dose-based RQs for large sized (238g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat except melons. There were no exceedances for |

| Assessment Endpoint | Effects Determination [1] | Basis for Determination |
|---|---|---|
| | | large sized (238g) CRLF consuming large insects, small insectivore mammals (15g or 35g), or small terrestrial-phase amphibians. The exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses except melons, indicates that the large sized CRLF could potentially be affected by acute exposures to paraquat.<br><br>Refined chronic dietary-based RQs for CRLFs consuming small insects and small herbivore mammals (either15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for all uses of paraquat. Refined chronic dietary-based RQs for CRLFs consuming large insects and small insectivore mammals (either 15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health, guava, and ginger uses of paraquat. The refined chronic dietary-based RQs for CRLFs consuming small terrestrial-phase amphibians using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health and guava uses of paraquat (the maximum uses). |
| | | **Potential for Indirect Effects** |
| | **LAA[1]** | ***Aquatic prey items, aquatic habitat, cover and/or primary productivity***<br><br>LOCs for non-vascular plants are exceeded for all uses. The non-vascular plant RQs range from 138 for airports, commercial/industrial areas, and public health areas to 4.1 for melons.<br><br>LOCs for vascular plants are not exceeded for any uses. The vascular plant RQs range from 0.77 (airports, commercial/industrial areas, public health areas) to 0.02 (melons).<br><br>LOCs for aquatic invertebrates are not exceeded for any uses. The acute RQs range from 0.730 for airports, commercial/industrial areas, and public health areas to 0.004 for melons. When comparing chronic indirect effects, the estimated chronic value at 0.174 ppm is not exceeded for any use.<br><br>For fish/frogs none of the uses exceed the LOCs for listed species. The RQs range from 0.004 for airports, commercial/industrial areas, and public health areas to < 0.001 for melons. When comparing chronic direct effects, the estimated chronic value at 1.89 ppm is not exceeded for any use. |
| | **LAA[1]** | ***Terrestrial prey items, riparian habitat***<br><br>RQs could not be calculated for terrestrial invertebrates as the endpoint was not definitive. The calculated EECs were compared to the toxicity endpoint, and it was determined that terrestrial invertebrates would not likely adversely affect the CRLF indirectly as food.<br><br>For small mammals the acute dose-based RQs exceed the Agency's LOC (0.1) for all uses of paraquat, the RQs ranged from 7.63 (airports/public health use/guava) to 0.34 (melons). The chronic dose-based RQs exceed the Agency's LOC (1.0) for all uses of paraquat, and range from 128.53 (airports/public health use/guava) to 5.78 (melons). The chronic dietary-based RQs exceed the Agency's LOC (1.0) for all uses except melons, and range from 14.81 (airports/public health use/guava) to 0.67 (melons).<br><br>The RQs for small terrestrial-phase amphibians did not exceed the listed species LOC (0.1) for any use of paraquat. Reduction in amphibian prey items, |

| Assessment Endpoint | Effects Determination [1] | Basis for Determination |
|---|---|---|
| | | specifically other frogs is not affected from paraquat use.<br><br>The RQs for non-target terrestrial monocot and dicot plants inhabiting semi-aquatic and upland dry areas do not exceed the Agency's LOC (1.0) for any uses. All aerial applications of paraquat results in spray drift exceedances for dicots (only). These exceedances range from 3.57 (Agricultural fallow/ideland maximum aerial application rate) to 1.07 (Melons, minimum aerial application rate). |

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

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

| Assessment Endpoint | Effects Determination | Basis for Determination |
|---|---|---|
| Modification of aquatic-phase PCE | **May affect** | Due to aquatic non-vascular and terrestrial plant communities being reduced from a majority of use sites, there is potential for alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond. These plant communities provide shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs. In addition, there is potential for 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.<br><br>LOCs are exceeded for terrestrial riparian plants and for aquatic non-vascular plants from exposure to paraquat from spray drift. LOCs for non-vascular plants are exceeded for all uses of paraquat. |
| Modification of terrestrial-phase PCE | **May affect** | The use of paraquat at all sites may create the following effects to PCE: elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs, elimination and/or disturbance of dispersal habitat, reduction and/or modification of food sources for terrestrial phase juveniles and adults, and alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.<br>The RQs for vascular plants did not exceed the Agency's LOC (1.0) for any uses of paraquat in California.<br><br>The RQs for non-target terrestrial monocot and dicot plants inhabiting semi-aquatic and upland dry areas do not exceed the Agency's LOC (1.0) for all uses. All aerial applications of paraquat results in spray drift exceedances for dicots (only).<br><br>The use of paraquat on most use sites will exceed the revised acute dietary- and dose-based LOC and chronic LOC for prey food items of small mammals, and invertebrates. Food sources for the CRLF are reduced, and the CRLF is indirectly affected from this reduction. |

**Table 1-3 Paraquat Use-specific Direct Effects Determinations[1] for the CRLF**

| Use(s) | Aquatic Habitat | | Terrestrial Habitat | |
|---|---|---|---|---|
| | Acute | Chronic | Acute | Chronic |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | NE | NE | LAA | LAA |
| GUAVA | NE | NE | LAA | LAA |
| GINGER | NE | NE | LAA | LAA |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER | NE | NE | LAA | LAA |
| CORN (SILAGE) | NE | NE | LAA | LAA |
| MELONS | NE | NE | NLAA | LAA |

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

**Table 1-4 Paraquat Use-specific Indirect Effects Determinations[1] Based on Effects to Prey**

| Use(s) | Algae | Aquatic Invertebrates | | Terrestrial Invertebrates (Acute) | Aquatic-phase frogs and fish | | Terrestrial-phase frogs | | Small Mammals | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Acute | Chronic | | Acute | Chronic | Acute | Chronic | Acute | Chronic |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/ INSTITUTIONAL/ INDUSTRIAL PREMISES/ EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/ FENCEROWS/ HEDGEROWS | LAA | NE | NE | NLAA | NE | NE | LAA | LAA | LAA | LAA |
| GUAVA | LAA | NE | NE | NLAA | NE | NE | LAA | LAA | LAA | LAA |
| GINGER | LAA | NE | NE | NLAA | NE | NE | LAA | LAA | LAA | LAA |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER | LAA | NE | NE | NLAA | NE | NE | LAA | LAA | LAA | LAA |
| CORN (SILAGE) | LAA | NE | NE | NLAA | NE | NE | LAA | LAA | LAA | LAA |
| MELONS | LAA | NE | NE | NLAA | NE | NE | NLAA | LAA | LAA | LAA |

[1] NE = No effect; NLAA = May affect, not likely to adversely affect; LAA = Likely to adversely affect

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 1998), 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 paraquat on a range of uses such as commercial and industrial non-agricultural uses, fruits, vegetables, feed for livestock, ornamental shrubs, flowers, and trees. 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 GENEEC2, T-REX, and AgDRIFT, all of which are described at length in the Overview Document. Additional refinements include the use of the T-HERPS model and PRZM/EXAMS when appropriate based on results of GENEEC2.

The T-HERPS model is used as a refinement tool to explore amphibian-specific food intake on potential exposures to the terrestrial phase CRLF. 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 paraquat is based on an action area. The action area is the area directly or indirectly affected by the federal action, as indicated by the exceedance of the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of paraquat 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 paraquat 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 methods show no direct or indirect effects (no LOC exceedances) upon individual CRLFs or upon the PCEs of the species' designated critical habitat, a "no effect" determination is made for use of paraquat 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 paraquat.

If a determination is made that use of paraquat 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 paraquat use sites) and further evaluation of the potential impact of paraquat on the PCEs is also used to determine whether effects to designated critical habitat may occur. Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the CRLF or affect the PCEs of its designated critical habitat. This information is presented as part of the Risk Characterization in Section 5 of this document.

The Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because paraquat is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for paraquat 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 paraquat 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

Please see Table 2-2 for a range of currently registered uses of paraquat in CA.

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

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

There are three PC codes associated with paraquat; 061601 for paraquat dichloride, 061602 for paraquat bis (methyl sulfate), and 061603 for paraquat. Paraquat bis (methyl sulfate) is no longer a registered product of paraquat, and the PC code for paraquat alone its unclear if it is the cation or not. Since paraquat dichloride and the paraquat cation are used interchangeably within the literature and in past assessments. For our assessment, data from all three PC codes and chemicals were incorporated, and converted to the paraquat cation.

QINA (4-carboxyl-1-methylpyridinium) is a minor photodegradate of paraquat. However, in the photodegradation in water study the quantity of degradate present was only 6% of the radioactivity of paraquat after 85 weeks of natural sunlight irradiation. Due to paraquat degrading very slowly, the minor degradate, QINA, does not pose as an important environmental concern and will not be evaluated in this assessment.

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

Document and the Services' Evaluation Memorandum (U.S., EPA 2004; USFWS/NMFS 2004).

Paraquat has registered products that contain multiple active ingredients. The results of available toxicity data for mixtures of paraquat with other pesticides are presented in Appendix B; however, there are no toxicity data for paraquat Multi-AI products. There are available open literature data from ECOTOX and three studies which contained information examining toxicity effects of paraquat when mixed with other chemicals. According to the available open literature data, other pesticides may combine with paraquat to produce additive, and/or antagonistic toxic effects. Mixtures included paraquat with linuron, and paraquat with copper sulfate.

## 2.3 Previous Assessments

Paraquat was discovered in 1882 and was registered in England in 1962 prior to being registered in the United States in 1964 for use as a contact herbicide to control or suppress a broad spectrum of emerged weeds under the name paraquat dichloride. The Agency classified paraquat dichloride as a restricted use pesticide due to high acute toxicity to animals and people in 1978 (February 9, 1978 (43 FR 5782)). Under the restricted use classification, only certified applicators or applicators working under their direct supervision, are authorized to apply paraquat dichloride end-use products.

Also in 1978, paraquat dichloride was accepted as a candidate for the Special Review board process because it was believed to exceed the risk criteria under 40 CFR 162.11: teratogenicity, lack of emergency treatment, chronic effects, reproductive effects, oncogenicity (data gap), mutagenicity (data gap), and acute effects. Other areas of concern included mammalian toxicity and avian reproductive effects.

In October 1982 (43 FR 30613), the Agency issued a Final Position Document which concluded that the available data did not support paraquat dichloride being placed into the Special Review status since the risk criteria identified in 1978 had not been exceeded. As a result, a Data Call-In (DCI) was issued requesting additional dermal and inhalation data, and more precise information to assess the potential acute effects to applicators.

In June 1987, a Registration Standard for paraquat dichloride was issued (NTIS#PB88-217005) in which the Agency evaluated the studies submitted as a result of the previous DCI. In 1991, additional data were requested and evaluated for use in the 1997 Reregistration Eligibility Decision (RED). In the 1997 RED, the Agency requested additional data in order to establish tolerances on taro foliage, corn and soybean aspirated grain fractions, wheat and hay, cotton and gin byproducts, and processed grapes, as well as data to confirm that the existing tolerance for field corn was adequate to cover the specialized use of paraquat as a harvest aid.

To mitigate risks of concern posed by the use of paraquat, the Agency noted a number of label amendments to address the worker, and ecological concerns.

- The maximum application rate for all paraquat dichloride products will be lowered from 1.6 lb cation/A to 1.0 lb cation/A.

    - Broadcast applications with backpack sprayers (non-spot) should not exceed the application rate 0.625 lb cation/A and the application volume should be no less than 20 gallons/A.
    - The maximum application rate for spot spraying on all paraquat labels will be no more than 0.0195 lbs cation/gallon.
- Remove the plastic acid bottle and tree injection directions for use from the resin soaking sections of all paraquat dichloride labels.
- Include the hazard statement "Paraquat dichloride is toxic to non-target crops and plants if off-target movement occurs. Extreme care must be taken to ensure that off-target drift is minimized to the greatest extent possible."
- For sole-active-ingredients end-use products that contain paraquat, the product labeling must be revised to adopt the handler personal protective equipment/engineering control requirements and remove any conflicting PPE requirements.
    - For multiple-active-ingredient end-use products that contain paraquat, the handler personal protective equipment/engineering control requirements set forth in this section must be compared to the requirements on the current labeling and the more protective must be retained.
- Implement best management practices (BMPs) to reduce spray drift, including BMPs for controlling droplet size, boom length, application height, swath adjustment, wind, temperature and humidity, temperature inversions, and sensitive areas.
- Implement use of PPE and engineering controls for workers.

A drinking water assessment was performed March 15, 2000, which determined paraquat under most circumstances was unlikely to infiltrate past the first few centimeters of soil, or to move off-field dissolved in runoff. Yet, monitoring data has demonstrated that despite its apparent immobility, paraquat can reach ground water. Paraquat was reported in 11 out of 971 wells sampled between 1983 and 1990 (USEPA Pesticides in Groundwater Database, 1992) with 65 samples taken from private drinking water wells having concentrations greater than 100 μg/L. These wells were located in coarse-grained glacial soils that are extremely permeable, with saturated hydraulic conductivities on the order of 20,000 ft/day (T.Mesko, USGS, personal communication). Detections were also reported in household wells at concentrations ranging up to 1.52 μg/L (Mostaghimi *et al.* 1998). Data in Smith and Mayfield (1978) suggests that the application of fertilizer may enhance the mobility of paraquat. The extremely slow breakdown of sorbed paraquat also suggests the possibility that saturation and breakthrough may occur after years of repeated application on some soils. Because of its strong cation-exchange sorption to soils, runoff modeling is not appropriate for paraquat dichloride. In most circumstances, the levels of paraquat residues in surface or ground water are expected to be insignificant. Because it should sorb to suspended sediment, coagulation and flocculation processes in drinking water treatment plants are likely to remove any paraquat residues present in the raw water. Residues of paraquat in drinking water derived from surface supplies can therefore be assumed to be negligible. For residues in ground water it was recommended to use the value of 1.52 μg/L for human exposure assessment.

On March 30, 2006, a risk assessment for proposed new uses of paraquat dichloride on cantaloupe, cucumber, summer squash, ginger, okra, onion, tanier, and wheat was performed. With the exception of wheat (where aerial and/or ground spray was to be allowed), the proposed new uses are for ground spray only. In most cases no more than 2.0 lbs a.i./A per season will be allowed. The exception is for the proposed use on ginger, for which a maximum of 6.0 lbs a.i./A per year is directed. The 2006 risk assessment concluded that these new uses are expected to have acute toxicological effects to terrestrial aquatic wildlife, aquatic plants, and terrestrial plants, and chronic toxicological effects on terrestrial wildlife. Likewise, the assessment determined that sub-lethal effects include lung damage in rats and oxidative stress in all organisms, which can lead to premature aging as well as early demise.

On July 31, 2006, uses on ginger and okra were proposed, and the uses on soybeans, wheat, cotton, cucurbits, onions, and tanier were amended. In this Human Health Risk Assessment (HED):

- Tolerances were established or amended for the uses
- The registrant requested amended registration for use on cotton, soybean, wheat, ginger, dry bulb onion, okra, and tanier (March 30, 2006 EFED assessment). In this assessment, the registrant proposed to cancel the addition of those uses, but did propose an amended use on cucurbits.
- Registrant needs to propose maximum seasonal rates for cotton, cucurbits, ginger, soybeans, and wheat, minimal retreatment intervals for multiple post emergence applications, and the directions for tanier needs to be modified to specify its geological restrictions in Florida.
- Crop field trials for certain uses were requested.

## 2.4 Stressor Source and Distribution

### 2.4.1 Environmental Fate Assessment

The primary route of environmental dissipation of paraquat is adsorption to soil clay particles. Paraquat does not hydrolyze, does not photodegrade in aqueous solutions, and is resistant to microbial degradation under aerobic and anaerobic conditions. Essentially no microbial degradation of paraquat was seen after 180 days of aerobic incubation or after 60 days of anaerobic incubation following a 30 day aerobic incubation.

Paraquat was shown to be very immobile in soil with batch equilibrium studies conducted on four soils in the laboratory. High rates of paraquat were added because at realistic field application rates, paraquat was below detection in the batch equilibrium adsorption solution. Adsorption Kds ranged from 68-50,000, and there was no detectable desorption.

In laboratory studies with radiolabeled paraquat, no radioactivity volatilized from the soil surface to adsorb to glass or to collect in volatile traps. With low vapor pressure and extremely high adsorption coefficients, paraquat would not be expected to volatilize once

applied to the soil, but spray drift could potentially be an issue since paraquat is extremely biologically active and toxic to plants and animals.

In short and long term field dissipation studies, paraquat residues were extractable only by acid reflux and were shown to be persistent and to accumulate slightly with repeated applications. Paraquat is dissipated by rapid adsorption to clay particles. Due to the apparent adsorption strength of paraquat for soil clays, these bound residues do not appear to be environmentally available. Adsorbed radiolabeled paraquat did undergo isotopic exchange when soil samples were shaken with a highly concentrated, non-labeled paraquat solution (7440 ppm paraquat in water), so the potential for desorption does exist; however, since there was no apparent exchange with calcium chloride in the batch equilibrium study, this exchange will probably not affect the environmental behavior of paraquat.

Paraquat is very persistent and is more likely to enter surface waters systems associated with soil particles carried by erosion that will most likely be found sorbed onto eroded particles at or near the application site rather than dissolved in the water column. Therefore, this chemical is expected to be transported primarily along with soil particles and subsequently redeposited onto the beds of surface water bodies or lowland areas that receive eroded sediments from uplands (e.g., riparian zones, wetlands). The primary route for dissipation of paraquat in the environment is through sorption onto solids; once sorbed, paraquat is very difficult to extract. As a result, paraquat is not expected to be a contaminant of groundwater, except in soils with very low clay content.

In previous reviews (reviews by Jordan, 2/14/1986), a minor photodegradate, 4-carboxyl-1-methylpyridinium (QINA) which comprised 6% of applied radioactivity after 85 weeks of natural sunlight irradiation, was determined to be mobile. According to the field data reviewed in this submission which showed that paraquat degraded very slowly, QINA would apparently not be an important environmental concern.

Table 2-1 lists the environmental fate properties of paraquat, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

**Table 2-1 Summary of Paraquat Environmental Fate Properties**

| Study | Value (units) | Major Degradates<br>*Minor Degradates* | MRID # | Study Status |
|---|---|---|---|---|
| Hydrolysis | Stable at pH 5, 7, 9 | No degradates reported | Upton et al., 1985 | Acceptable |
| Direct Aqueous Photolysis | Stable | No degradates reported<br>$CO_2$ (0.15%)<br><br>4-carboxyl-1-methylpyridinium (QINA) (6%) | MRID 40562301<br><br>(Jordan, 1986) | Acceptable<br><br>Supplemental |
| Soil Photolysis | Stable | No degradates reported | MRID 146807 | Acceptable |

| Study | Value (units) | Major Degradates<br>*Minor Degradates* | MRID # | Study Status |
|---|---|---|---|---|
| Aerobic Soil Metabolism | Stable | Did not degrade. No degradates reported. | MRID 41319301 | Acceptable |
| Anaerobic Soil Metabolism | Stable | No degradates reported. 0.29% uncharacterized radioactivity. | MRID 41319302 | Acceptable |
| Anaerobic Aquatic Metabolism | No Study | No Study | No Study | No Study |
| Aerobic Aquatic Metabolism | <2 weeks (only represents water phase. Did not measure amount of paraquat sorbed to the soil) | No degradates reported | MRID 00055093 | Supplemental |
| $K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g)<br><br>$K_{oc\text{-}ads}$ / $K_{oc\text{-}des}$ (mL/g) | 68 – 50,000 (no measureable correlation with % OC)<br><br>15,473 to 1,000,000 | No degradates reported | MRID 40762701<br><br>http://www.ermanz.govt.nz/consultations/ceir/t.pdf | Acceptable<br><br>Supplemental |
| Terrestrial Field Dissipation | Half-life not calculated; however, cited reference indicates a half-life of > 10 years | No degradates reported. | MRID 41293202<br>42802101<br>42738701<br>42738702<br>42802102 | Acceptable |
| Aquatic Field Dissipation | No Study | No Study | No Study | No Study |

### 2.4.2 Environmental Transport Assessment

Potential transport mechanisms include pesticide spray drift, and secondary drift of soil-bound residues leading to deposition onto nearby or more distant ecosystems. Spray drift is expected to be the major route of exposure for paraquat.

In general, deposition of drifting pesticides is expected to be greatest close to the site of application. A computer model of spray drift (AgDRIFT) is used to determine potential exposures to aquatic and terrestrial organisms via spray drift. The distance of potential impact away from the use sites (action area) is determined by the distance required to fall below the LOC for airports/commercial/public health areas (non-agricultural use) and guava (agricultural use). These uses have the greatest application rate, greatest number of applications per season, and the least amount of time between applications.

Due to model limitations, it may not be possible to provide a quantitative estimate of exposure with known uncertainty, beyond the range of AgDRIFT.

### 2.4.2 Mechanism of Action

Paraquat dichloride is a quaternary nitrogen compound widely used for broadleaf weed control. It is a fast-acting contact herbicide used to suppress or eradicate a wide spectrum of post-emergent weeds. It also functions as a defoliant and desiccant and is most effective on growing plants with abundant green tissue. It is highly toxic (EPA toxicity class I) but readily immobilized. Paraquat is quickly absorbed by living (esp. healthy) plant tissue and produces superoxides during photosynthesis, which destroy plant cells. It is less effective on dry, drought-stressed, woody, or fully mature plants.

### 2.4.3 Use Characterization

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

There are a few uses that are not being assessed because they are either restricted in California or the crop is not grown in California. The following uses will not be assessed because they are not grown in California: cocoa, coffee, banana, plantain, pineapple, and soybeans. If the use patterns indicate that these crops are grown in CA in the future, the conclusions of this assessment may need to be revisited. The following uses, listed with their respective labels, will not be assessed because they are restricted in California:

- Label 100-1217, Label 48273-00027: asparagus, broad beans, dried beans, moth beans, mung beans, rice beans, lima beans, snap beans, tepary beans, urd beans, catjang, cowpea/blackeyed pea, garbanzos, guar, lentils, lupine, pastures, and dried and southern peas.
- Label 66222-00130 and Label 74530-00032: asparagus, broad beans, dried beans, moth beans, mung beans, rice beans, lima beans, tepary beans, urd beans, catjang, cocoa, cowpea/blackeyed pea, garbanzos, guar, lentils, lupine, pastures, dried and southern peas, and persimmon.
- Label 82542-00003 and Label 82557-00001: asparagus, broad beans, dried beans, moth beans, mung beans, rice beans, lima beans, tepary beans, urd beans, catjang, cocoa, cowpea/blackeyed pea, garbanzos, guar, lentils, lupine, pastures, and dried and southern peas.

The labels listed below are Section 24c labels for paraquat in other states and do not apply to California. As a result, they will not be assessed in this assessment.

- Label CO06000700: alfalfa.
- Label ID08000900 and WY08000600: clover.
- Label MS05002100: agricultural crops/soils.
- Label NC06000400: sage.
- Label NJ06000100 and VA06000200: unspecified vegetables.
- Label TX06001700, TX08001900, and TX08002000: cotton

Table 2-2 presents the uses and corresponding application rates and methods of application considered in this assessment.

**Table 2-2 Paraquat Uses Assessed for the CRLF[1]**

| Use (Application Method) | Max. Single Appl. Rate (lb ai/A) | Max. Number of Application per Year | Application Method |
|---|---|---|---|
| ACEROLA (WEST INDIES CHERRY), APRICOT, CHERRY, NECTARINE, PEACH, PLUM, KIWI FRUIT | 1.0 | 3 | Ground |
| DECIDUOUS FRUIT TREES (UNSPECIFIED), FOREST TREES (SOFTWOODS - CONIFERS) | | | |
| AGRICULTURAL FALLOW/IDLELAND | 1.0 | 5 | Aircraft |
| | | | Ground |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 1.0 | 10 | Ground |
| ALFALFA, BROCCOLI, ENDIVE (ESCAROLE), LETTUCE | 1.0 | 2 | Aircraft |
| | | | Ground |
| RHUBARB | | | Ground |
| ALMOND, BEECH NUT, BRAZIL NUT, BUTTERNUT, CASHEW, CHESTNUT, CHINQUAPIN, FILBERT (HAZELNUT), HICKORY NUT, MACADAMIA NUT (BUSHNUT), PECAN, PISTACHIO, WALNUT (ENGLISH/BLACK), APPLE, FIG, ORCHARDS (UNSPECIFIED), PEAR, PRUNE, ARBORVITAE/ ASH /ELM /FIR /OAK /PINE (FOREST/SHELTERBELT), AVOCADO, CALAMONDIN, CITRON (CITRUS), GRAPEFRUIT, KUMQUAT, LEMON, LIME, ORANGE, PAPAYA, PUMMELO (SHADDOCK), GRAPES, ORNAMENTAL AND/OR SHADE TREES, WOODY SHRUBS AND VINES | 1.0 | 5 | Ground |
| ARTICHOKE | 1.0 | 3 | Ground |
| CABBAGE, CABBAGE - CHINESE, COLLARDS, | | | Aircraft |
| | | | Ground |
| ASPARAGUS, RICE, BARLEY, SAFFLOWER (UNSPECIFIED), SMALL GRAINS (UNSPECIFIED), SORGHUM, WHEAT, CAULIFLOWER, CORN (UNSPECIFIED)/ SWEET/ FIELD/ POP, SUNFLOWER, COTTON (UNSPECIFIED) | 1.0 | 3 | Aircraft |
| | | | Ground |

| Use (Application Method) | Max. Single Appl. Rate (lb ai/A) | Max. Number of Application per Year | Application Method |
|---|---|---|---|
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER, CHAYOTE, CUCUMBER, GOURD (WAX) - CHINESE, GOURDS, MELONS - BITTER (BALSAM PEAR)/ CANTALOUPE/ CITRON /MUSK /WATER, PEPINO (MELON PEAR), PUMPKIN, SQUASH (ALL OR UNSPECIFIED), EGGPLANT, GROUNDCHERRY (STRAWBERRY TOMATO/TOMATILLO), TOMATILLO, TOMATO, TURNIP (GREENS) | | | Ground |
| | | | Aircraft |
| GARLIC, ONION | 1.0 | 1 | Ground |
| BLACKBERRY, BOYSENBERRY, ELDERBERRY, GOOSEBERRY, HUCKLEBERRY, LOGANBERRY, RASPBERRY (BLACK - RED), BLUEBERRY, CURRANT | 1.0 | 5 | Ground |
| BRUSSELS SPROUTS, KALE, VEGETABLES (UNSPECIFIED), KOHLRABI | 1.0 | 3 | Aircraft |
| | | | Ground |
| CITRUS HYBRIDS OTHER THAN TANGELO, TANGELO, CRABAPPLE, LOQUAT, QUINCE, MAYHAW (HAWTHORN) | 1.0 | 5 | Ground |
| CORN (SILAGE), STRAWBERRY | | | |
| GUAR | | | Ground |
| PASTURES, POTATO - WHITE/IRISH | 0.5 | 3 | Aircraft |
| | | | Ground |
| GHERKIN, SUGAR BEET | | | Aircraft |
| | | | Ground |
| GRASSES GROWN FOR SEED | 1.0 | 3 | Ground |
| GINGER | 1.0 | 6 | Ground |
| GUAVA | 1.0 | 10 | Ground |
| MELONS | 0.3 | 1 | Aircraft |
| | | | Ground |
| MINT/PEPPERMINT/SPEARMINT | 0.8 | 2 | Aircraft |
| | | | Ground |
| OKRA | 1.0 | 1 | Ground |
| OLIVE | 1.0 | 4 | Ground |

| Use (Application Method) | Max. Single Appl. Rate (lb ai/A) | Max. Number of Application per Year | Application Method |
|---|---|---|---|
| PASSION FRUIT (GRANADILLA) | 1.0 | 10 | Ground |
| PEANUTS (UNSPECIFIED) | 0.3 | 1 | Ground |
| PERSIMMON | 0.9 | 5 | Ground |

[1] Uses assessed based on memorandum from SRRD dated February 5, 2009

Provided below, Figure 2-1 shows the estimated poundage of paraquat uses across the United States. The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website.

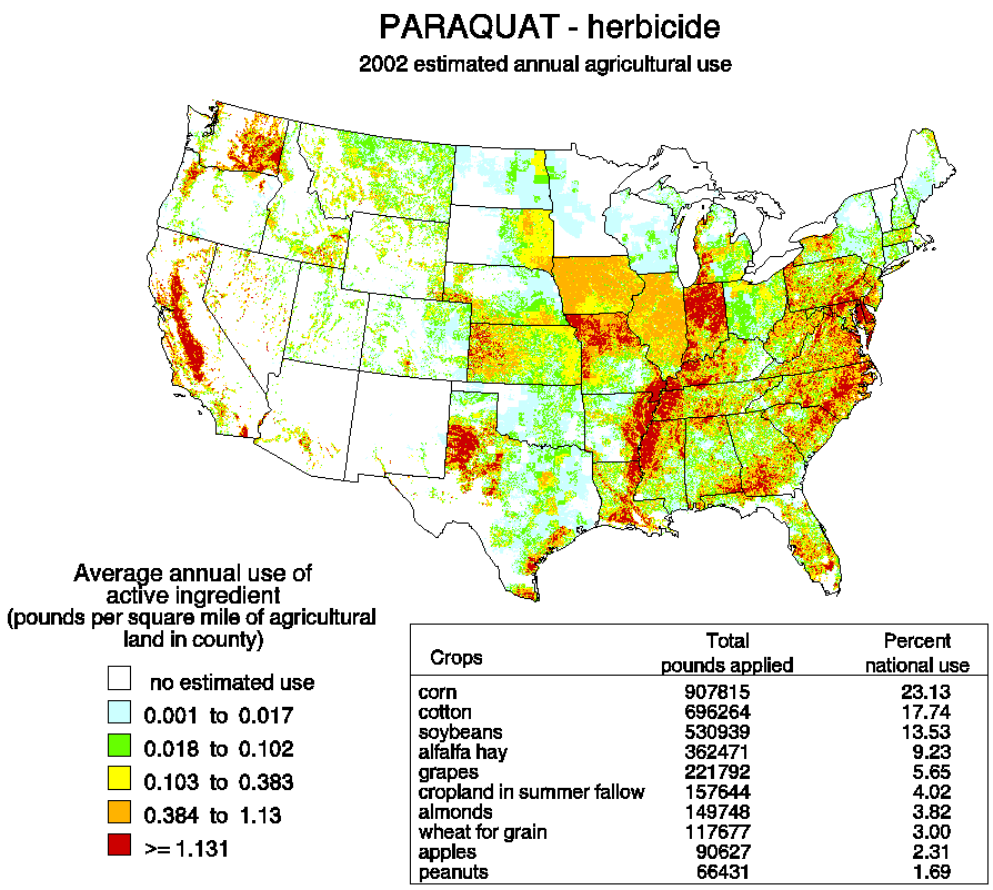



**Figure 2-1 Paraquat Use in Total Pounds per County**

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Memo: County-Level Usage for Propanil, Paraquat Dichloride, Pendimehtalin, Myclobutanil, Prometryn, Dicofol, Alachlor, and Endosulfan in California in Support of a Red Legged Frog Endangered

Species Assessment, 04 February 2009) using state-level usage data obtained from USDA-NASS[1], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[2] . CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for paraquat by county in this California-specific assessment were generated using CDPR PUR data. Eight years (1999-2006) of usage data were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all eight years. The units of area treated are also provided where available.

The usage data reported by CDPR PUR summarizing paraquat's usage for all California use sites is provided below in Table 2-3. The uses range from commercial and industrial non-agricultural uses to agricultural uses such as fruits, vegetables, feed for livestock, and ornamental shrubs, flowers, and trees. 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 reported use, such as may be seen in the CDPR PUR database, represent either historic uses that have been canceled, mis-reported uses, or mis-use. Historical uses, mis-reported uses, and misuse are not considered part of the federal action and, therefore, are not considered in this assessment.

**Table 2-3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2006 for Currently Registered Paraquat Uses**

| Site Name | Average Pounds All Uses | Avg App Rate All Uses | Avg 95th% App Rate | Avg 99th% App Rate | Avg Max App Rate |
|---|---|---|---|---|---|
| ALFALFA | 3,034.6 | 0.7 | 1.0 | 1.3 | 2.4 |
| ALMOND | 8,778.1 | 0.9 | 1.4 | 2.2 | 5.5 |
| APPLE | 234.2 | 0.8 | 1.6 | 2.5 | 3.2 |
| APRICOT | 79.6 | 0.9 | 1.4 | 2.1 | 3.0 |
| ARTICHOKE, GLOBE | 432.8 | 0.9 | 1.1 | 1.1 | 2.5 |
| ASPARAGUS | 189.8 | 1.0 | 1.3 | 1.3 | 1.3 |
| AVOCADO | 31.1 | 0.9 | 2.0 | 2.4 | 2.4 |

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

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

| Site Name | Average Pounds All Uses | Avg App Rate All Uses | Avg 95th% App Rate | Avg 99th% App Rate | Avg Max App Rate |
|---|---|---|---|---|---|
| BARLEY | 21.2 | 0.7 | 0.8 | 0.8 | 0.8 |
| BEAN, DRIED | 43.4 | 0.9 | 1.1 | 1.1 | 1.1 |
| BEAN, SUCCULENT | 46.6 | 1.1 | 1.5 | 2.5 | 2.9 |
| BEAN, UNSPECIFIED | 11.9 | 1.0 | 1.8 | 1.8 | 1.8 |
| BLACKBERRY | 18.1 | 0.8 | 1.0 | 4.2 | 4.2 |
| BLUEBERRY | 317.0 | 0.9 | 2.2 | 2.6 | 2.6 |
| BOYSENBERRY | 8.8 | 0.7 | 1.2 | 1.2 | 1.2 |
| BROCCOLI | 59.3 | 0.9 | 1.2 | 1.2 | 1.2 |
| BRUSSELS SPROUT | 0.2 | 1.3 | 1.3 | 1.3 | 1.3 |
| BUILDINGS/NON-AG OUTDROOR | 2.9 | 1.3 | 1.3 | 1.3 | 1.3 |
| CABBAGE | 9.6 | 1.1 | 1.5 | 1.5 | 1.5 |
| CANTALOUPE | 57.6 | 0.8 | 1.1 | 1.1 | 1.1 |
| CARROT | 46.7 | 1.1 | 1.1 | 1.1 | 1.1 |
| CAULIFLOWER | 20.5 | 1.1 | 1.2 | 2.2 | 2.2 |
| CHERRY | 439.4 | 0.9 | 1.6 | 2.3 | 3.5 |
| CHESTNUT | 16.3 | 0.7 | 1.3 | 1.3 | 1.3 |
| CHINESE CABBAGE (NAPPA) | 21.5 | 1.0 | 1.1 | 1.1 | 1.1 |
| CHRISTMAS TREE | 2.2 | 0.9 | 0.9 | 0.9 | 0.9 |
| CITRUS | 24.9 | 0.8 | 1.1 | 1.3 | 1.3 |
| COLLARD | 8.5 | 1.0 | 1.0 | 1.0 | 1.0 |
| CORN (FORAGE - FODDER) | 576.1 | 1.0 | 1.3 | 1.4 | 2.4 |
| CORN, HUMAN CONSUMPTION | 26.6 | 1.5 | 1.6 | 1.6 | 1.6 |
| COTTON | 15,389.3 | 0.5 | 1.0 | 1.1 | 2.6 |
| CUCUMBER | 48.6 | 1.0 | 1.8 | 2.0 | 2.0 |
| DITCH BANK | 9.7 | 2.3 | 4.8 | 4.8 | 4.8 |
| EGGPLANT | 19.5 | 1.1 | 1.6 | 1.6 | 1.6 |
| ENDIVE (ESCAROLE) | 2.2 | 1.4 | 1.4 | 1.4 | 1.4 |
| FIG | 56.6 | 0.8 | 1.1 | 1.3 | 1.3 |
| FORAGE HAY/SILAGE | 7.4 | 0.7 | 0.9 | 0.9 | 0.9 |
| GARLIC | 27.2 | 1.0 | 1.0 | 1.0 | 1.0 |
| GRAIN | 7.4 | 0.6 | 0.6 | 0.6 | 0.6 |
| GRAPE | 4,519.4 | 0.9 | 1.3 | 1.5 | 2.9 |
| GRAPE, WINE | 2,574.0 | 0.7 | 1.2 | 1.6 | 2.6 |
| GRAPEFRUIT | 22.6 | 0.8 | 1.2 | 3.1 | 3.1 |
| GRASS, SEED | 23.1 | 1.0 | 1.0 | 1.0 | 1.0 |
| INDUSTRIAL SITE | 0.2 | 0.9 | 0.9 | 0.9 | 0.9 |
| KALE | 0.4 | 1.2 | 1.2 | 1.2 | 1.2 |
| KIWI | 95.0 | 1.8 | 3.9 | 5.2 | 5.2 |

| Site Name | Average Pounds All Uses | Avg App Rate All Uses | Avg 95th% App Rate | Avg 99th% App Rate | Avg Max App Rate |
|---|---|---|---|---|---|
| KOHLRABI | 0.6 | 1.3 | 1.3 | 1.3 | 1.3 |
| LANDSCAPE MAINTENANCE | 6.6 | 1.7 | 2.2 | 2.2 | 2.2 |
| LEMON | 96.8 | 0.9 | 1.5 | 3.7 | 3.7 |
| LETTUCE, HEAD | 320.1 | 1.3 | 1.9 | 2.5 | 3.9 |
| LETTUCE, LEAF | 57.4 | 1.1 | 1.5 | 1.5 | 1.5 |
| MELON | 41.8 | 0.9 | 1.0 | 1.0 | 1.0 |
| MINT | 373.6 | 0.7 | 0.9 | 2.6 | 2.9 |
| NECTARINE | 894.2 | 0.7 | 1.2 | 1.9 | 2.8 |
| N-GRNHS FLOWER | 2.8 | 1.2 | 1.5 | 1.6 | 1.6 |
| N-GRNHS PLANTS IN CONTAINERS | 5.0 | 14.6 | 28.0 | 28.0 | 28.0 |
| N-OUTDR FLOWER | 10.7 | 0.8 | 1.1 | 2.7 | 2.7 |
| N-OUTDR PLANTS IN CONTAINERS | 28.5 | 1.4 | 2.2 | 2.8 | 2.8 |
| N-OUTDR TRANSPLANTS | 15.1 | 0.9 | 3.0 | 3.5 | 3.5 |
| OLIVE | 132.8 | 0.9 | 1.9 | 2.2 | 2.5 |
| ONION, DRY | 86.1 | 1.1 | 1.4 | 1.5 | 1.5 |
| ONION, GREEN | 11.9 | 1.1 | 1.4 | 1.4 | 1.4 |
| ORANGE | 575.9 | 1.1 | 1.6 | 3.0 | 4.9 |
| ORCHARD FLOOR | 2.7 | 0.9 | 1.1 | 1.1 | 1.1 |
| PASTURELAND | 15.2 | 0.8 | 1.1 | 1.1 | 1.1 |
| PEACH | 747.5 | 0.9 | 1.5 | 1.8 | 3.2 |
| PEANUT | 1.3 | 1.2 | 1.2 | 1.2 | 1.2 |
| PEAR | 139.0 | 0.8 | 1.3 | 2.6 | 3.2 |
| PEAS | 8.8 | 1.2 | 1.6 | 1.6 | 1.6 |
| PECAN | 26.1 | 1.1 | 2.8 | 2.8 | 2.8 |
| PEPPER, FRUITING | 125.1 | 1.0 | 2.1 | 2.3 | 2.4 |
| PEPPER, SPICE | 411.3 | 1.0 | 1.8 | 1.8 | 2.4 |
| PERSIMMON | 3.3 | 0.9 | 1.2 | 1.2 | 1.2 |
| PISTACHIO | 1,511.7 | 0.8 | 1.3 | 2.1 | 4.8 |
| PLUM | 727.8 | 0.7 | 1.1 | 1.3 | 2.5 |
| POTATO | 46.3 | 1.0 | 1.2 | 1.7 | 1.7 |
| PRUNE | 515.7 | 0.8 | 1.3 | 2.1 | 3.3 |
| PUMPKIN | 1.3 | 0.9 | 0.9 | 0.9 | 0.9 |
| RANGELAND | 27.3 | 0.6 | 0.6 | 0.6 | 0.6 |
| RASPBERRY | 67.7 | 1.1 | 1.5 | 2.3 | 3.7 |
| REGULATORY PEST CONTROL | 5.1 | 0.7 | 0.7 | 0.7 | 0.7 |
| RESEARCH COMMODITY | 9.7 | 0.8 | 1.5 | 2.4 | 2.4 |
| RHUBARB | 3.1 | 1.3 | 1.3 | 1.3 | 1.3 |
| RICE | 58.8 | 1.3 | 2.0 | 2.0 | 2.0 |

| Site Name | Average Pounds All Uses | Avg App Rate All Uses | Avg 95th% App Rate | Avg 99th% App Rate | Avg Max App Rate |
|---|---|---|---|---|---|
| RIGHTS OF WAY | 407.3 | 0.9 | 1.0 | 1.0 | 1.0 |
| SAFFLOWER | 98.1 | 0.9 | 1.2 | 1.9 | 1.9 |
| SORGHUM (FORAGE - FODDER/ MILO) | 10.6 | 0.4 | 0.5 | 0.5 | 0.5 |
| SOYBEAN | 9.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| SQUASH | 14.1 | 1.1 | 1.3 | 1.3 | 1.3 |
| SQUASH, SUMMER | 9.9 | 1.6 | 4.3 | 4.3 | 4.3 |
| SQUASH, WINTER | 2.6 | 0.8 | 0.9 | 0.9 | 0.9 |
| SQUASH, ZUCCHINI | 6.5 | 0.9 | 1.0 | 1.0 | 1.0 |
| STRAWBERRY | 75.1 | 0.9 | 1.6 | 2.5 | 2.9 |
| STRUCTURAL PEST CONTROL | 1.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| SUDANGRASS | 10.2 | 0.7 | 0.8 | 0.8 | 0.8 |
| SUGARBEET | 61.2 | 1.0 | 1.2 | 1.2 | 1.2 |
| SUNFLOWER | 326.7 | 0.8 | 1.9 | 2.7 | 2.7 |
| TANGELO | 15.9 | 1.1 | 1.7 | 1.7 | 1.7 |
| TOMATO | 270.0 | 0.9 | 1.2 | 1.7 | 1.8 |
| UNCULTIVATED AG | 394.1 | 1.0 | 1.9 | 2.4 | 2.7 |
| UNCULTIVATED NON-AG | 60.8 | 1.3 | 1.9 | 4.8 | 4.9 |
| VEGETABLE | 4.8 | 0.7 | 0.9 | 0.9 | 0.9 |
| VERTEBRATE CONTROL | 3.2 | 0.2 | 0.5 | 0.5 | 0.5 |
| WALNUT | 796.6 | 0.8 | 1.3 | 1.9 | 4.0 |
| WATERMELON | 43.1 | 1.2 | 2.4 | 2.4 | 2.4 |
| WHEAT | 41.2 | 0.8 | 1.0 | 1.0 | 1.0 |

## 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 in Sections 2.5.1 through 2.5.4, respectively. Further information on the status, distribution, and life history of and specific threats to the CRLF is provided in Attachment I.

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

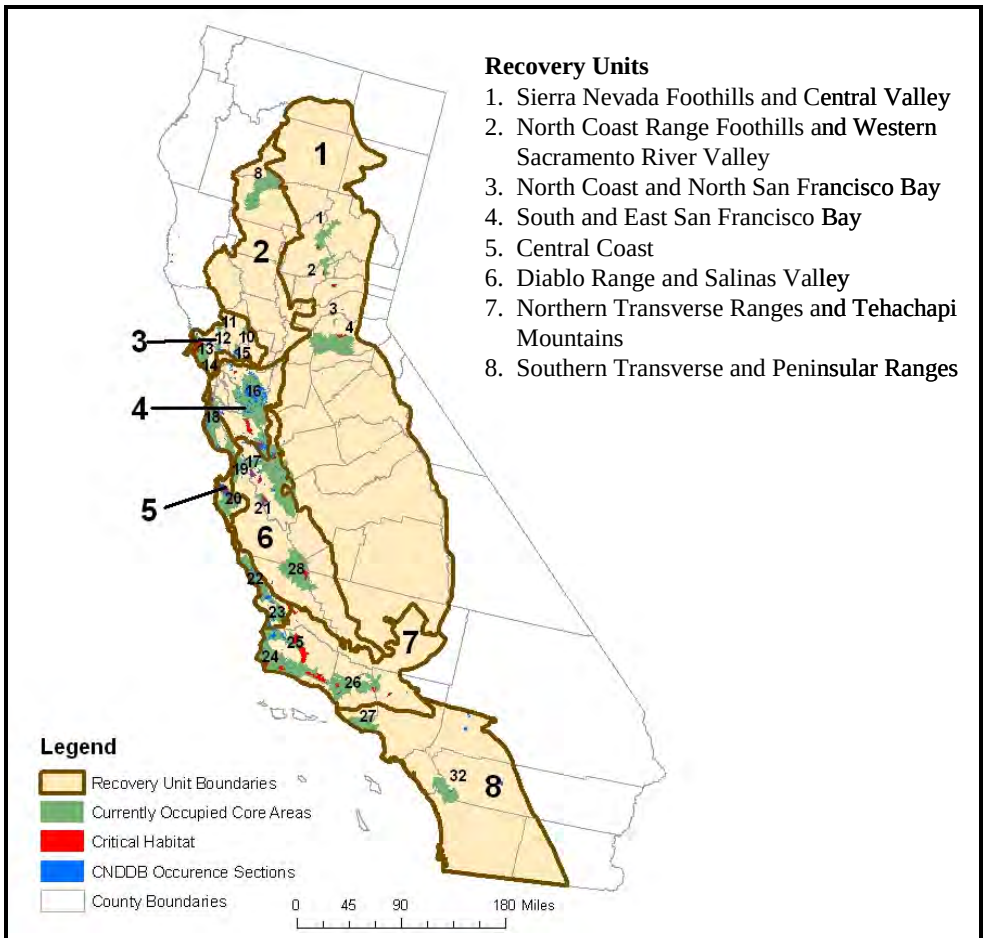
interior mountain ranges (U.S. FWS 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (U.S. FWS 1996). The species has an elevational range of near sea level to 1,500 meters (5,200 feet) (Jennings and Hayes 1994); however, nearly all of the 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 (see Attachment I). 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.




## Core Areas

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

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

**Figure 2-2 Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF**

### 2.5.2 Reproduction

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers 2005a). According to the Recovery Plan (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 2-3 depicts CRLF annual reproductive timing.

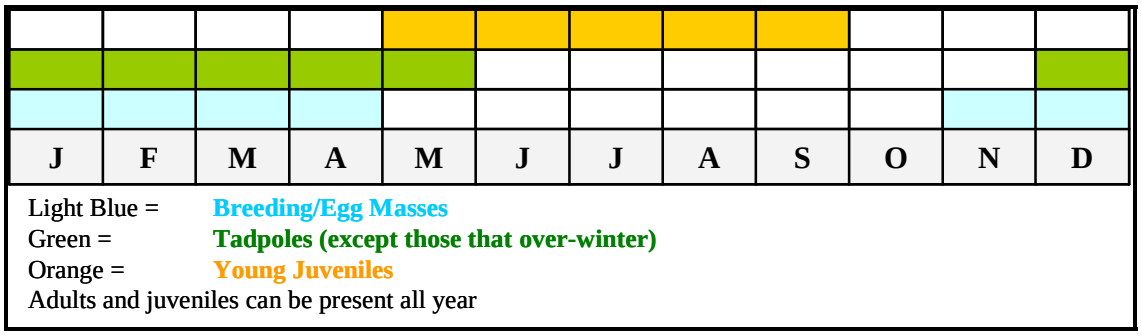



**Figure 2-3 CRLF Reproductive Events by Month**

### 2.5.3 Diet

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus (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://ecos.fws.gov/speciesProfile/SpeciesReport.do?spcode=D02D).

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 (U.S. FWS 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 2.5.1) is provided in Attachment I.

'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species.' All designated critical habitat for the CRLF was occupied at the time of listing. Critical habitat receives protection under Section 7 of the ESA (Section 7) through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

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

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

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

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, 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 the Final Rule (FR) listing notice in April 2006 (71 FR 19243, 2006). The FR notice designating critical habitat for the CRLF includes a special rule exempting routine ranching activities associated with livestock ranching from incidental take prohibitions. The purpose of this exemption is to promote the conservation of rangelands, which could be beneficial to the CRLF, and to reduce the rate of conversion to other land uses that are incompatible with CRLF conservation. Please see Attachment I for a full explanation on this special rule.

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 paraquat 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 paraquat is expected to directly impact living organisms within the action area, critical habitat analysis for paraquat 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 paraquat 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 paraquat may be expected to have on the environment, the exposure levels to paraquat that are associated with those effects, and the best available information concerning the use of paraquat and its fate and transport within the state of California. Specific measures of ecological effect that define the action area include any direct and indirect toxic effect and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature. Therefore, the action area extends to a point where environmental exposures are below any measured lethal or sublethal effect threshold for any biological entity at the whole organism, organ, tissue, and cellular level of organization. In situations where it is not possible to determine the threshold for an observed effect, the action area is not spatially limited and is assumed to be the entire state of California.

The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for paraquat. An analysis of labeled uses and review of available product labels was completed. Several of the currently labeled uses are special local needs (SLN) uses or are restricted to specific states other than California and are excluded from this assessment. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. The agricultural uses as well as the non-agricultural and non-food uses relevant to the CRLF can be found in Table 2-2.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of paraquat 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 paraquat is presented in Figure 2-4.

The uses represented by paraquat are depicted by the following land cover types: cultivated crops (51%), developed/high intensity (0.83%), developed/low intensity (1.7%), developed/open space (0.83%), forest (9.9%), orchards/vineyards (33%), and pasture/hay (2.5%). Cultivated crops are areas used for the production of annual crops, such as corn, soybeans, vegetables, and cotton. This class also includes all land being actively tilled. Developed/high intensity areas are where people reside, or work in high numbers. The impervious surfaces account for 80-100% of the total cover. Developed/low intensity areas include a mixture of constructed materials and vegetation with impervious surfaces accounting for 20-40% of total cover. Developed/open space includes areas with a mixture of constructed materials, but mainly vegetation in the form of lawn grasses. Impervious surfaces account for lass than 20% of total cover. Forest represents deciduous, evergreen, and mixed vegetation. These areas are dominated by trees that are generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Orchards/vineyards represent areas used for the cultivation of crops, such as fruits and nuts, which grow on vines or trees. Lastly, pasture/hay represents areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops. Typically, pasture/hay vegetation accounts for greater than 20% of total vegetation. For more information regarding which specific uses are represented by each land cover type, see Appendix D.

Paraquat appears to be applied in 55 out of 58 counties in California per the CAPUR database. In addition, paraquat has both a wide range of agricultural and non-agricultural uses throughout the state. Likewise, when modeling with AgDRIFT, the buffer zone needed to prevent ecological effects from spray drift is greater than 1,000 feet. As a result, the entire state of California will be the action area.

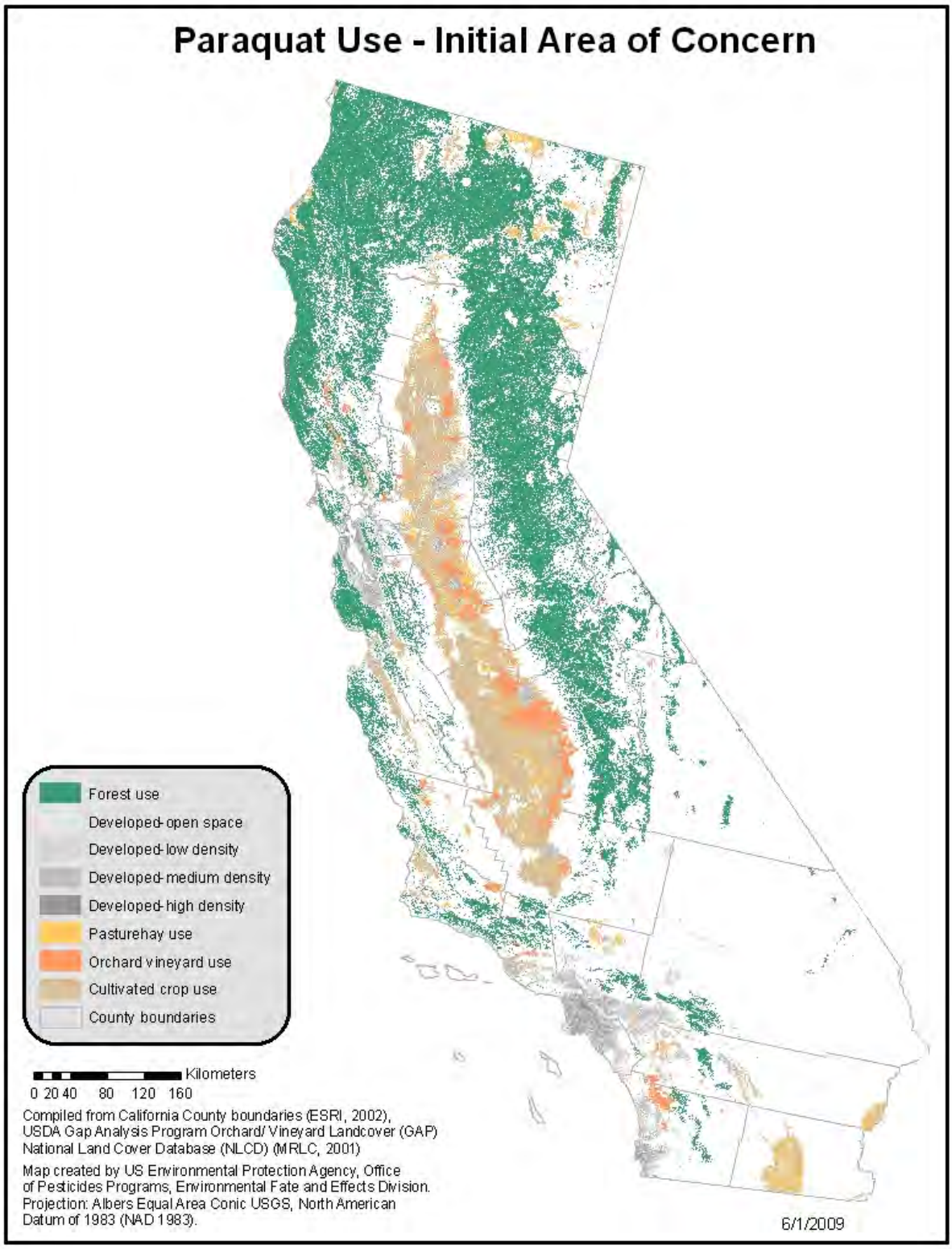



**Figure 2-4 Initial area of concern, or "footprint" of potential use, for Paraquat**

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

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

The primary route of environmental dissipation of paraquat dichloride is adsorption to biological material and soil clay particles. Paraquat dichloride has been shown to adsorb to clay crystalline lattices with no apparent correlation between organic matter content and paraquat adsorption. Paraquat does not hydrolyze, does not photodegrade in aqueous solutions, and is resistant to microbial degradation under aerobic and anaerobic conditions. Paraquat is also very immobile in soil and is not expected to volatilize once applied. However, spray drift could potentially be a problem because paraquat is very biologically active and toxic to plants and animals before it becomes adsorbed to soil clay particles.

The AgDRIFT model (Version 2.01) is used to define how far from the initial area of concern an effect to a given species may be expected via spray drift. The spray drift analysis uses the most sensitive endpoint. The cocklebur ($EC_{25}$ = 0.014 lb cation/A) was used to represent the non-listed plant species. The AgDRIFT results suggest that ground applications for non-listed plants need a spray drift buffer distance of approximately 361 feet. However, aerial applications yielded a spray drift buffer distance that was out of range for the AgDRIFT model (1,000 feet). Therefore, a maximum spray drift distance of greater than 1,000 feet was derived. Further detail on the spray drift analysis is provided in Section 5.1.4.1.

In addition to the buffered area from the spray drift analysis, the final action area also considers the downstream extent of paraquat that exceeds the LOC (discussed in Section 5.1.4.2). An evaluation of usage information was conducted to determine the area where use of paraquat may impact the CRLF. This analysis is used to characterize where predicted exposures are most likely to occur, but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed. These data suggest that paraquat has historically been used on a wide variety of agricultural and non-agricultural uses in approximately 55 counties in California. As a result, since paraquat has both agricultural and non-agricultural uses, it is applied in 55 of 58 counties, and has a buffer zone greater than 1,000 feet for aerial application, with such widespread use the action area is the entire state of California.

## 2.8 Assessment Endpoints and Measures of Ecological Effect

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected."[3] Selection of the assessment endpoints is based on valued entities (*e.g.*, CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (*e.g.*, waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of paraquat (*e.g.*, runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to paraquat (*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 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 4.0 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to paraquat is provided in Table 2-4.

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

**Table 2-4 Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of Paraquat (in terms of the Paraquat Cation) on the CRLF.**

| Assessment Endpoint | Measures of Ecological Effects[4] |
|---|---|
| **Aquatic-Phase CRLF (Eggs, larvae, juveniles, and adults)[a]** | |
| *Direct Effects* | |
| 1. Survival, growth, and reproduction of CRLF | 1a. Rainbow trout (*Oncorhynchus mykiss*) $LC_{50}$<br>1b. No Chronic Fish Data |
| *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. Algae (*Navicula pelliculosa*) $EC_{50}$<br>2b. No Chronic Invertebrate Data<br>2c. Water flea (*Daphnia magna*) $EC_{50}$ |
| 3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community) | 3a. Duckweed (*Lemna gibba*) $EC_{50}$<br>3b. Algae (*Navicula pelliculosa*) $EC_{50}$ |
| 4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation | 4a. Monocots: Seedling Emergence, Vegetative Vigor $EC_{25}$<br>4b. Dicots: Seedling Emergence, Vegetative Vigor $EC_{25}$ |
| **Terrestrial-Phase CRLF (Juveniles and adults)[b]** | |
| *Direct Effects* | |
| 5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles | 5a. Japanese Quail (*Coturnix coturnix japonica*) $LC_{50}$<br>5b. Mallard duck (*Anas platyrhynchos*) NOEAC |
| *Indirect Effects and Critical Habitat Effects* | |
| 6. Survival, growth, and reproduction of CRLF individuals via effects on terrestrial prey (*i.e.*,terrestrial invertebrates, small mammals , and frogs) | 6a. Laboratory rat (*Rattus norvegicus*) Female $LD_{50}$<br>6b. Wistar Derived Rats-Alderley Park Strain NOAEL<br>6c. Honey bee (*Apis mellifera*) $LD_{50}$<br>6d. Northern Bobwhite Quail (*Colinus virginianus*) $LD_{50}$<br>6e. Japanese Quail (*Coturnix coturnix japonica*) $LC_{50}$<br>6f. Mallard duck (*Anas platyrhynchos*) NOEAC |
| 7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian and upland vegetation) | 7a. Monocots: Seedling Emergence, Vegetative Vigor $EC_{25}$<br>7b. Dicots: Seedling Emergence, Vegetative Vigor $EC_{25}$ |

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

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

### 2.8.2 Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of paraquat 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 affect 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 paraquat effects data are available. Adverse modification to the critical habitat of the CRLF includes, but is not limited to, those PCEs listed in Section 2.6.

Measures of such possible effects by labeled use of paraquat on critical habitat of the CRLF are described in Table 2-5. 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 2-5 Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat[a]**

| Assessment Endpoint | Measures of Ecological Effect[4] |
|---|---|
| **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. | 1a. Algae (*Navicula pelliculosa*) $EC_{50}$<br>1b. Duckweed (*Lemna gibba*) $EC_{50}$<br>1c. Monocots: Seedling Emergence, Vegetative Vigor $EC_{25}$<br>1d. Dicots: Seedling Emergence, Vegetative Vigor $EC_{25}$ |
| 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. | 2a. Algae (*Navicula pelliculosa*) $EC_{50}$<br>2b. Duckweed (*Lemna gibba*) $EC_{50}$<br>2c. Monocots: Seedling Emergence, Vegetative Vigor $EC_{25}$<br>2d. Dicots: Seedling Emergence, Vegetative Vigor $EC_{25}$ |
| Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source. | 3a. Water flea (*Daphnia magna*) $EC_{50}$<br>3b. Rainbow trout (*Oncorhynchus mykiss*) $LC_{50}$<br>3c. No chronic fish or aquatic-phase amphibians or aquatic invertebrates data |
| Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae) | 4a. Algae (*Navicula pelliculosa*) $EC_{50}$ |
| **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 | 5a. Monocots: Seedling Emergence, Vegetative Vigor $EC_{25}$<br>5b. Dicots: Seedling Emergence, Vegetative Vigor $EC_{25}$<br>5c. Laboratory rat (*Rattus norvegicus*) Female $LD_{50}$<br>5d. Wistar Derived Rats-Alderley Park Strain NOAEL<br>5e. Honey bee (*Apis mellifera*) $LD_{50}$<br>5f. Northern Bobwhite Quail (*Colinus virginianus*) $LD_{50}$<br>5g. Japanese Quail (*Coturnix coturnix japonica*) $LC_{50}$<br>5h. Mallard duck (*Anas platyrhynchos*) NOEAC |
| Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal | |
| Reduction and/or modification of food sources for terrestrial phase juveniles and adults | |
| Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. | |

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

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

## 2.9 Conceptual Model

### 2.9.1 Risk Hypotheses

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

The labeled use of paraquat within the action area may:

- directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect the CRLF by reducing or changing the composition of food supply;
- indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;
- indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- affect the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- affect the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- affect the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance;
- affect the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal; 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 paraquat release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for terrestrial and aquatic exposures are shown in Figure 2-5 and Figure 2-6, respectively, which include the

conceptual models for the aquatic and terrestrial PCE components of critical habitat. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the CRLF and effects to designated critical habitat is expected to be negligible.

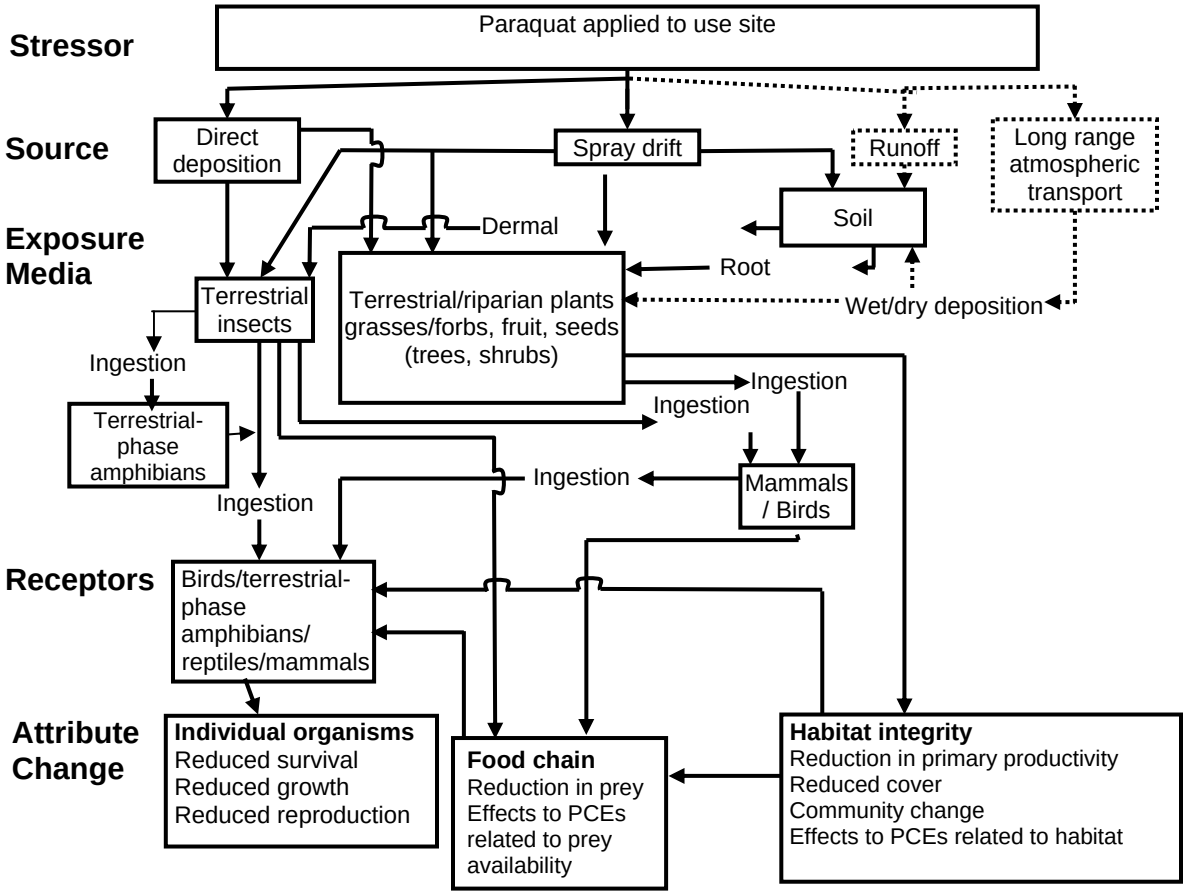
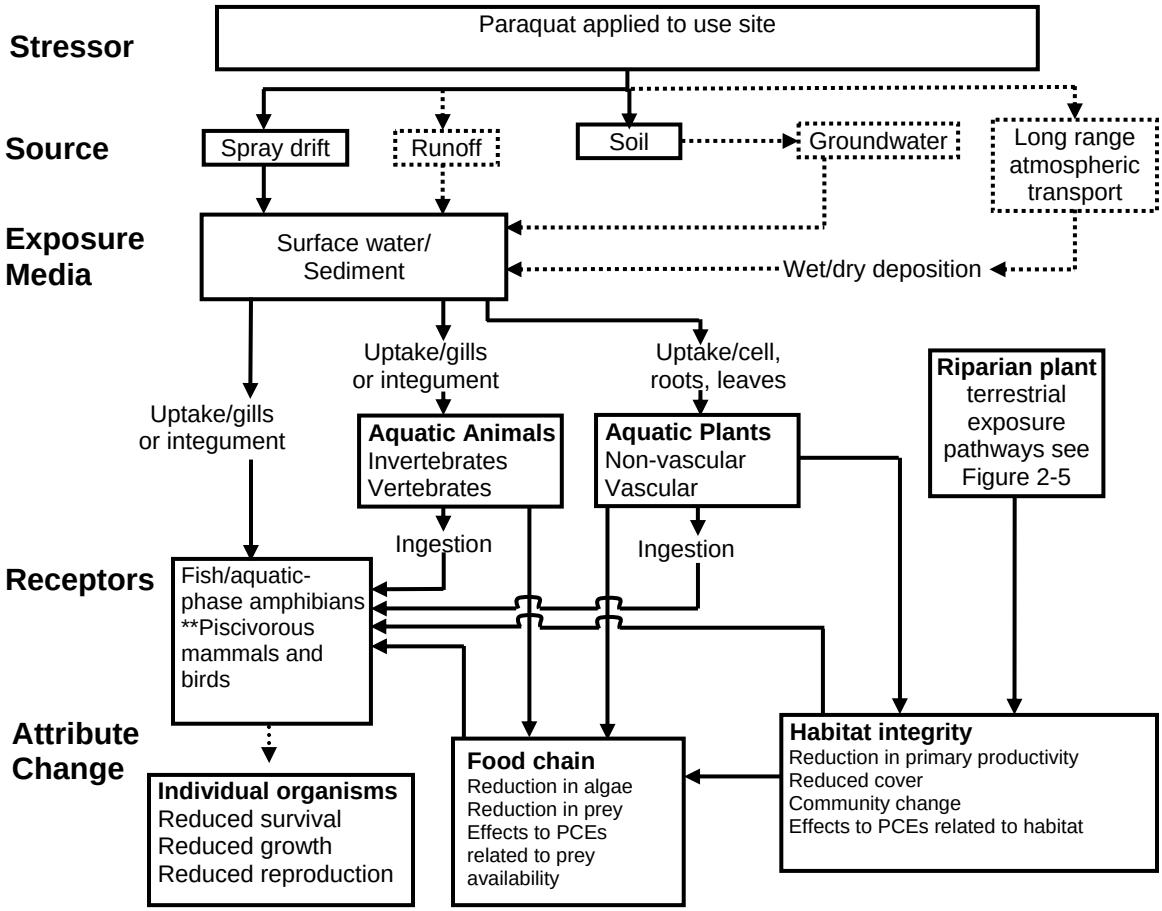



**Figure 2-5 Conceptual Model for Pesticide Effects on Terrestrial Phase of the CRLF**




** Route of exposure includes only ingestion of aquatic fish and invertebrates

**Figure 2-6 Conceptual Model for Pesticide Effects on Aquatic Phase of the CRLF**

## 2.10 Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the CRLF, its prey, and its habitat is estimated. In the following sections, the use, environmental fate, and ecological effects of paraquat 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 paraquat is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

### 2.10.1 Measures to Evaluate the Risk Hypothesis and Conceptual Model

#### 2.10.1.1 Measures of Exposure

The environmental fate properties of paraquat along with available monitoring data indicate that runoff and spray drift are the principle potential transport mechanisms of paraquat to the aquatic and terrestrial habitats of the CRLF. In this assessment, transport of paraquat through runoff and spray drift is considered in deriving quantitative estimates of paraquat exposure to CRLF, its prey and its habitats. Paraquat is not expected to volatilize once applied to soil due to its extremely high adsorption coefficients. As a result, atmospheric transport is unlikely. See Section 3.2.4 for an explanation of existing monitoring data.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of paraquat using maximum labeled application rates and methods of application. The model used to predict aquatic EECs was the GENeric Estimated Environmental Concentration Model (GENEEC2) which mimics the Tier II models 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. These models are parameterized using relevant reviewed registrant-submitted environmental fate data.

GENEEC2 (v2.0, August 2001) is a Tier I computer program, that 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. This first tier is designed as a coarse screen and estimates conservative pesticide concentrations in surface water from a few basic chemical parameters and pesticide label use and application information. Tier I is used to screen chemicals to determine which ones potentially pose sufficient risk to warrant higher level modeling. It calculates acute as well as longer-term estimated environmental concentration (EEC) values. It considers reduction in dissolved pesticide concentration due to adsorption of pesticide to soil or sediment, incorporation, degradation in soil before runoff to a water body, direct deposition of spray drift into the water body, and degradation of the pesticide within the water body. It is designed to mimic a PRZM-EXAMS simulation.

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

Chemicals failing to pass the GENEEC2 program move on to the Tier II (PRZM/EXAMS) modeling. However, in the case of paraquat, all direct aquatic, indirect aquatic, and vascular aquatic plant EECs do not result in an exceedance. The non-vascular aquatic plant EECs result in an exceedance, but paraquat is an herbicide and exceedances for plants is expected.

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 paraquat 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 paraquat are bound by using the dietary based EECs for small insects and large insects.

For an additional refinement of terrestrial-phase CLRF dose and dietary-based exposures the T-HERPS model is employed. The T-HERPS is used as a refinement tool to explore amphibian-specific food intake on potential exposures to the terrestrial phase CRLF. It incorporates the same inputs as T-REX with equations adjusted for poikilotherm food intake.

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

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

#### 2.10.1.2 Measures of Effect

Data identified in Section 2.8 are used as measures of effect for direct and indirect effects to the CRLF. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. The ECOTOXicology database (ECOTOX) was searched in order to provide more ecological effects data and in an attempt to bridge existing data gaps. ECOTOX is a source for locating single chemical toxicity data for aquatic life, terrestrial plants, and wildlife. ECOTOX was created and is maintained by the 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 paraquat to birds is similar to or less than the toxicity to the terrestrial-phase CRLF. The same assumption is made for fish and aquatic-phase CRLF. Algae, aquatic invertebrates, fish, and amphibians represent potential prey of the CRLF in the aquatic habitat. Terrestrial invertebrates, small mammals, and terrestrial-phase amphibians represent potential prey of the CRLF in the terrestrial habitat. Aquatic, semi-aquatic, and terrestrial plants represent habitat of CRLF.

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

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

#### 2.10.1.3 Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from agricultural and non-agricultural uses of paraquat, 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 paraquat 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 paraquat directly to the CRLF. If estimated exposures directly to the CRLF of paraquat 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 paraquat resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is a "may affect." If the RQ being considered also exceeds the non-listed species acute risk LOC, then the effects determination is a LAA. If the acute RQ is between the listed species LOC and the non-listed acute risk species LOC, then further lines of evidence (*i.e*. probability of individual effects, species sensitivity distributions) are considered in distinguishing between a determination of NLAA and a LAA. When considering indirect effects to the CRLF due to effects to algae as dietary items or plants as habitat, the non-listed species LOC for plants is used because the CRLF does not have an obligate relationship with any particular aquatic and/or terrestrial plant. If the RQ being considered for a particular use exceeds the non-listed species LOC for plants, the effects determination is "may affect". Further information on LOCs is provided in Appendix C.

#### 2.10.1.4 Data Gaps

The long-term stability of sediment-bound paraquat under various conditions (such as changes in pH, Eh, etc.) is unknown. There is insufficient data to determine to what extent paraquat will accumulate at the same site with successive applications, and what the effects of accumulation might be. Likewise, paraquat is expected to adsorb to soils with high clay content. Therefore, a batch equilibrium study using soils with varying percents of clay content as well as soils with low clay content would be beneficial to better understand which types of soils paraquat may not adsorb to and possibly leach to ground water.

The effect of consuming soil-bound paraquat on organisms is unknown. The fate of paraquat dichloride residues in desiccated plant material (that is, how tightly bound to biological material does it remain relative to clay-bound paraquat) is unknown.

Therefore, conservative assumptions were made when running the models to determine the effects. Please see Section 3 and Section 5 for further explanation on assumptions made for modeling.

Paraquat is likely to reach the aquatic environment via erosion and runoff, and persist in the aquatic sediment resulting in exposure to benthic dwelling freshwater invertebrates and fish. Currently, however no chronic toxicity studies for freshwater invertebrates or fish have been submitted to the Agency. Therefore, there is a data gap for chronic freshwater invertebrates and fish toxicity. Due to this data gap we used the chemical diquat, which is similar in structure to calculate an acute to chronic ratio (ACR). Only the freshwater invertebrate data were used as two different species of fish were studied and an ACR could not be calculated across species.

There is only one multi-active ingredient product containing paraquat and Carfentrazone-ethyl as Cyclone Star (EPA Reg Number 00010001316). There is no toxicity data relative to this compound (Carfentrazone-ethyl) in the literature or in the assessment provided by Human Helath and Effects Division (HED). Therefore, no difnitive statement can be made as to whether this product poses any toxic risk greater or less than paraquat product alone. The best available information suggests that the assessment based on paraquat alone is adequate to understand risk to non-target receptors.

## 3.0 Exposure Assessment

Paraquat is formulated as an emulsifiable concentrate. Application methods include ground, aerial, and by various sprayers (band, hooded, low-pressure, and shielded). Risks from ground boom and aerial applications are expected to result in the highest off-target levels of paraquat 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

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

Currently registered agricultural and non-agricultural uses of paraquat within California are listed in Table 2-2. The uses being assessed are summarized in Table 3-1 below. The uses assessed were the non-agricultural use and agricultural use with the maximum application rate/largest number of applications per year/smallest application interval, the median agricultural use, and the agricultural use with smallest application rate/the least number of applications per year /largest application interval.

**Table 3-1 Paraquat Uses and Application Information for the CRLF risk assessment[1]**

| Uses Represented by Scenario | Application Rate (lb cation/A) | Number of Applications | Application Interval | Application Method |
|---|---|---|---|---|
| AGRICULTURAL FALLOW/IDLELAND | 1.0 | 5 | 5 | Aircraft<br>Ground |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 1.0 | 10 | 5 | Ground |
| GUAVA, PASSION FRUIT (GRANADILLA) | 1.0 | 10 | 5 | Ground |
| MELONS, PEANUTS (ground only) | 0.3 | 1 | 1 | Aircraft<br>Ground |

[1] Uses assessed based on memorandum from SRRD dated February 5, 2009

## 3.2 Aquatic Exposure Assessment

### 3.2.1 Modeling Approach

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

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

### 3.2.2 Model Inputs

Paraquat is an herbicide used on various crops such as apricots, loganberries, corn, peanuts, coffee, lettuce, and non-crop areas such as airport landing fields, and commercial, industrial and institutional premises. Paraquat's environmental fate data used for generating model parameters is listed in Table 2-2. The input parameters for the GENEEC2 model are in Table 3-2.

Most of the inputs used in the GENEEC2 model followed the Input Parameter Guidance; however, since paraquat's adsorption Kds ranged from 68-50,000 (mobile to highly immobile), the average Kd would not necessarily be an accurate depiction of paraquat's mobility. Paraquat is an interesting chemical due to its high affinity to clay (negatively charged particles) as a result of its cationic charge in the molecule. Therefore, paraquat may be more mobile in soil that is less charged, such as sand, and will become increasingly less mobile in soils with higher percentages of clay. The Kd was determined by plotting the Kds along with their corresponding concentrations (lb cation/A) in order to determine the linear regression. Once this was established, the maximum allowable application rate (1 lb cation/A) was plugged into the equation given by the regression to determine the corresponding Kd. This was done for all four soils in the study (MRID 40762701). Then, the average Kd was determined and used as the input. Determining

Kd in this manner is believed to be very conservative because the Kd value calculated by this method assumes paraquat to be more mobile than expected.

**Table 3-2 Summary of GENEEC2 Environmental Fate Data Used for Aquatic Exposure Inputs for Paraquat Endangered Species Assessment for the CRLF [1] Based on the Paraquat Cation**

| Fate Property | Value (unit) | MRID (or source) |
|---|---|---|
| Molecular Weight | 186 g/mol | http://toxnet.nlm.nih.gov |
| Henry's constant | $1.9 \times 10^{-9}$ atm $m^3$ $mol^{-1}$ | http://toxnet.nlm.nih.gov |
| Vapor Pressure | 0 | http://toxnet.nlm.nih.gov |
| Solubility in Water | 7,000,000 mg/l (700,000* mg/l x 10 per input guidance) | *http://www.inchem.org/documents/icsc/icsc/eics0005.htm Per Input Parameter Guidance |
| Photolysis in Water | 0 (Stable) | MRID 40562301 |
| Aerobic Soil Metabolism Half-lives | 0 (Stable) | MRID 41319301 |
| Hydrolysis | 0 (Stable) | MRID 41319302 |
| Aerobic Aquatic Metabolism (water column) | 0 (0.5 x Aerobic Soil Metabolism study) | Per Input Parameter Guidance |
| Anaerobic Aquatic Metabolism (benthic) | 0 (0.5 x Anaerobic Soil Metabolism study) | Per Input Parameter Guidance |
| Kd | 295 | MRID 40762701 |
| Application rate and frequency | Various (see Table 3.3) | Per Label Instructions |
| Application intervals | Various (see Table 3.3) | Per Label Instructions |

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

### 3.2.3 Results

The aquatic EECs for the various application practices using the GENEEC2 model are listed in Table 3-3**.** The maximum non-agricultural and agricultural application rate/interval/applications per year were calculated, along with the median use application rate/interval/applications per year, and minimum use application rate/interval/applications per year. See Appendix I for a summary of the outputs. Peak EECs ranged from 1.6 ppb to 55 ppb for use on melons, and airports/commercial/public health areas (impervious areas) and guava/passion fruit respectively.

Since some of the application data needed for modeling were not stated on the labels, assumptions were made by EFED analysts regarding the maximum number of

applications allowed per season, and/or the interval between applications. The assumptions were as follows:

- For the application intervals that were not stated, the most conservative (minimum) known application interval was used (5 days). Five days was chosen because it was the minimum known interval that was registered.
- If the maximum number of applications was not stated, the most conservative (maximum) known number of applications was used (10 applications). Ten applications were chosen because 10 was the maximum known number of applications allowed that was registered.
- If the maximum number of applications was not stated, but the uses had an application timing of pre-emergence or pre-plant, and was not listed as having multiple crop seasons per year in California, per a table created by the Biological and Economic Analysis Division (BEAD), the maximum application number was assumed to be one.

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

| Application Rate (lkg cation/ha) | Crops Represented | Peak EEC | 21-day average EEC | 60-day average EEC |
|---|---|---|---|---|
| | | 33 | 20 | 10 |
| 1.0 | AGRICULTURAL FALLOW/IDLELAND | 27 | 17 | 8.5 |
| 1.0 | AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 55 | 34 | 17 |
| 1.0 | GUAVA, PASSION FRUIT (GRANADILLA) | 55 | 34 | 17 |
| | | 2.0 | 1.2 | 0.62 |
| 0.3 | MELONS, PEANUTS (ground only) | 1.6 | 1.0 | 0.51 |

### 3.2.4 Existing Monitoring Data

Whenever it is available, monitoring data is included in assessments in order to better characterize the EECs calculated in the modeled estimates. In this assessment, monitoring data was sought from the following sources: the USGS NAWQA program (http://water.usgs.gov/nawqa), the California Department of Pesticide Regulation (CDPR), and the California Air Review Board.

#### 3.2.4.1 USGS NAWQA Surface Water Data

The USGS has not looked for any samples containing paraquat. Therefore, no surface water data are available.

#### 3.2.4.2 USGS NAWQA Groundwater Data

The USGS has not collected any samples looking for paraquat. Therefore, no ground water data are available.

#### 3.2.4.3 California Department of Pesticide Regulation (CDPR) Data

The California Department of Pesticide Regulation (CDPR) has been collecting surface water data on paraquat for many years. Out of 399 samples, 398 of the samples did not contain paraquat. One sample showed a detection of paraquat at 0.24 ppb; the detection limit was 1 ppb.

The positive sample was taken on May 16, 2006 in the Merced River. 99.7 % of the samples did not detect any paraquat from July 2005 to October 2006. The samples were taken in the Summer, Spring, and Fall seasons.

#### 3.2.4.4 Atmospheric Monitoring Data

The California Air Review Board has not conducted ambient air monitoring of paraquat. Therefore, no atmospheric monitoring data are available.

## 3.3 Terrestrial Animal Exposure Assessment

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

Instead of running all of the uses, the maximum non-agricultural use, the maximum agricultural use, the median agricultural use, and the minimum agricultural use were run using T-Rex in order to get an upper and lower bound for the terrestrial effects. Maximum is defined as the use with the largest application rate, the shortest intervals, and the most applications.

Terrestrial EECs for foliar formulations of paraquat were derived for the uses summarized in Table 3-4. The non-agricultural and agricultural uses with the maximum application rates, along with the agricultural use with the median application rate, and the agricultural use with the lowest application rate were all modeled. The third and second lowest application rates were also modeled, to determine the lowest rates in which there were no exceedances. Given that no data on interception and subsequent dissipation from foliar surfaces was available for paraquat, a default foliar dissipation half-life of 35 days was used based on the work of Willis and McDowell (1987). Use specific input values, including number of applications, application rate and application interval are provided in Table 3-4. An example output from T-REX is available in Appendix E.

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

| Use (Application method) | Application rate (lbs ai/A) | Number of Applications | Intervals Between Applications (Days) |
|---|---|---|---|
| Airports (Maximum, Non-agricultural) | 1 | 10 | 5 |
| Guava (Maximum, Agricultural) | 1 | 10 | 5 |
| Ginger (Median, Agricultural) | 1 | 6 | 30 |
| Corn (Third lowest, Agricultural) | 0.5 | 3 | 5 |
| Carrots (Second lowest, Agricultural) | 1 | 1 | 1 |
| Melons (Lowest, Agricultural) | 0.3 | 1 | 1 |

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

For modeling purposes, exposures of the CRLF to paraquat through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey are assessed using the small mammal (15 g) which consumes short grass. Upper-bound Kenega nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential prey (Table 3-5). Dietary-based EECs for small and large insects reported by T-REX as well as the resulting adjusted EECs are available in Table 3-6. An example output from T-REX v. 1.3.1 is available in Appendix E.

Any RQs that exceed the LOC for listed species will be analyzed in T-HERPS. The T-HERPS model will therefore be employed as a refinement tool to explore amphibian-specific food intake on potential exposures to the terrestrial phase CRLF. The T-HERPS model incorporates the same inputs as T-REX with equations adjusted for poikilotherm food intake. An example output from T-HERPS is available in Appendix J.

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

| Use | EECs for CRLF (Avian, 20 g) | | EECs for Prey (small mammals, 15 g) | |
|---|---|---|---|---|
| | Dietary-based EEC (ppm) | Dose-based EEC (mg/kg-bw) | Dietary-based EEC (ppm) | Dose-based EEC (mg/kg-bw) |
| Airports | 900 | 1025 | 1600 | 1530 |
| Guava | 900 | 1025 | 1600 | 1530 |
| Ginger | 293 | 333 | 520 | 500 |
| Corn | 184 | 209 | 327 | 175 |
| Carrots | 135 | 154 | 240 | 229 |
| Melons | 41 | 46 | 72 | 69 |

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

| Use | Small Insect | Large Insect |
|---|---|---|
| Airports | 900 | 100 |
| Guava | 900 | 100 |
| Ginger | 293 | 33 |
| Corn | 184 | 20 |
| Carrots | 135 | 15 |
| Melons | 41 | 4.5 |

## 3.4 Terrestrial Plant Exposure Assessment

AgDRIFT (Version 2.01) is used to calculate spray drift; it was also used to estimate terrestrial plant exposure. The spray drift analysis uses the most sensitive endpoint. See section 5.2.5.1 for the spray drift analysis.

## 4.0 Effects Assessment

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

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

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (U.S. EPA 2004). Open literature data presented in this assessment were obtained from RED 1997, the EFED and HED new use chapters 2006 as well as ECOTOX information obtained on December 31, 2008. In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

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

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than

[5] 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.

the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, maintenance of CRLF survival, reproduction, and growth) identified in Section 2.8. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, unless quantitative relationships between modifications and reduction in species survival, reproduction, and/or growth are 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 paraquat.

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 Appendices F and G. Both Appendix F and G also include 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 bibliography of the available ECOTOX open literature data, including the full suite of lethal and sublethal endpoints are presented in Appendices F and G. A summary of the human health effects data for paraquat is found in Appendix K.

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 paraquat (Appendix H). A summary of the available aquatic and terrestrial ecotoxicity information, use of the probit dose response relationship, and the incident information for paraquat are provided in Sections 4.1 through 4.4, respectively.

Paraquat has registered products that contain multiple active ingredients. The results of available toxicity data for mixtures of paraquat with other pesticides are presented in Appendix B; however, there is no toxicity data for paraquat Multi-AI products. There is available open literature data from ECOTOX and three studies contained information examining toxicity effects of paraquat when mixed with other chemicals. The bibliographic information of these studies is presented in Appendix F. According to the available open literature data, other pesticides may combine with paraquat to produce additive, and/or antagonistic toxic effects. Mixtures included paraquat with linuron, and paraquat with copper sulfate.

If chemicals that show additive effects with paraquat are present in the environment in combination with paraquat, the toxicity of paraquat may be increased, offset by other environmental factors, or even reduced by the presence of antagonistic contaminants if they are also present in the mixture. The variety of chemical interactions presented in the available data set suggest that the toxic effect of paraquat, in combination with other pesticides used in the environment, can be a function of many factors including but not

necessarily limited to (1) the exposed species, (2) the co-contaminants in the mixture, (3) the ratio of paraquat and co-contaminant concentrations, (4) differences in the pattern and duration of exposure among contaminants, and (5) the differential effects of other physical/chemical characteristics of the receiving waters (e.g., organic matter present in sediment and suspended water). Quantitatively predicting the combined effects of all these variables on mixture toxicity to any given taxa with confidence is beyond the current abilities of ecotoxicology. However, a qualitative discussion of implications of the available pesticide mixture effects data involving paraquat on the confidence of risk assessment conclusions for the freshwater vascular plant (duckweed, *Lemna minor* vs *L. gibba*), and mammals is part of the uncertainty analysis for this effects determination.

Paraquat plus copper sulfate mixture was found to exhibit both an antagonistic and additive relationship in the vascular aquatic plant *Lemna minor* (E 102140). In the presence of both paraquat and copper sulfate there was a reduction in the percent inhibition of $F_v/F_m$, a measurement of the efficiency of Photosystem II (PSII), indicating an antagonistic relationship. An additive relationship was observed in two other parameters; $O_2$ evolution and the fraction of inhibited centers (FIC). This study was completed in 48h, whereas guideline studies on vascular plants range from 7-14 days, therefore the effects observed with this mixture may potentially change over time.

The mixture of paraquat plus linuron (formulations used for potatoes) was found to not be genotoxic, but was found to be cytotoxic to adult wistar rats (E104633). However, this mixture (paraquat plus linuron) would not be found in California as linuron is not registered for use on potatoes in California. The final mixture study in ECOTOX was a field study that examined the impacts of herbicides on species found in a field that was treated with herbicides (E147983). Other studies examine impacts to non-target organisms off the pesticide treated field as a result of runoff or spray drift. The treatments examined compared herbicide treatments to other cultural practices (tillage), which showed impacts to the “native field species” from tilling alone. This paper is only mentioned and will not be used quantitatively or qualitatively, it is simply an additional reference that demonstrates the potential impacts of cultural practices on the reduction in CRLF food sources. Bibliographic information is presented in Appendix F.

## 4.1 Evaluation of Aquatic Ecotoxicity Studies

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

**Table 4-1 Freshwater Aquatic Toxicity Profile for Paraquat Dichloride (expressed as the cation)**

| Assessment Endpoint | Species | Toxicity Value Used in Risk Assessment | Describe effect (i.e. mortality, growth, reproduction) | Citation MRID # (Author & Date) | Study Classification |
|---|---|---|---|---|---|
| **Direct Toxicity to Aquatic-Phase CRLF** | | | | | |
| Acute | Bluegill sunfish | 96h $LC_{50}$ = 13 mg/L | Mortality | 40098001 (Mayer & Ellersieck 1986) | Acceptable |
| Chronic | **Estimated – See Section 5** | | | | |
| **Indirect Toxicity to Aquatic-Phase CRLF** | | | | | |
| via Acute Toxicity to Freshwater Invertebrates (i.e. prey items) | *Daphnia magna* | 48h $EC_{50}$ = 1.2 mg/L | Mortality | 00114473 (Wheeler 1978) | Acceptable |
| via Chronic Toxicity to Freshwater Invertebrates (i.e. prey items) | **Estimated – See Section 5** | | | | |
| via Acute Toxicity to Freshwater Fish (i.e. prey items) | Bluegill sunfish | 96h $LC_{50}$ = 13 mg/L | Mortality | 40098001 (Mayer & Ellersieck 1986) | Acceptable |
| via Chronic Toxicity to Freshwater Fish (i.e. prey items) | **Estimated – See Section 5** | | | | |
| via Toxicity to Non-vascular Aquatic Plants | *Navicula pelliculosa* (freshwater diatom) | 4d $EC_{50}$ = 0.396 µg/L | Growth | 42601006 (Smyth et al. 1992) | Acceptable |
| via Toxicity to Vascular Aquatic Plants | *Lemna gibba* (Duckweed) | 14d $EC_{50}$ = 71 µg/L | Growth and Reproduction | 42601003 (Smyth et al. 1992) | Acceptable |

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

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

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

### 4.1.1 Toxicity to Freshwater Fish

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

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

#### 4.1.1.1 Freshwater Fish: Acute Exposure (Mortality) Studies

Freshwater fish data were used as a surrogate to estimate direct acute risks to the CRLF. Effects to freshwater fish from direct exposure to Paraquat could also indirectly affect the CRLF from reduction in available food.

Paraquat is classified as slightly toxic to warm and cold freshwater fish on an acute exposure basis. The most sensitive freshwater species was the bluegill sunfish, with a 96h $LC_{50}$ of 13 mg/L (MRID 40098001 Mayer and Ellersieck 1986). Freshwater fish acute toxicity values range from a 96h $LC_{50}$ of 13 mg/L to 156 mg/L (both endpoints are bluegill sunfish, MRID 40098001 Mayer and Ellersieck 1986). Other species within that range include the rainbow trout (15, 29, and 38.68 mg/L) (MRIDs 40098001, 00162738, and 00162736). These studies were completed using formulated products that contained 21.2% to 29% of the paraquat cation. In general, the toxicity of these formulated products are similar in toxicity to a range of different species of freshwater fish.

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

There are no available freshwater fish chronic exposure toxicity studies conducted with Paraquat. The direct chronic toxicity values for the CRLF were calculated using an acute to chronic ratio (ACR) using a similar chemical compound, diquat dibromide (Section 5.1.1).

#### 4.1.1.3 Freshwater Fish: Sublethal Effects and Additional Open Literature Information

There were numerous studies found within the ECOTOX database, however they were not integrative in the measurements of growth and reproduction. Potential sublethal effects on fish are evaluated qualitatively and not used as part of the quantitative risk characterization. One study did provide some information regarding different biochemical factors influenced by exposures to paraquat (E104191). Further details on

ECOTOX studies are provided in Appendix F, which also contains the rejection codes and other information as to why studies from ECOTOX were not used.

#### 4.1.1.4 Aquatic-phase Amphibian: Acute and Chronic Studies

Studies were found in ECOTOX that used aquatic-phase amphibians as study organisms. However, there were some fatal flaws with all the frog studies that were reviewed and they were therefore, not used in this risk assessment. In particular there were concerns with the husbandry of the organisms (i.e., the amount of individuals per treatment replicate), as well as the lack of detailed information within the published literature. Also of concern was the presence of the solvent dimethyl sulfoxide (DMSO) as a co-solvent, which confounds the experiment as the solvent could be resulting in increased toxicity, and not the chemical being tested. In general there was an overall lack of information within the studies, especially in regards to the controls and the chemical solutions that were used within the experiments. There is also some concern with the testing methods used, Frog Embryo Teratogenesis Assay-*Xenopus* (FETAX). The study conditions do not provide the ability to deduce the chronic endpoints of the frogs, and the age of organisms used in this type of assay results in inherent variability. There are problems with the rearing of the frogs out past stage 54 as mortality levels are too high, resulting from the loading rate within the containers, and the feeding on the yolk until further development. Appendix F contains information as to why these studies and others from ECOTOX were not used within the assessment.

### 4.1.2 Toxicity to Freshwater Invertebrates

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

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

#### 4.1.2.1 Freshwater Invertebrates: Acute Exposure (Mortality) Studies

Paraquat is classified as moderately toxic to freshwater invertebrates based on acceptable studies of the water flea (*Daphnia magna*). This species exhibited a 48h $EC_{50}$ value of 1.2 mg/L (MRID 0014473 Wheeler 1973).

#### 4.1.2.2 Freshwater Invertebrates: Chronic Exposure (Reproduction) Studies

There are no available freshwater invertebrate chronic exposure toxicity studies conducted with Paraquat. The indirect chronic toxicity values for the CRLF were

calculated using an acute to chronic ratio (ACR) using a similar chemical compound, diquat dibromide (Section 5.1.1).

#### 4.1.2.3 Freshwater Invertebrates: Sublethal Effects and Open Literature Data

There were numerous studies found within the ECOTOX database, however they were not integrative in the measurements of growth and reproduction. The studies instead provided information on the sublethal effects observed. Additionally, the studies were not usable in this Risk Assessment. Further details on ECOTOX studies are provided in Appendix F, which also contains the rejection codes and other information as to why studies from ECOTOX were not used.

### 4.1.3 Toxicity to Aquatic Plants

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

Laboratory studies were used to determine whether paraquat may cause direct effects to aquatic plants. A summary of the laboratory data and freshwater field studies for aquatic plants is provided in Sections 4.1.3.2 and 4.1.3.2.

#### 4.1.3.1 Aquatic Plants: Laboratory Data

Both the vascular and non-vascular aquatic plant studies that include the most sensitive species are Tier II toxicity tests. The freshwater diatom (*Navicula pelliculosa*) was the most sensitive non-vascular plant with a 4d $EC_{50}$ of 0.396 µg/L (MRID 42601006 Smyth et al. 1992). The vascular plant *Lemna gibba* was the most sensitive vascular plant with a 14d $EC_{50}$ of 71 µg/L (MRID 42601003 Smyth et al. 1992).

#### 4.1.3.2 Freshwater Field Studies

There were no submitted field studies.

## 4.2 Toxicity of Paraquat to Terrestrial Organisms

Table 4-3 summarizes the most sensitive terrestrial toxicity endpoints for the CRLF, based on an evaluation of both the submitted studies and the open literature. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the CRLF is presented below.

**Table 4-3 Terrestrial Toxicity Profile for Paraquat Dichloride (expressed as the cation)**

| Assessment Endpoint | Species | Toxicity Value Used in Risk Assessment | Describe effect (i.e. mortality, growth, reproduction) | Citation MRID # (Author & Date) | Study Classification |
|---|---|---|---|---|---|
| **Direct Toxicity to Terrestrial-phase CRLF** | | | | | |
| Acute Dose-based | *Colinus virginianus* (Northern Bobwhite) | $LD_{50}$ = 128.1 mg/kg bw | Mortality | 00029001 (Fink et al. 1979) | Acceptable |
| Acute Dietary-based | *Coturnix coturnix japonica* (Japanese Quail) | 5d $LC_{50}$ = 703 ppm | Mortality | 00022923 (Hill et al. 1975) | Supplemental |
| Chronic | *Anas platyrhynchos* (Mallard Duck) | NOAEC = 30 ppm | % viable eggs, eggs set, normality of hatchlings and # of 14d old survival | 00110455 (Fink et al. 1982) | Acceptable |
| **Indirect Toxicity to Terrestrial-phase CRLF** | | | | | |
| via acute toxicity to mammalian prey items | Rat | $LD_{50}$ = 90 mg/kg bw (F) | Mortality | 00054573 (Rittenhouse 1977) | Acceptable |
| via chronic toxicity to mammalian prey items | Wistar Derived Rats-Alderley Park Strain | NOAEL= 7.5 mg/kg-bw<br>NOAEC = 108 ppm | Reproductive Toxicity- 3 generation study Reproduction | 00126783<br>00149748<br>00149749 | Acceptable<br>(HED 2006) |
| via acute toxicity to terrestrial invertebrate prey items | *Apis mellifera* (Honey bee) | 48h $LD_{50}$ > 34.8 µg/bee | Mortality | 05001991 (Stevenson 1978) | Acceptable |
| via acute toxicity to terrestrial invertebrate prey items | *Colinus virginianus* (Northern Bobwhite) | $LD_{50}$ = 128.1 mg/kg bw | Mortality | 00029001 (Fink et al. 1979) | Acceptable |
| via acute toxicity to terrestrial invertebrate prey items | *Coturnix coturnix japonica* (Japanese Quail) | 5d $LC_{50}$ = 703 ppm | Mortality | 00022923 (Hill et al. 1975) | Supplemental |

| Assessment Endpoint | Species | Toxicity Value Used in Risk Assessment | Describe effect (i.e. mortality, growth, reproduction) | Citation MRID # (Author & Date) | Study Classification |
|---|---|---|---|---|---|
| via chronic toxicity to terrestrial invertebrate prey items | *Anas platyrhynchos* (Mallard Duck) | NOAEC = 30 ppm | % viable eggs, eggs set, normality of hatchlings and # of 14d old survival | 00110455 (Fink et al. 1982) | Acceptable |
| via toxicity to terrestrial plants | Seedling Emergence Monocots | $EC_{25}$ = 0.84 lbs cation/A (using most sensitive species (dicot data)) | Growth | 42639601 (Canning and White 1992) | Acceptable |
| | Seedling Emergence Dicots (Cocklebur) | $EC_{25}$ = 0.84 lbs cation/A | Growth | 42639601 (Canning and White 1992) | Acceptable |
| | Vegetative Vigor Monocots (Corn) | $EC_{25}$ = 0.16 lbs cation/A | Growth | 42601001 (Canning and White 1992) | Acceptable |
| | Vegetative Vigor Dicots (Cocklebur ) | $EC_{25}$ = 0.014lbs cation/A | Growth | 42601001 (Canning and White 1992) | Acceptable |

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

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

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

### 4.2.1 Toxicity to Birds

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

#### 4.2.1.1 Birds: Acute Exposure (Mortality) Studies

There were two acute avian oral studies that were submitted, one classified as acceptable, and the other classified as supplemental (MRID 00029001 Fink et al. 1979, & 00160000 Hudson et al. 1984). The most sensitive species was the Northern Bobwhite quail with an acute oral $LD_{50}$ value of 128.1 mg/kg (MRID 00029001 Fink et al. 1979). The mallard duck acute oral toxicity classification to paraquat ranges from moderately toxic (144.8 mg/kg) to slightly toxic (436.8 mg/kg), both studies are supplemental (Fink et al. 1979). Paraquat is classified as being moderately toxic to birds on an acute oral basis.

Subacute dietary tests are required to establish toxicity of paraquat to birds. The preferred test species are the mallard duck and the bobwhite quail. The most sensitive subacute dietary 5d $LC_{50}$ value was 703 ppm for the Japanese quail (a non-guideline test species, indicating that the study was supplemental MRID 00022923 Hill et al. 1975). However, the Japanese quail is believed to be an acceptable representative of avain subacute dietary toxicity. Acceptable studies (from guideline bird species, the mallard duck and bobwhite quail) resulted in 5d $LC_{50}$ values of 711 ppm for the northern bobwhite quail, and 2914.6 ppm for the mallard duck. Paraquat is classified as being moderately toxic to slightly toxic to birds on a subactue dietary basis.

#### 4.2.1.2 Birds: Chronic Exposure (Growth, Reproduction) Studies

Avian reproductive toxicity endpoints were submitted for two species, the northern bobwhite quail (MRID 00110453 Fink et al. 1981) and the mallard duck (MRID 00110455 Fink et al. 1982). The northern bobwhite quail appeared to be the less sensitive of the two species with an 8d NOAEC value of 100 ppm with adult mortality as the endpoint. The mallard duck was the most sensitive species with an 18 week NOAEC of 30 ppm, and a LOAEC value of 100 ppm (the highest concentration tested). Concentrations of the paraquat cation for the one generation mallard duck toxicity test were 0, 10, 30, and 100 ppm. Adverse affect endpoints were the reduction in the % viable eggs, the number of eggs set, the number of 14d old survivors, and normality of hatchlings (MRID 00110455 Fink et al. 1982).

#### 4.2.1.3 Terrestrial-phase Amphibian Acute and Chronic Studies

There were no terrestrial-phase amphibian acute or chronic studies submitted or available in the open literature.

### 4.2.2 Toxicity to Mammals

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

#### 4.2.2.1 Mammals: Acute Exposure (Mortality) Studies

Paraquat is classified as moderately toxic on an acute oral basis to mammals. This is based on an acute oral $LD_{50}$ value of 90.98 mg/kg-bw (MRID 00054573 Rittenhouse 1977). See the HED Table from the most recent HED Human Health Risk Assessment in Appendix K.

#### 4.2.2.2 Mammals: Chronic Exposure (Growth, Reproduction) Studies

In a 3-generation reproduction and fertility study in rats, paraquat was administered to Wistar Derived Rats-Alderley Park Strain (MRIDs 00126783, 00149748, & 00149749). The offspring and reproductive NOAEL were both 7.5 mg/kg-bw, and the both NOAECs were 108 ppm (MRIDs 00149748 & 00149749). Reproductive NOAEC was used to calculate RQ values. This study is classified as acceptable/guideline and satisfies the guideline for a reproduction toxicity study, OPPTS 870.3800. The parental NOAEL was 0.9 mg/kg-bw, and the parental NOAEC was 18 ppm (MRID 00126783 Lindsay et al. 1982). The parental LOAEL was 2.7 mg/kg-bw, and the parental LOAEC was 54 ppm (MRID 00126783 Lindsay et al. 1982). Parental toxicity endpoints were mortality and lung damage (particularly increased incidences of alveolar histiocytes), indicating a sublethal impact lower than the acute oral endpoints. HED determined that paraquat dichloride was not a mutagen or a carcinogen (HED 2006). Paraquat was found to be weakly positive in the mouse lymphoma assay and human lymphocyte cytogenetic assay and was positive in the sister chromatid exchange assay (HED 2006). Paraquat was not mutagenic in the bacterial gene mutation assay, not genotoxic in the unscheduled DNA synthesis assay *in vitro* or *in vivo*, was negative for chromosomal aberration in the bone marrow test, and no evidence was found for suppressed fertility or dominant lethal mutagenicity in mice. There was also no evidence of carcinogenicity in animal studies, and paraquat was classified as a Group E chemical (evidence of non-carcinogenicity in humans) (Cancer Peer Review Committee and the Science Advisory Committee 1989, HED 2006). See the HED Table from the most recent HED Human Health Risk Assessment in Appendix K.

### 4.2.3 Toxicity to Terrestrial Invertebrates

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

#### 4.2.3.1 Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

A honeybee acute contact study (TGAI) resulted in a 48h $LD_{50}$ > 34.8 µg/bee (MRID 05001991 Stevenson 1978). Paraquat is classified as practically non-toxic to honeybees.

#### 4.2.3.2 Terrestrial Invertebrates: Open Literature Studies

There were no terrestrial invertebrate studies available in the open literature.

### 4.2.4 Toxicity to Terrestrial Plants

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

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

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

The most sensitive results of the Tier II seedling emergence and vegetative vigor toxicity tests on non-target plants are summarized below in Table 4-5**.** For seedling emergence only one of four monocot species had scientifically sound results, and it was higher than dicot values. Therefore, it was assumed that monocots were as sensitive as the most sensitive dicot. An addendum DER to MRID 42601001 (Canning and White 1992) was made as the statistics for the non-target plants vegetative vigor phytotoxicity study were recalculated using the NUTHATCH statistical program.

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

| Crop | Type of Study Species | NOAEC (lb cation/A) | $EC_{25}$ (lb cation/A) | Most sensitive parameter |
|---|---|---|---|---|
| ***Seedling Emergence*** | | | | |
| Monocots | Assumed as sensitive as dicots | | | |
| Dicots | Cocklebur | 0.423 | 0.85 | Dry weight |
| ***Vegetative Vigor*** | | | | |
| Monocots | Corn | 0.064 | 0.16<br>(95% CI 0.073–0.36) | Dry weight |
| Dicots | Cockelbur | $EC_{05}$ = 0.0065<br>(95% CI 0.0040–0.01) | 0.014<br>(95% CI 0.01–0.019) | Dry weight |

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

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

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

## 4.4 Incident Database Review

A review of the EIIS database for ecological incidents involving paraquat and paraquat dichloride, which are used interchangeably, was completed on April 17, 2009. The results of this review for terrestrial, plant, and aquatic incidents are discussed below in Sections 4.4.1 through 4.4.3, respectively. A total of 4 incidents involving paraquat (PC code 061603) were reported, and a total of 26 incidents involving paraquat dichloride (PC

code 061601) were reported. There were no incidents reported for paraquat bis (methyl sulfate) (PC code 061602). A complete list of the incidents involving paraquat and paraquat dichloride including associated uncertainties is included as Appendix H.

### 4.4.1 Terrestrial Incidents

There were no reported terrestrial incidents for paraquat (PC code 061603). There were three reported terrestrial incidents for paraquat dichloride (PC code 061601). Two incidents resulted in the mortality of birds, and the other reported both bird mortality and plant damage (I008168-001, I000097-015, and I007334-001). Two of the incidents occurred in Virginia one was a formulation with a registered use on corn that resulted in the mortality of 5 Canadian geese where paraquat dichloride was the probable cause of the incident in June 1998 (I008168-001). The other incident was from the consumption of granules resulting in the death of approximately 12 birds. However, paraquat dichloride was unlikely the cause of the incident on May 1989 (I000097-015), as there are no granular forms of paraquat. Paraquat was reported since it was applied within the area of the observed incident. The other incident occurred in Illinois resulting in plant damage on 18 of 103 acres of corn, and the death of 4 unknown species of birds in June 1998 from drift/spray exposure (I007334-001), the legal classification was that paraquat was of probable cause for the incident.

### 4.4.2 Plant Incidents

There were a total of four plant incidents listed for paraquat (PC code 061603). Plant damage was sustained to three non-target species; radishes, apples, and ornamentals (I014409-001, I013884-038, and I013884-014), while plant mortality was reported for alfalfa (I014409-024). All incidents reported were from Washington, one from a registered use on peas where ornamentals were affected, and paraquat was the probable cause of plant damage; one from a misuse (alfalfa) where paraquat was a possible cause of mortality; and the other two the use was of undetermined legality, and paraquat was a possible cause of plant damage. All exposures occurred from drift, with apples also being exposed from direct spray. The total magnitude of exposure was not reported.

There were a total of 17 plant incidents listed for paraquat dichloride (PC code 061601). Two accidental misuse incidents occurred in an agricultural area in Wisconsin resulting in plant damage to alfalfa, ash, and ornamentals (I005660-005), and ash, oats and discoloration to alfalfa (I005880-005) from drift exposure. Paraquat was the probable cause of these incidents. Three accidental misuse incidents on corn resulted in plant damage to grass (I007371-033, I007371-034, and I007371-035) on June 17, 1997, and paraquat was the propable cause of these incidents. 120 acres of a corn field was damaged after undetermined legality of broadcast application occurred May 9, 2000, and paraquat was a possible cause of this incident (I012366-023). Plant damage to 181 acres of peppermint occurred after registered use May 1, 1996, and paraquat was a possible cause of this incident (I013636-029). Undetermined legality use of paraquat dichloride application was the possible cause of 150 (75% of 200) acres of corn damaged on May 11, 1999 in Alabama (I009573-009). After the registered use application of paraquat

dichloride 10 acres of peanuts were damaged June 19, 2001 in North Carolina, and paraquat was a possible cause of this incident (I011838-055). Carryover from the broadcast application of paraquat dichloride was the probable cause of damage to 1040 acres of corn May 24, 2002 in Illinois (I013554-040). The registered use application of paraquat dichloride was a possible cause of the damage to 60 acres of pasture grass April 23, 2003 in Georgia (I014034-009). The registered application of paraquat dichloride on peanuts was a possible cause of plant damage to 5 acres of peanuts in Virginia May 23, 2001 (I012684-010). Undetermined legality use of paraquat dichloride on peanuts was a possible cause of plant damage to 80 acres of peanuts in Oklahoma (I011838-091) and all 25 acres in Georgia (I011838-038). Registered use of broadcast application of paraquat dichloride to soybeans was a possible cause of plant damage to an unknown tree as a result of drift June 27, 1994 in Arkansas (I001131-001). It is highly probable that the accidental misuse of paraquat dichloride on soybeans resulted in plant damage to unknown amounts of soybeans as the result of drift May 20, 1997 in Pennsylvania (I007371-008). Intentional misuse of paraquat dichloride by spray application on wheat was the probable cause of plant damage to 120 of 184 acres from drift January 26, 2005 in California (I016940-005).

### 4.4.3 Aquatic Incidents

There were no reported aquatic incidents listed for paraquat (PC code 061603). There were six reported aquatic incidents listed for paraquat dichloride (PC code 061601). Undetermined legality use of paraquat dichloride on an agricultural area was a possible cause of the mortality of 54 fish (1 largemouth bass, and 53 sunfish) due to runoff June 4, 1981 in Virginia (B0000-502-18). Registered usage of paraquat dichloride application on an agricultural area in North Carolina was unlikely the cause of the mortality to unknown amount of unknown fish November 29, 1993 (I003654-012). Registered use of paraquat dichloride on corn was unlikely the cause of the mortality of numerous unknown fish from runoff in Kentucky April 1, 1992 (B000175-001). The application of paraquat dichloride on a field was a possible cause of the mortality of fish (bass, bluegill, and crappie) in Indiana June 2, 1997 (I009314-005). An undetermined legality application of paraquat dichloride was a possible cause of the mortality of an unknown amount of bass, bluegill, and crappie to die in Indiana January 1, 1997 (I005805-001). Paraquat dichloride was was a possible cause of the 200 bass and bluegills that were found dead after an undetermined legality application of paraquat dichloride June 3, 1999 (I008768-007).

# 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 effects to its designated critical habitat from the use of paraquat 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 in its terrestrial environment and mammals, the LOC is 0.1. The LOC for chronic exposures to CRLF and its prey, as well as acute exposures to plants is 1.0.

Risk to the aquatic-phase CRLF is estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended paraquat usage scenarios summarized in Table 3-3 and the appropriate aquatic toxicity endpoint from Table 4-1. Risks to the terrestrial-phase CRLF and its prey (*e.g*. terrestrial insects, small mammals and terrestrial-phase frogs) are estimated based on exposures resulting from applications of paraquat (Table 3-5 and Table 3-6) and the appropriate toxicity endpoint from Table 4-3. Exposures are also derived for terrestrial plants, as discussed in Section 3.4 and toxicity summarized in Section 4.2.4, based on the highest application rates of paraquat use within the action area.

Due to Paraquat being a cation, the risk estimated may be more conservative for soils with higher clay contents due to paraquat's ability to dissipate by rapid adsorption to biological materials and clay particles. The bound residues do not appear to be environmentally available because they are so strongly adsorbed. Paraquat is also very immobile in soil with adsorption Kds ranging from 68-50,000. Paraquat has such extremely high adsorption coefficients, it is not expected to desorb from the soil.

### 5.1.1 Exposures in the Aquatic Habitat

#### 5.1.1.1 Direct Effects to Aquatic-Phase CRLF

Direct acute effects to the aquatic-phase CRLF are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60-day EECs and the lowest chronic toxicity value for freshwater fish are used. However, since freshwater fish chronic toxicity values are not

available at this time, the direct chronic toxicity values for the CRLF were calculated using an acute to chronic ratio. The acute to chronic ratio (ACR) was completed using a similar chemical compound, diquat dibromide. However, the ACR could not be calculated for freshwater fish (direct effects to the CRLF) using the same method as the indirect effects, as the species of fish were different in the diquat acute and chronic studies for the direct effects. There is greater uncertainty when using two different species of fish, in addition to the general uncertainty related with comparing toxicity of two different compounds. The ACR for invertebrates was completed and the estimated indirect chronic toxicity of paraquat to the CRLF was approximately 0.174 ppm (174 ppb). For qualitative purposes, although it is not general practice, the chronic direct effect was calculated using the calculated chronic ratio from the invertebrates divided by the acute $LC_{50}$ value from the freshwater fish. Because these species are different, it increases the uncertainty, but can provide valuable information in helping to discuss the possible toxicity to the aquatic phase CRLF directly. The ACR for freshwater fish and the estimated direct chronic toxicity of paraquat to the CRLF was found to be approximately 1.89 ppm (1890 ppb). As seen in Table 5-1, none of the EECs exceed 1, 890 ppb. As a result, it appears that paraquat **is determined to have no direct effect on the aquatic-phase of the CRLF on a chronic basis.**

Based on the data presented in Table 5-1, it appears that paraquat **has no acute direct affects on the aquatic-phase CRLF since there are no LOC exceedences.**

**Table 5-1 Summary of Acute Direct Effect RQs* for the Aquatic-phase CRLF**

| Use | EEC (µg/L)[b] | RQ | Probability of Individual Effect at RQ[C] | LOC Exceedance and Risk Interpretation |
|---|---|---|---|---|
| AGRICULTURAL FALLOW/IDLELAND | 33 | 0.003 | No exceedance | **NO** |
| | 27 | 0.002 | No exceedance | **NO** |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 55 | 0.004 | No exceedance | **NO** |
| GUAVA, PASSION FRUIT (GRANADILLA) | 55 | 0.004 | No exceedance | **NO** |
| MELONS, PEANUTS (ground only) | 2.0 | <0.001 | No exceedance | **NO** |
| | 1.6 | <0.001 | No exceedance | **NO** |

[a] RQs associated with acute direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. No chronic data is available.
[b] The highest EEC based on maximum application rate per use (see Table 3-3).
[c] A probit slope value for the acute bluegill sunfish toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986). (Only calculated when there was an exceedance).
[*] RQ < acute endangered species LOC of 0.05.
^ The most sensitive species used to determine the acute direct effects (surrogate species) was the bluegill Sunfish (96h $LC_{50}$ = 13000 ppb).

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

##### a) Non-vascular Aquatic Plants

Indirect effects of paraquat 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's exceed the modeled EECs (Table 5-2); therefore, paraquat may affect the aquatic-phase CRLF indirectly via effects to non-vascular aquatic plants.**

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

| Use | Peak EEC (µg/L) | Indirect effects RQ [a] (food and habitat) |
|---|---|---|
| AGRICULTURAL FALLOW/IDLELAND | 33 | **82** |
| | 27 | **69** |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 55 | **138** |
| GUAVA, PASSION FRUIT (GRANADILLA) | 55 | **138** |
| MELONS, PEANUTS (ground only) | 2.0 | **4.9** |
| | 1.6 | **4.1** |

[a] RQs used to estimate indirect effects to the CRLF via toxicity to vascular aquatic plants are summarized in Table 5-4
* LOC exceedances (RQ $\geq$ 1) are bolded and shaded. RQ = use-specific peak EEC/ most sensitive non-vascular aquatic plant endpoint (Acute: *Navicula pelliculosa* $EC_{50}$= 0.396 ppb).

##### b) Aquatic Invertebrates

As mention in Section 5.1.1.1, in the absence of chronic data, the acute to chronic ratio (ACR) between diquat and paraquat was calculated. The ACR for invertebrates and the estimated indirect chronic toxicity of paraquat to the CRLF was found to be approximately 174 ppb (0.174 ppm). As seen in Table 5-3, RQs do not exceed the LOC and therefore, paraquat **has no indirect effects on the CRLF via reduction in freshwater invertebrate prey items on a chornic basis.**

A summary of the acute RQ values for exposure to aquatic invertebrates (as prey items of aquatic-phase CRLFs) is provided in Table 5-3. As described above for Table 5-1, probit slope analysis was not performed because there were no exceedances for any use. Based on the data presented in Table 5-3 paraquat has **no indirect effect on the CRLF via reduction in freshwater invertebrate prey items on an acute basis.**

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

| Use | Peak EEC (µg/L) | Indirect Effects Acute RQ* | Probability of Individual Effect at RQ[a] |
|---|---|---|---|
| AGRICULTURAL FALLOW/IDLELAND | 33 | 0.025 | No exceedance |
| | 27 | 0.021 | No exceedance |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 55 | 0.042 | No exceedance |
| GUAVA, PASSION FRUIT (GRANADILLA) | 55 | 0.042 | No exceedance |
| MELONS, PEANUTS (ground only) | 2.0 | 0.002 | No exceedance |
| | 1.6 | 0.001 | No exceedance |

* = LOC exceedances (acute RQ $\geq$ 0.05) are bolded and shaded. Acute RQ = use-specific peak EEC / acute freshwater invertebrate endpoint (*Daphnia magna* $EC_{50}$ =1200 ppb). No chronic data is available.
[a] A probit slope value for the acute *Daphnia magna* toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).

#### c) Fish and Frogs

Fish and frogs also represent potential prey items of adult aquatic-phase CRLFs. RQs associated with acute and chronic direct toxicity to the CRLF (Table 5-1) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. However, since freshwater fish chronic toxicity values are not available at this time, the indirect chronic toxicity values for the CRLF were estimated using the ACR of freshwater invertebrates exposed to diquat. Based on Table 5-1 it can be concluded that paraquat **will have no indirect effects on the aquatic-phase of the CRLF on an acute or chronic basis from fish or other aquatic-phase frogs as prey items.**

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

Indirect effects to the CRLF via direct toxicity to aquatic plants are estimated using the most sensitive non-vascular and vascular plant toxicity endpoints. Because there are no obligate relationships between the CRLF and any aquatic plant species, the most sensitive $EC_{50}$ values, rather than NOAEC values, were used to derive RQs. Based on the data presented in Tables 5-2 and 5-4, paraquat **may affect the CRLF via reduction in non-vascular plants, but will have no indirect effect via reduction in vascular plants.**

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

| Use | Peak EEC (µg/L) | Indirect effects RQ [a] (food and habitat) |
|---|---|---|
| AGRICULTURAL FALLOW/IDLELAND | 33 | 0.46 |
| | 27 | 0.38 |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE), NONAGRICULTURAL RIGHTS-OF-WAY/FENCEROWS/HEDGEROWS | 55 | 0.77 |
| GUAVA, PASSION FRUIT (GRANADILLA) | 55 | 0.77 |
| MELONS, PEANUTS (ground only) | 2.0 | 0.03 |
| | 1.6 | 0.02 |

[a] RQs used to estimate indirect effects to the CRLF via toxicity to non-vascular aquatic plants are summarized in Table 5-2
* = LOC exceedances (RQ $\geq$ 1) are bolded and shaded. RQ = use-specific peak EEC / vascular aquatic plant endpoint (*Lemna gibba* $EC_{50}$= 71 ppb).

### 5.1.2 Exposures in the Terrestrial Habitat

#### 5.1.2.1 Direct Effects to Terrestrial-phase CRLF

As previously discussed in Section 3.3, potential direct effects to terrestrial-phase CRLFs are based on broadcast foliar (ground and aerial) application of paraquat. Potential direct acute effects of paraquat to the terrestrial-phase CRLF are derived by considering dose- and dietary-based EECs modeled in T-REX for a small bird (20 g) consuming small invertebrates (Table 3-5) and acute oral and subacute dietary toxicity endpoints for avian species. Acute effects are estimated using the lowest available toxicity data for birds. EECs are divided by toxicity values to estimate acute dietary-based RQs (Table 5-5). The Japanese quail was the most sensitive to paraquat on a subacute dietary basis ($LC_{50}$ = 703ppm), and the Northern bobwhite quail was the most sensitive on an acute dietary basis ($LD_{50}$ = 128.1 mg/kg-bw) were therefore selected to serve as a surrogate for the CRLF. Resulting acute dietary and dose-based RQs for all but one use (melons with the lowest application rate) of paraquat exceed the Agency's acute endangered species LOC of 0.1 for the CRLF (Table 5-5). The probability of individual effect at the endangered species LOC (0.1) ranges from 1 in 1.46 with a 95% CI of 1 in 1.71 to 1 in 1.20 (for airports) to 1 in $1.71*10^3$ with a 95% CI of 1 in $1.34*10^1$ to 1 in $2.35*10^{10}$ (for carrots). The effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).

Potential direct chronic effects of paraquat to the terrestrial-phase CRLF are derived by considering dietary-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates (Table 3-5). Chronic effects are estimated using the lowest available toxicity data for birds. EECs are divided by toxicity values to estimate chronic dietary-based RQs (Table 5-6). Chronic reproductive effects for the Mallard duck were observed

with a NOAEC of 30 ppm. The chronic dietary-based RQs for the terrestrial phase CRLF exceed the Agency's chronic LOC of 1.0 for all uses of paraquat (Table 5-6). The probability of individual effect probit slope analysis is not applicable for chronic endpoints. **Based on the potential for both acute and chronic effects (Tables 5-5 and 5-6) paraquat may directly affect the terrestrial-phase of the CRLF.**

**Table 5-5 Summary of Acute RQs* Used to Estimate Direct Effects to the Terrestrial-phase CRLF (foliar application) From T-REX**

| Use<br>Application Rate (lb cation/acre) | Dietary-based Acute RQ[1] | Probability of Individual Effect at RQ[a] |
|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum-non-ag) | **1.28** | 1 in 1.46<br>(1 in 1.71 to 1 in 1.20)[a] |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **1.28** | 1 in 1.46<br>(1 in 1.71 to 1 in 1.20)[a] |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **0.42** | 1 in 2.22 E+01<br>(1 in 4.43 E+01 to 1 in 2.87 E+03) [a] |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **0.26** | 1 in 2.36 E+02<br>(1 in 8.27 to 1 in 1.43 E+07)[a] |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **0.19** | 1 in 1.71 E+03<br>(1 in 1.34E+01 to 1 in 2.35 E+10) [a] |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 0.06 | No exceedance |

* = LOC exceedances (Acute RQ $\geq$ 0.1) are bolded and shaded.
[1] Based on Japanese quail $LC_{50}$ = 703 ppm.
[a] A probit slope value for the acute avian toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).

**Table 5-6 Summary of Chronic RQs* Used to Estimate Direct Effects to the Terrestrial-phase CRLF (foliar application) From T-REX**

| Use<br>(Application Rate) | Dietary-based Chronic RQ[1] |
|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | **30.00** |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **30.00** |

| Use (Application Rate) | Dietary-based Chronic RQ[1] |
|---|---|
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **9.76** |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **6.13** |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **4.50** |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | **1.35** |
| * = LOC exceedances (Chronic RQ ≥ 1) are bolded and shaded.<br>[1] Based on Mallard duck NOAEC = 30 ppm. | |

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

##### a) Terrestrial Invertebrates

In order to assess the risks of paraquat to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the honey bee is used as a surrogate for terrestrial invertebrates. The toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available acute contact $LD_{50}$ > 34.6µg cation/bee by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs (µg a.i./g of bee) calculated by T-REX for small and large insects are divided by the calculated toxicity value for terrestrial invertebrates, which is > 270.3 µg cation/g of bee, to calculate RQs. Indirect effects cannot be precluded from available data because the $LD_{50}$ exceeds the levels tested even though pesticide related mortality was observed **Therefore, it is determined that paraquat may indirectly affect the CRLF via reduction in terrestrial invertebrate prey items.**

##### b) Mammals

Risks associated with ingestion of small mammals by large terrestrial-phase CRLFs are derived for dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass. Acute and chronic effects are estimated using the most sensitive mammalian toxicity data ($LD_{50}$ = 90.98 mg/kg-bw). EECs are divided by the toxicity value to estimate acute and chronic dose-based RQs as well as chronic dietary-based RQs (Table 5-7). RQs representing acute and chronic exposures of small mammals consuming short grass on the treated field contaminated with paraquat exceed endangered species LOC of 0.1 (acute) and 1 (chronic) for all uses except melons (Table 5-7). Melons chronic dietary based RQ does not exceed the endangered species LOC of 0.1. The probability of individual effect at the endangered species LOC (0.1) is 1 in 2.94*105 (95%CI: 1 in 4.40*101 to 8.86*1018). The effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).

The probability of individual effect probit slope analysis is not applicable for chronic endpoints. HED determined that paraquat dichloride was not a mutagen or a carcinogen (HED 2006). Paraquat was found to be weakly positive in the mouse lymphoma assay and human lymphocyte cytogenetic assay and was positive in the sister chromatid exchange assay (HED 2006). Paraquat was not mutagenic in the bacterial gene mutation assay, not genotoxic in the unscheduled DNA synthesis assay in vitro or in vivo, was negative for chromosomal aberration in the bone marrow test, and not evidence was found for suppressed fertility or dominant lethal mutagenicity in mice. There was also no evidence of carcinogenicity in animal studies, and paraquat was classified as a Group E chemical (evidence of non-carcinogenicity in humans) (Cancer Peer Review Committee and the Science Advisory Committee 1989, HED 2006). **Based on the acute and chronic LOC exceedances of paraquat on small mammal prey (Table 5-7), paraquat may indirectly affect the CRLF via reduction in small mammal prey items.**

**Table 5-7 Summary of Acute and Chronic RQs* Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Small Mammals as Dietary Food Items (foliar application)**

| Use (Application Rate) | Chronic RQ | | Acute RQ | Probability of % Effect at Acute RQ[a] |
|---|---|---|---|---|
| | Dose-based Chronic RQ[1] | Dietary-based Chronic RQ[2] | Dose-based Acute RQ[3] | |
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | **128.53** | **14.81** | **7.63** | 100%<br>1 in 1 (1 in 1.04 to 1 in 1)[a] |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **128.53** | **14.81** | **7.63** | 100%<br>1 in 1 (1 in 1.04 to 1 in 1)[a] |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **41.82** | **4.82** | **2.48** | 96%<br>1 in 1.04 ( 1 in 1.27 to 1 in 1)[a] |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **26.28** | **3.03** | **1.56** | 81%<br>1 in 1.24 (1 in 1.54 to 1 in 1.04)[a] |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **19.28** | **2.22** | **1.14** | 60%<br>1 in 1.66 (1 in 1.83 to 1 in 1.44)[a] |

| | | | | |
|---|---|---|---|---|
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | **5.78** | 0.67 | **0.34** | 1.75%<br>1 in 57.1 (1 in 5.73 to 1 in 8.07E+04) [a] |

* = LOC exceedances (acute RQ ≥ 0.1 and chronic RQ ≥ 1) are bolded and shaded.

[1] Based on dose-based EEC and paraquat rat NOAEL = 5.4 mg/kg-bw.
[2] Based on dietary-based EEC and paraquat rat NOAEC = 108 mg/kg-diet.
[3] Based on dose-based EEC and paraquat rat acute oral $LD_{50}$ = 90.98 mg/kg-bw.
[a] A probit slope value for the acute avian toxicity test is not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986).

#### c) Frogs

An additional prey item of the adult terrestrial-phase CRLF is other species of frogs. In order to assess risks to these organisms, dietary-based and dose-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates are used. See Section 5.1.2.1 and associated table (Table 5-5 and 5-6) for results. The acute LOC is exceeded for all uses of paraquat except Melons, and the chronic LOC is exceeded for all uses of paraquat. **Based on the acute and chronic LOC exceedances, paraquat may indirectly affect the CRLF via reduction in frogs as prey items.**

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

Potential indirect effects to the CRLF resulting from direct effects on riparian and upland vegetation are assessed using the most sensitive terrestrial plant data, in this case vegetative vigor $EC_{25}$ data, as a screen. The vegetative vigor endpoint is $EC_{25}$ = 0.014 lb cation/acre. To determine the reduction in terrestrial plants, a spray drift analysis using AgDRIFT was performed. Please see Section 5.2.5.1 for an explanation of the effects of spray drift.

P**araquat may indirectly affect the CRLF via reduction in terrestrial plants from both aerial and ground application for vegetation that is located between the site of application to the border of where plant exposure is expected. The distance of effect is expected to be 1,000 feet or possibly greater.**

### 5.1.3 Primary Constituent Elements of Designated Critical Habitat

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

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

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

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

Reduction of aquatic based food sources may occur from most use sites.
Because reduction of aquatic based food sources may occur from most use sites, paraquat may be likely to indirectly affect the CRLF. Likewise, due to paraquat's ability to reduce aquatic non-vascular plants used as food source and habitat for CRLF, paraquat may be likely to indirectly affect the CRLF. Since there are LOC exceedances on non-target terrestrial dicot plants from spray drift at the minimum application rate, paraquat may indirectly affect the CRLF via reduction in terrestrial plants from aerial application as well. As a result, due to aquatic vascular and terrestrial plant communities being reduced from most use sites, there is potential for alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond and for 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.

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 paraquat 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 Sections 5.1.1.1 and 5.1.1.2. **Based on acute LOC exceedances for aquatic plants, paraquat may result in effects to aquatic-phase PCEs.**

#### 5.1.3.2 Terrestrial-Phase (Upland Habitat and Dispersal Habitat)

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

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

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

The risk estimation for terrestrial-phase PCEs of designated habitat related to potential effects on terrestrial plants is provided in Section 5.1.2.3. These results will inform the effects determination for effects to designated critical habitat for the CRLF. There were no LOC exceedances for non-target monocot plants (inhabiting upland dry, semi-dry areas) or resulting from spray drift. Although there were no LOC exceedances for non-target dicot plants inhabititing upland dry and semi-dry area RQ's, there was an exceedance for spray drift. The buffer determined from AgDRIFT (Section 5.2.5.1) yielded a buffer of at least 1,000 feet. Therefore, any plants with in a 1,000 foot radious from the application site may potentially be affected. **Based on the results paraquat may affect the first and second terrestrial-phase PCEs.**

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of paraquat 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 5.1.2.2. **Based on acute and chronic LOC exceedances for CRLF prey items of small mammals, terrestrial invertebrates and other frogs, paraquat may result in effects to the third terrestrial-phase PCE.**

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. Direct acute and chronic RQs for terrestrial-phase CRLFs are presented in Section 5.2.1.2. **Due to acute and chronic LOC exceedances at all but one use sites (acute only) to terrestrial-phase CRLFs, paraquat may result in effects to the fourth terrestrial-phase PCE.**

## 5.2 Risk Description

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

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

A summary of the risk estimation results are provided in Table 5-8 for direct and indirect effects to the CRLF and in Table 5-9 for the PCEs of designated critical habitat for the CRLF.

**Table 5-8 Risk Estimation Summary for Paraquat - Direct and Indirect Effects to CRLF**

| Assessment Endpoint | LOC Exceedances (Y/N) | Description of Results of Risk Estimation |
|---|---|---|
| ***Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)*** | | |
| Direct Effects<br>Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases | No | The aquatic phase amphibian acute LOCs for listed species (0.05) are not exceeded for any uses of paraquat in California. The RQs range from 0.004 for airports, commercial/industrial areas, and public health areas to < 0.001 for melons.<br><br>When comparing chronic direct effects, the estimated chronic value at 1.89 ppm is not exceeded for any use. |
| Indirect Effects<br>Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants) | Yes | LOCs for aquatic invertebrates are not exceeded for any uses. The acute RQs range from 0.042 for airports, commercial/industrial areas, and public health areas to < 0.01 for melons.<br><br>When comparing chronic indirect effects, the estimated chronic value at 0.174 ppm is not exceeded for any use. |
| Indirect Effects<br>Survival, growth, and reproduction of CRLF individuals via effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community) | Yes | RQs for vascular aquatic plants do not exceed the Agency's LOC (1.0) for any uses. These range from 0.77 (airports, commercial/industrial areas, public health areas) to 0.02 (melons).<br><br>LOCs for non-vascular plants are exceeded for all uses. The RQs range from 138 (airports, commercial/industrial areas, and public health areas) to 4.1 (melons). |
| Indirect Effects<br>Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range. | Yes | RQs for non-target terrestrial monocot and dicot plants inhabitating semi-aquatic and upland dry areas do not exceed the Agency's LOC for any uses except for dicot plants exposed to agricultural follow/ideland, and melon applications for spray drift. Spray drift RQs for these applications range from 3.57 to 1.07 respectively. |
| ***Terrestrial Phase (Juveniles and adults)*** | | |
| Direct Effects<br>Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles | yes | Refined acute dietary-based RQs for CRLFs consuming small insects exceed the acute listed species LOC (0.1) for all uses of paraquat except melons, RQs ranged from 1.28 (Airport/public health use/guava) to 0.06 (melons). The Refined acute dietary-based RQs for CRLFs consuming large insects and 15g small insectivore mammals resulted in paraquat use on airports/public health use/guava exceeding the listed species LOC (0.1), with an RQ of 0.14 for both. The refined acute dietary-based RQs for CRLFs consuming small herbivore mammals (15g) resulted |

| Assessment Endpoint | LOC Exceedances (Y/N) | Description of Results of Risk Estimation |
|---|---|---|
| | | in all uses exceeding the listed species LOC, RQs ranged from 2.17 (Airport/public health use/guava) to 0.10 (melons) and for 35g small mammals all uses except melons exceed the listed species LOC, RQs ranged from 1.50 (Airport/public health use/guava) to 0.77 (melons). There are no exceedances for CRLFs consuming small terrestrial-phase amphibians.<br><br>Refined dose-based RQs for CRLF of varying weights (1.4g, 37g and 238g) consuming small insects exceed the acute endangered species LOC (0.1) for only the Airport/public health and Guava uses of paraquat for all weights of CRLF). There are no exceedances for small sized (1.4g) CRLF consuming large insects and CRLF this size are too small to consume small mammals or small terrestrial-phase amphibians. The RQs for small sized (1.4g) CRLF are 0.27 suggesting that small CRLF consuming small insects are potentially affected by acute exposures to paraquat.<br><br>Refined dose-based RQs for medium sized (37g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat. There were also exceedances in the acute listed species LOC (0.1) for medium sized CRLF consuming small insectivore (15g) mammals for the airports/public health, guava, and ginger uses of paraquat. For medium sized CRLF consuming small insectivore (35g) mammals there were exceedances in the acute listed species LOC (0.1) for all uses of paraquat except carrots and melons. There are no exceedances for medium sized (37g) CRLF consuming large insects or small terrestrial-phase amphibians. Due to exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses, and exceedances of LOCs for CRLF consuming small insectivore mammals (either 15g or 35g) for a majority of paraquat uses indicate that the medium sized CRLF could potentially be affected by acute exposures to paraquat.<br><br>Refined dose-based RQs for large sized (238g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat except melons. There were no exceedances for large sized (238g) CRLF consuming large insects, small insectivore mammals (15g or 35g), or small terrestrial-phase amphibians. The exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses except melons, indicates that the large sized CRLF could potentially be affected by acute exposures to paraquat.<br><br>Refined chronic dietary-based RQs for CRLFs consuming small insects and small herbivore mammals (either15g or 35g) using |

| Assessment Endpoint | LOC Exceedances (Y/N) | Description of Results of Risk Estimation |
|---|---|---|
| | | T-HERPS model exceed the chronic species LOC (1.0) for all uses of paraquat. Refined chronic dietary-based RQs for CRLFs consuming large insects and small insectivore mammals (either 15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health, guava, and ginger uses of paraquat. The refined chronic dietary-based RQs for CRLFs consuming small terrestrial- phase amphibians using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health and guava uses of paraquat (the maximum uses). |
| Indirect Effects<br>Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial mammals and terrestrial phase amphibians) | yes | The acute-dose based RQs for small mammals exceed the endangered species LOC for all uses except Melons, and ranged from 7.63 (Airports/public health use, maximum application rate) to 0.34 (Melons). These results are summarized in Table 5-7.<br><br>The chronic dietary-based RQs for small mammals exceed the endangered species LOC for all uses except Melons, and ranged from 14.81 (Airports/public health use, maximum application rate) to 0.67 (Melons). The chronic dose-based RQs for small mammals exceed the endangered species LOC for all uses, and ranged from 128.53 (Airports/public health use) to 5.78 (Melons). These results are summarized in Table 5-7. |
| Indirect Effects<br>Survival, growth, and reproduction of CRLF individuals via effects on habitat (*i.e.*, riparian vegetation) | yes | The RQs for non-target terrestrial monocot and dicot plants inhabiting semi-aquatic and upland dry areas do not exceed the Agency's LOC (1.0) for all uses. All aerial applications of paraquat results in spray drift exceedances for dicots (only). These exceedances range from 3.57 (Agricultural fallow/ideland maximum aerial application rate) to 1.07 (Melons, minimum aerial application rate). |

**Table 5-9 Risk Estimation Summary for Paraquat – PCEs of Designated Critical Habitat for the CRLF**

| Assessment Endpoint | Habitat Effects (Y/N) | Description of Results of Risk Estimation |
|---|---|---|
| ***Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)*** | | |
| Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs. | Yes | LOCs are exceeded for terrestrial riparian plants and for aquatic non-vascular plants from exposure to paraquat from spray drift. |
| Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source. | Yes | LOCs are exceeded for terrestrial riparian plants and for aquatic plants from exposure to paraquat from spray drift. Alteration of riparian and non-vascular plants may result in alteration of temperature, turbidity, and oxygen content. |
| Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source. | Yes | LOC is exceeded for indirect effects on terrestrial phase CRLF from most paraquat applications. |
| Reduction and/or modification of aquatic-based food sources for pre-metamorphs (e.g., algae) | Yes | LOCs for non-vascular plants are exceeded for all uses. |
| ***Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)*** | | |
| Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 feet of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance | yes | The AgDRIFT model was used to evaluate potential distances beyond which exposures would be expected to be below the LOC. The Tier I ground application output for the maximum application rate of paraquat indicated a buffer zone of >1,000 feet for non-listed plants to be below the LOC. For the minimum application rate, the output indicated a buffer zone of of >1,000 feet for non-listed species.<br><br>Both the Tier I and Tier II aerial application output for the maximum and minimum application rates of paraquat indicated that the buffer zone required would be greater than 1,000 feet for non-listed plants. Since the model is restricted to accurately discerning a buffer within 1,000 feet of the application, the exact distance needed for a buffer to protect listed and non-listed plants is unknown. |
| 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 | yes | Effects are expected to non-target plants over 1,000 feet from the use site from aerial application of paraquat at the maximum application use rate. |

| Assessment Endpoint | Habitat Effects (Y/N) | Description of Results of Risk Estimation |
|---|---|---|
| which do not contain barriers to dispersal | | |
| Reduction and/or modification of food sources for terrestrial phase juveniles and adults | yes | Acute RQs for small mammals and birds exceed the endangered species LOC for all uses of paraquat except Melons.<br><br>Chronic dietary RQs for birds exceed the endangered species LOC for all uses of paraquat. For small mammals the chronic dietary-based RQs exceed the endangered species LOC for all uses of paraquat except Melons. The chronic dose-based RQs for small mammals exceed the endangered species LOC for all uses of paraquat. |
| Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. | yes | All aerial applications of paraquat results in spray drift exceedances for non-target terrestrial plants inhabiting semi-aquatic and upland dry areas. |

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.

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the CRLF 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 is provided in Sections 5.2.1 through 5.2.3.

### 5.2.1 Direct Effects

#### 5.2.1.1 Aquatic-Phase CRLF

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

Paraquat is considered "moderately toxic" to the freshwater fish, which are surrogates for the aquatic phase CRLF. The aquatic animal acute LOCs for listed species (0.05) was not exceeded for any of the uses. The RQ's ranged from 0.004 for airports to <0.001 for melons.

As discussed in Section 5.1.1.1, the acute to chronic ratio (ACR) was used to estimate chronic exposure to aquatic animals. With this method, the chronic exposure values are estimated to be at levels far less than 0.05 LOC for listed species. It is important to note that since there isn't any actual data from paraquat to determine the actual chronic exposure to aquatic animals, the estimated chronic exposure determined using the ACR contains uncertainty.

Of the aquatic animal incidents that were reported for paraquat, and in all of the reported incidents the certainty of paraquat being responsible was either unlikely or possible. Three were from registered uses of paraquat, and three were from the undetermined legality use of paraquat dichloride. Two of the incidents related to the registered use of paraquat dichloride believed that paraquat dichloride was the unlikely cause of mortality seen; the total mortality of the unknown fish was also unknown in 1993 and 1992 (I003654-012 and B000175-001 respectively). The other incident related to the registered use of paraquat was possibly responsible for the deaths of unknown amounts of bass, bluegill sunfish, and crappie in 1997 (I009314-005). The other three paraquat incidents were the possible result of undertermined legality usage of paraquat. A total of 54 dead fish (1 largemouth bass, and 53 sunfish) were observed in 1981 (B0000-502-18), an unknown amount of dead bass, bluegill, and crappie were observed in 1997 (I005805-001), and a total of 400 dead fish (200 each of bass and bluegill) were observed in 1999 (I008768-007).

**Because there are no LOC exceedances from registered uses of paraquat to the CRLF surrogate species (freshwater fish), because monitored concentrations in surface water are far below modeled estimates, and because the non-target incidents resulting from paraquat use are judged to be unlikely to possible, the Agency concludes that paraquat will have no direct effects on aquatic-phase CRLF.**

#### 5.2.1.2 Terrestrial-Phase CRLF

The RQs representing acute dietary-based exposures exceed the Agency's LOC (0.1) for all uses of paraquat except melon (Section 5.1.2.1.). The RQs ranged from 1.28

(Airport/public health use) to 0.06 (Melons) (Table 5-5). The chronic dietary-based RQs all exceed the Agency's LOC (1.0) for all uses of paraquat (Section 5.1.2.1.). The RQs ranged from 30.0 (Airports/public health use) to 1.35 (Melons) (Table 5-6). These RQs were derived using the T-REX model, which estimates exposures that are specific to food intake equations for birds. RQs generated for birds are used as surrogates to represent RQs for the terrestrial-phase CRLF. Based on these exceedances to the terrestrial-phase CRLF, a "May Affect" determination was made.

The T-HERPS model was therefore employed as a refinement tool to explore amphibian-specific food intake on potential exposures to the terrestrial phase CRLF. The T-HERPS model incorporates the same inputs as T-REX with equations adjusted for poikilotherm food intake. The dietary-based and dose-based EECs generated by T-HERPS are found in Tables 5-10a & b and 5-11a & b, respectively. An example output from T-HERPS is available in Appendix J.

**Table 5-10a Upper-bound Kenega Nomogram T-HERPS EECs (mg/kg-diet) for Dietary-based Exposures of the CRLF and its Prey to Paraquat, the weights of small herbivore and insectivore mammals are 15 g.**

| Scenario | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | 899.99 | 100.00 | 1525.46 | 95.34 | 31.24 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | 899.99 | 100.00 | 1525.46 | 95.34 | 31.24 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | 292.84 | 32.54 | 496.36 | 31.02 | 10.16 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | 184.01 | 20.45 | 311.89 | 19.49 | 6.39 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | 135.00 | 15.00 | 228.82 | 14.30 | 4.69 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 40.50 | 4.50 | 68.65 | 4.29 | 1.41 |

**Table 5-11b Upper-bound Kenega Nomogram T-HERPS EECs (mg/kg-diet) for Dietary-based Exposures of the CRLF and its Prey to Paraquat, the weights of small herbivore and insectivore mammals are 35 g.**

| Scenario | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | 899.99 | 100.00 | 1054.30 | 65.89 | 31.24 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | 899.99 | 100.00 | 1054.30 | 65.89 | 31.24 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | 292.84 | 32.54 | 343.05 | 21.44 | 10.16 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | 184.01 | 20.45 | 215.56 | 13.47 | 6.39 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | 135.00 | 15.00 | 158.15 | 9.88 | 4.69 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 40.50 | 4.50 | 47.44 | 2.97 | 1.41 |

**Table 5-12a Upper-bound Kenega Nomogram T-HERPS EECs (mg/kg-bw) for Dose-based Exposures of the CRLF and its Prey to Paraquat, the weights of small herbivore and insectivore mammals are 15 g.**

| Scenario | CRLF Size (g) | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | 1.4 | 34.97 | 3.89 | N/A | N/A | N/A |
| | 37 | 34.36 | 3.82 | 618.43 | 38.65 | 1.19 |
| | 238 | 22.52 | 2.50 | 96.14 | 6.01 | 0.78 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | 1.4 | 34.97 | 3.89 | N/A | N/A | N/A |
| | 37 | 34.36 | 3.82 | 618.43 | 38.65 | 1.19 |
| | 238 | 22.52 | 2.50 | 96.14 | 6.01 | 0.78 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | 1.4 | 11.38 | 1.26 | N/A | N/A | N/A |
| | 37 | 11.18 | 1.24 | 201.23 | 12.58 | 0.39 |
| | 238 | 7.33 | 0.81 | 31.28 | 1.96 | 0.25 |

| | | | | | | |
|---|---|---|---|---|---|---|
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | 1.4 | 7.15 | 0.79 | N/A | N/A | N/A |
| | 37 | 7.03 | 0.78 | 126.44 | 7.90 | 0.24 |
| | 238 | 4.60 | 0.51 | 19.66 | 1.23 | 0.16 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | 1.4 | 5.24 | 0.58 | N/A | N/A | N/A |
| | 37 | 5.15 | 0.57 | 92.77 | 5.80 | 0.18 |
| | 238 | 3.38 | 0.38 | 14.42 | 0.90 | 0.12 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 1.4 | 1.57 | 0.17 | N/A | N/A | N/A |
| | 37 | 1.55 | 0.17 | 27.83 | 1.74 | 0.05 |
| | 238 | 1.01 | 0.11 | 4.33 | 0.27 | 0.04 |

**Table 5-131b Upper-bound Kenega Nomogram T-HERPS EECs (mg/kg-bw) for Dose-based Exposures of the CRLF and its Prey to Paraquat, the weights of small herbivore and insectivore mammals are 35 g.**

| Scenario | CRLF Size (g) | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | 1.4 | 34.97 | 3.89 | N/A | N/A | N/A |
| | 37 | 34.36 | 3.82 | 997.31 | 62.33 | 1.19 |
| | 238 | 22.52 | 2.50 | 155.04 | 9.69 | 0.78 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | 1.4 | 34.97 | 3.89 | N/A | N/A | N/A |
| | 37 | 34.36 | 3.82 | 997.31 | 62.33 | 1.19 |
| | 238 | 22.52 | 2.50 | 155.04 | 9.69 | 0.78 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | 1.4 | 11.38 | 1.26 | N/A | N/A | N/A |
| | 37 | 11.18 | 1.24 | 324.50 | 20.28 | 0.39 |
| | 238 | 7.33 | 0.81 | 50.45 | 3.15 | 0.25 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | 1.4 | 7.15 | 0.79 | N/A | N/A | N/A |
| | 37 | 7.03 | 0.78 | 203.91 | 12.74 | 0.24 |
| | 238 | 4.60 | 0.51 | 31.70 | 1.98 | 0.16 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | 1.4 | 5.24 | 0.58 | N/A | N/A | N/A |
| | 37 | 5.15 | 0.57 | 149.60 | 9.35 | 0.18 |
| | 238 | 3.38 | 0.38 | 23.26 | 1.45 | 0.12 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 1.4 | 1.57 | 0.17 | N/A | N/A | N/A |
| | 37 | 1.55 | 0.17 | 44.88 | 2.80 | 0.05 |
| | 238 | 1.01 | 0.11 | 6.98 | 0.44 | 0.04 |

*Acute Exposures*

Refined acute dietary-based RQs for CRLFs consuming small insects and small herbivore mammals exceed the acute listed species LOC (0.1) for all uses of paraquat except Melons (only small insects when the small mammals weigh 15g). The acute dietary-based RQs for CRLFs consuming large insects exceed the acute listed species LOC for Airports/public health uses and Guava for both the 15g and 35g small mammals. The acute dietary-based RQs for CRLFs consuming small insectivore mammals exceed the acute listed species LOC for Airports/public health uses and Guava for the 15g small herbivore mammal only. No acute dietary based LOCs were exceeded for CLRF consuming small terrestrial phase amphibians for any paraquat use. Results are presented in Tables 5-12a and 5-12b

Refined dose-based RQs for CRLF of varying weights (1.4g, 37g and 238g) consuming small insects exceed the acute endangered species LOC (0.1) for only the Airport/public health and Guava uses of paraquat for all weights of CRLF (Table 5-13a and Table 5-13b). There are no exceedances for small sized (1.4g) CRLF consuming large insects (Table 5-13a), and CRLF this size are too small to consume small mammals or small terrestrial-phase amphibians. The RQs for small sized (1.4g) CRLF are 0.27 suggesting that small CRLF consuming small insects are potentially affected by acute exposures to paraquat.

Refined dose-based RQs for medium sized (37g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat (Table 5-13a and Table 5-13b). There were also exceedances the acute listed species LOC (0.1) for medium sized CRLF consuming small insectivore (15g) mammals for the airports/public health, guava, and ginger uses of paraquat (Table 15-13a). For medium sized CRLF consuming small insectivore (35g) mammals there were exceedances in the acute listed species LOC (0.1) for all uses of paraquat except carrots and melons (Table 5-13b). There are no exceedances for medium sized (37g) CRLF consuming large insects or small terrestrial-phase amphibians (Table 15-13a and Table 15-13b). Due to exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses, and exceedances of LOCs for CRLF consuming small insectivore mammals (either 15g or 35g) for a majority of paraquat uses indicate that the medium sized CRLF could potentially be affected by acute exposures to paraquat.

Refined dose-based RQs for large sized (238g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat except melons (Table 5-13a and Table 5-13b). There were no exceedances for large sized (238g) CRLF consuming large insects, small insectivore mammals (15g or 35g), or small terrestrial-phase amphibians (Table 15-13a and Table 15-13b). Due to exceedances of of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses except melons, indicate that the large sized CRLF could potentially be affected by acute exposures to paraquat.

**Table 5-14a Revised Acute Dietary-based RQs* for CRLF consuming different food items (RQs calculated using T-HERPS), the weights of small herbivore and insectivore mammals are 15 g.**

| Scenario | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | **1.28** | **0.14** | **2.17** | **0.14** | 0.04 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **1.28** | **0.14** | **2.17** | **0.14** | 0.04 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **0.42** | 0.05 | **0.71** | 0.04 | 0.01 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **0.26** | 0.03 | **0.44** | 0.03 | 0.01 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **0.19** | 0.02 | **0.33** | 0.02 | 0.01 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 0.06 | 0.01 | **0.10** | 0.01 | <0.01 |
| *RQs exceeding the Listed LOC (0.10) are bolded and shaded | | | | | |

**Table 5-15b Revised Acute Dietary-based RQs* for CRLF consuming different food items (RQs calculated using T-HERPS), the weights of small herbivore and insectivore mammals are 35 g.**

| Scenario | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | **1.28** | **0.14** | **1.50** | 0.09 | 0.04 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **1.28** | **0.14** | **1.50** | 0.09 | 0.04 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **0.42** | 0.05 | **0.49** | 0.03 | 0.01 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **0.26** | 0.03 | **0.31** | 0.02 | 0.01 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **0.19** | 0.02 | **0.22** | 0.01 | 0.01 |

| | | | | | |
|---|---|---|---|---|---|
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 0.06 | 0.01 | 0.07 | <0.01 | <0.01 |
| *RQs exceeding the Listed LOC (0.10) are bolded and shaded | | | | | |

**Table 5-16a Refined Dose-based RQs* for CRLF consuming different food items (RQs calculated using T-HERPS), the weights of small herbivore and insectivore mammals are 15 g.**

| Scenario | CRLF Size (g) | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL /INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | 1.4 | **0.27** | 0.03 | N/A | N/A | N/A |
| | 37 | **0.27** | 0.03 | **4.83** | **0.30** | 0.01 |
| | 238 | **0.18** | 0.02 | **0.75** | 0.05 | 0.01 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | 1.4 | **0.27** | 0.03 | N/A | N/A | N/A |
| | 37 | **0.27** | 0.03 | **4.83** | **0.30** | 0.01 |
| | 238 | **0.18** | 0.02 | **0.75** | 0.05 | 0.01 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | 1.4 | 0.09 | 0.01 | N/A | N/A | N/A |
| | 37 | 0.09 | 0.01 | **1.57** | **0.10** | < 0.01 |
| | 238 | 0.06 | 0.01 | **0.24** | 0.02 | < 0.01 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | 1.4 | 0.06 | 0.01 | N/A | N/A | N/A |
| | 37 | 0.05 | 0.01 | **0.99** | 0.06 | < 0.01 |
| | 238 | 0.04 | < 0.01 | **0.15** | 0.01 | <0.01 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | 1.4 | 0.04 | < 0.01 | N/A | N/A | N/A |
| | 37 | 0.04 | < 0.01 | **0.72** | 0.05 | < 0.01 |
| | 238 | 0.03 | < 0.01 | **0.11** | 0.01 | < 0.01 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 1.4 | 0.01 | < 0.01 | N/A | N/A | N/A |
| | 37 | 0.01 | < 0.01 | **0.22** | 0.01 | < 0.01 |
| | 238 | 0.01 | < 0.01 | 0.03 | < 0.01 | < 0.01 |
| *RQs exceeding the Listed LOC (0.10) are bolded and shaded | | | | | | |

**Table 5-17b Refined Dose-based RQs* for CRLF consuming different food items (RQs calculated using T-HERPS), the weights of small herbivore and insectivore mammals are 35 g.**

| Scenario | CRLF Size (g) | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | 1.4 | **0.27** | 0.03 | N/A | N/A | N/A |
| | 37 | **0.27** | 0.03 | **7.79** | **0.49** | 0.01 |
| | 238 | **0.18** | 0.02 | **1.21** | 0.08 | 0.01 |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | 1.4 | **0.27** | 0.03 | N/A | N/A | N/A |
| | 37 | **0.27** | 0.03 | **7.79** | **0.49** | 0.01 |
| | 238 | **0.18** | 0.02 | **1.21** | 0.08 | 0.01 |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | 1.4 | 0.09 | 0.01 | N/A | N/A | N/A |
| | 37 | 0.09 | 0.01 | **2.53** | **0.16** | < 0.01 |
| | 238 | 0.06 | 0.01 | **0.39** | 0.02 | < 0.01 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | 1.4 | 0.06 | 0.01 | N/A | N/A | N/A |
| | 37 | 0.05 | 0.01 | **1.59** | **0.10** | < 0.01 |
| | 238 | 0.04 | < 0.01 | **0.25** | 0.02 | < 0.01 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | 1.4 | 0.04 | < 0.01 | N/A | N/A | N/A |
| | 37 | 0.04 | < 0.01 | **1.17** | 0.07 | < 0.01 |
| | 238 | 0.03 | < 0.01 | **0.18** | 0.01 | < 0.01 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | 1.4 | 0.01 | < 0.01 | N/A | N/A | N/A |
| | 37 | 0.01 | < 0.01 | **0.35** | 0.02 | < 0.01 |
| | 238 | 0.01 | < 0.01 | 0.05 | < 0.01 | < 0.01 |

*RQs exceeding the Listed LOC (0.10) are bolded and shaded

A probit slope value for the acute avian toxicity test was not available; therefore, the effect probability was calculated based on a default slope assumption of 4.5 with upper and lower 95% confidence intervals of 2 and 9 (Urban and Cook, 1986). For all uses with RQs that exceed the endangered species LOCs the probability of individual effects were conducted to determine the probability that one individual could be impacted by exposure to paraquat. Using the revised acute dietary-based RQs for CRLF consuming different food items the chance of individual mortality for which the RQs exceed the LOC (0.1) range from approximately 1 in $2.94*10^{5}$ (95 % CI: 1 in $4.4*10^{1}$ to 1 in $8.86*10^{18}$) (<1%) at an RQ 0.10 (Melons, small herbivore mammals weighing 15g) to approximately 1 in 1 (95 % CI: 1 in 1.33 to 1 in 1) (100%) at an RQ of 2.17 (Airports/public health use/Guava, small herbivore mammals weighing 15g) (Table 5-

12a). This range of RQs is relevant to CRLF consuming small and large insects, and small herbivore and insectivore mammals. This range is not relevant to CRLF consuming small terrestrial-phase amphibians modeled for any use scenario since there was no LOC exceedance.

Since the CRLF also consumes larger sizes of mammals RQs were also calculated for small herbivore and insectivore mammals weighing 35g. Using the revised acute dietary-based RQs for CRLF consuming different food items the chance of individual mortality for which the RQs exceed the LOC (0.1) range from approximately 1 in $1.64*10^{4}$ (95 % CI: 1 in $2.28*10^{1}$ to 1 in $1.31*10^{14}$) (<1 %) at an RQ 0.14 (Airports/public health use/ Guava, large insects) to approximately 1 in 1.27 (95 % CI: 1 in 1.57 to 1 in 1.06) (86%) at an RQ of 1.50 (Airports/public health use/Guava, small herbivore mammals weighing 35g) (Table 5-12b). This range of RQs is relevant to CRLF consuming small and large insects, and small herbivore mammals. This range is not relevant to CRLF consuming small insectivore mammals or small terrestrial-phase amphibians modeled for any use scenario since there was no LOC exceedance.

Using the revised acute dose-based RQs for CRLF consuming different food items the chance of individual mortality for which the RQs exceed the LOC (0.1) range from approximately 1 in $2.94*10^{5}$ (95 % CI: 1 in $4.4*10^{1}$ to 1 in $8.86*10^{18}$) (<1%) at an RQ 0.10 (Ginger, small herbivore mammals weighing 15g, 37g CRLF) to approximately 1 in 1 (95 % CI: 1 in 1.09 to 1 in 1) (100%) at an RQ of 4.83 (Airports/public health use/Guava, small herbivore mammals weighing 15g, 37g CRLF) (Table 5-13a). This range of RQs is relevant to all sizes of CRLF consuming small insects, and small herbivore and insectivore mammals. This range is not relevant to CRLF (of any size) consuming large insects or small terrestrial-phase amphibians modeled for any use scenario since there were no LOC exceedances.

Using the revised acute dose-based RQs for CRLF consuming different food items the chance of individual mortality for which the RQs exceed the LOC (0.1) range from approximately 1 in $2.94*10^{5}$ (95 % CI: 1 in $4.4*10^{1}$ to 1 in $8.86*10^{18}$) (<1%) at an RQ 0.10 (Corn, small insectivore mammals weighing 35g, 37g CRLF) to approximately 1 in 1 (95 % CI: 1 in 1.04 to 1 in 1) (100%) at an RQ of 7.79 (Airports/public health use/Guava, small herbivore mammals weighing 35g, 37g CRLF) (Table 5-13b). This range of RQs is relevant to all sizes of CRLF consuming small insects, and small herbivore and insectivore mammals. This range is not relevant to CRLF (of any size) consuming large insects or small terrestrial-phase amphibians modeled for any use scenario since there were no LOC exceedances.

*Chronic Exposures*

Refined chronic dietary-based RQs for CRLFs consuming small insects and small herbivore mammals (either 15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for all uses of paraquat (Table 5-14a and 5-14b). Refined chronic dietary-based RQs for CRLFs consuming large insects and small insectivore mammals (either 15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health, guava, and ginger uses of paraquat (Table 5-14b). The refined

chronic dietary-based RQs for CRLFs consuming small terrestrial- phase amphibians using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health and guava uses of paraquat (the maximum uses) (Table 5-14a and 5-14b).

**Table 5-18a Revised Chronic Dietary-based RQs* for CRLF consuming different food items (RQs calculated using T-HERPS), the weights of small herbivore and insectivore mammals are 15 g.**

| Scenario | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | **30.0** | **3.33** | **50.85** | **3.18** | **1.04** |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **30.0** | **3.33** | **50.85** | **3.18** | **1.04** |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **9.76** | **1.08** | **16.55** | **1.03** | 0.34 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **6.13** | 0.68 | **10.40** | 0.65 | 0.21 |
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **4.50** | 0.50 | **7.63** | 0.48 | 0.16 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | **1.35** | 0.15 | **2.29** | 0.14 | 0.05 |
| *RQs exceeding the Listed LOC (1.0) are bolded and shaded | | | | | |

**Table 5-194b Revised Chronic Dietary-based RQs* for CRLF consuming different food items (RQs calculated using T-HERPS), the weights of small herbivore and insectivore mammals are 35 g.**

| Scenario | Small Insects | Large Insects | Small Herbivore Mammals | Small Insectivore Mammals | Small Terrestrial Phase Amphibians |
|---|---|---|---|---|---|
| AIRPORTS/LANDING FIELDS, COMMERCIAL/INSTITUTIONAL/INDUSTRIAL PREMISES/EQUIPMENT (OUTDOOR), NONAGRICULTURAL AREAS (PUBLIC HEALTH USE) (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- non-ag) | **30.0** | **3.33** | **35.14** | **2.20** | **1.04** |
| Guava (1 lb cation/acre; 10 times/yr; 5 day intervals) (maximum- ag) | **30.0** | **3.33** | **35.14** | **2.20** | **1.04** |
| Ginger (1 lb cation/acre; 6 times/yr; 30 day intervals (ag)) | **9.76** | **1.08** | **11.43** | 0.71 | 0.34 |
| CORN (SILAGE) (0.5 lb cation/acre; 3 times/year; 5 day intervals) | **6.13** | 0.68 | **7.19** | 0.45 | 0.21 |

| | | | | | |
|---|---|---|---|---|---|
| BEANS - SUCCULENT (LIMA/SNAP), CARROT (INCLUDING TOPS), PEAS (UNSPECIFIED), PEPPER (1 lb cation/acre; 1 time/yr; 1 day intervals) | **4.50** | 0.50 | **5.27** | 0.33 | 0.16 |
| Melons (0.3 lb cation/acre; 1 time/yr; 1 day intervals) (minimum-ag) | **1.35** | 0.15 | **1.58** | 0.10 | 0.05 |
| *RQs exceeding the Listed LOC (1.0) are bolded and shaded | | | | | |

In the available chronic study where Mallard duck were exposed to paraquat, the NOAEC was 30 ppm and the LOAEC was 100 ppm, based on effects to % viable egs, eggs set, normality of hatchlings, and number of 14-day old survivors. In comparing the LOAEC to the chronic dietary-based EECs for CRLF small insects and small herbivore mammals indicate that the EECs for all uses except melons exceed the concentration where reproductive effects were observed within the laboratory. For CRLF consuming large insects (except airport/public health/guava use), small insectivore mammals (15g or 35g), and small terrestrial-phase amphibians all uses except those previously listed have EECs which do not exceed the LOAEC. Therefore, some CRLF feeding categories, paraquat EECs are at levels were reproductive effects were observed in birds, which serve as surrogates for the CRLF.

Of the terrestrial animal incidents that were reported paraquat was not the only chemical that was present in the field. Only one incident was from the registered use of paraquat, and paraquat was considered as being probably responsible, for the death of approximately 5 Canadian geese, as it had the highest acute toxicity to birds of the pesticides applied in the mix tank (the others were Atrazine, Simazine, Cyanazine, and Esfenvalerate) (I008168-001). With the other two incidents, paraquat was considered to be unlikely or possibly responsible for the incident (I000097-015, I007334-001).

Avian dietary and dose-based toxicity is very different, based upon the chemical properties of paraquat. This is a conservative estimate as paraquat's toxicity may vary due to it binding to the food residue and maybe less biologically available to the organism.

**Based on the line of evidence, and on these refined acute and chronic risk quotients (RQs) and their exceedances of the Agency's LOC a May Affect and is Likely to Adversely Affect (LAA) determination is made for paraquat use in California.**

### 5.2.2 Indirect Effects (via Reductions in Prey Base)

#### 5.2.2.1 Algae (non-vascular plants)

As discussed in Section 2.5.3, the diet of CRLF tadpoles is composed primarily of unicellular aquatic plants (i.e., algae and diatoms) and detritus. Indirect effects of paraquat to the aquatic-phase CRLF (tadpoles) via reduction in non-vascular aquatic plants in its diet are based on peak EECs from the standard pond and the lowest acute toxicity value for aquatic non-vascular plants. The Agency's LOC (1.0) is exceeded for all uses of paraquat in California. The RQs range from 2213 for airports, commercial/industrial areas, and public health areas to 11 for melons (Section 5.1.1.2).

The fate characteristics indicate that paraquat is expected to be persistent in aquatic environments. As a result, the primary food source for the aquatic-phase CRLF (non-vascular aquatic plants) is expected to be adversely affected.

**Because of non-vascular LOC exceedance from registered uses of paraquat the Agency concludes that there is a potential of indirect impact to the aquatic-phase of the CRLF from reduction of food items (algae). Therefore, paraquat May Affect and is Likely to Adversely Affect (LAA) the CRLF.**

#### 5.2.2.2 Aquatic Invertebrates

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

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. The fate properties of paraquat suggest that paraquat is expected to be transported primarily along with soil particles and subsequently redeposited onto the beds of surface water bodies or lowland areas that receive eroded sediments from uplands, such as riparian zones.

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. The acute RQs range from 0.042 for airports, commercial/industrial areas, and public health areas to 0.001 for melons.

Since there are not any aquatic chronic data values for paraquat, the chronic risk to aquatic animals is estimated using the ACR as described in Section 5.1.1.1. There is believed to be no risk to invertebrates using this method due to the ACR being much higher than the EECs calculated using GENEEC2 for the invertebrates.

**Because there are no LOC exceedances from registered uses of paraquat to the CRLF surrogate species (freshwater invertebrates), because monitored concentrations in surface water are far below modeled estimates, and because the non-target incidents resulting from paraquat use are judged to be unlikely to possible, the Agency concludes that paraquat will not indirectly affect the CRLF.**

#### 5.2.2.3 Fish and Aquatic-phase Frogs

As discussed in Section 2.5.3, the diet of CRLF also includes small fish and other aquatic-phase frogs. Direct effects to the aquatic-phase CRLF are based on peak EECs in

the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60 day EECs and the lowest chronic toxicity value for freshwater fish would be used. However, since there are not any aquatic chronic data values, the chronic RQs could not be calculated. Therefore, the chronic exposure to CRLF is uncertain.

**Because there are no LOC exceedances from registered uses of paraquat to the CRLF surrogate species (freshwater fish), the Agency concludes that paraquat will not indirectly affect the aquatic-phase of the CRLF on an acute or chronic basis from fish or other aquatic-phase frogs as prey items.**

#### 5.2.2.4 Terrestrial Invertebrates

When the terrestrial-phase CRLF reaches juvenile and adult stages, its diet is mainly composed of terrestrial invertebrates. Terrestrial invertebrate toxicity data is used to assess potential indirect effects of paraquat to the terrestrial-phase CRLF. Effects to terrestrial invertebrates resulting from exposure to paraquat may also indirectly affect the CRLF via reduction in available food.

Because the $LD_{50}$ was not definitive, and there was little incidence of mortality, RQs were not calculated. However, EECs were compared to the highest concentration tested. All of estimated EEC's the level tested for all uses for small insects and all of the uses greater than 6 applications per year with 30 day intervals at 1 lb cation/acre per application for large insects; therefore, a preliminary "May Affect" determination was made. However, the calculated EEC's for Airports/public health use/Guava (899.99 ppm small insects and 100.00 ppm large insects) were 26 and 2.9 times the level of paraquat tested (>34.6 µg cation/bee), at which there was a low incidence of mortality. Therefore, it is reasonable to assume that the effects to terrestrial invertebrate populations will be negligible for the uses of paraquat in California. **Therefore, based on the weight-of-evidence, the Agency concludes that there is a negligible potential impact to terrestrial invertebrates that the CRLF consumes, and therefore paraquat May Affect but is Not Likely to Adversely Affect (NLAA) the CRLF.**

#### 5.2.2.5 Mammals

Life history data for terrestrial-phase CRLFs indicate that large adult frogs consume terrestrial vertebrates, including mice. Acute dose based RQs exceed the Agency's endangered species LOC (0.1) for all uses of paraquat. The dose based RQs that exceed the LOC range from 0.34 (Melons) to 7.63 (Airports/public health uses/Guava) (Table 5-7). Chronic dose based RQs exceed the Agency's LOC (1.0) for all uses and range from 5.78 (Melons) to 128.53 (Airports/public health use/Guava) (Table 5-7). The dietary based chronic RQs exceed the Agency's LOC for all uses except melons and range from 3.03 (Corn) to 14.81 (Airports/public health use/Guava) (Table 5-7).

Based on the mammalian dose-based acute RQs and a probit dose-response default slope of 4.5 the estimated mammalian prey item population reduction for which RQs exceed

the Listed (endangered species) LOCs are approximately 1 in 1 for all uses except melon (no exceedance) (Table 5-7). The acute dose-based EECs are well above the levels mortality was documented at. The chronic dose-based and dietary-based EECs are also well above the levels that were tested, and showed mortality and sublethal effects (lung damage). Because environmental exposure levels are estimated to be much higher than the level which may cause acute effects to mammals, the CRLF may be indirectly affected by acute exposure to paraquat.

Reproductive and sublethal effects (lung damage) were observed in chronic mammalian studies, and resulted in RQ values that exceeded the LOC (1.0) for all uses (chronic dose-based) and all uses except melons (chronic dietary-based). The RQs ranged from 128.53 to 5.78 for the dose-based, and 14.81 to 0.67 for the dietary-based (Table 5-7). Paraquats toxicity, when combined in the diet is lower than the gavage (dose) based treatment, indicating that the toxicity may be reduced in combination with the diet. Chronic exposure to paraquat is likely.

**Based on effects to small mammals, there is a potential indirect impact to the CRLF via reduction in small mammal prey items, and therefore paraquat May Affect and is Likely to Adversely Affect (LAA) the CRLF.**

#### 5.2.2.6 Terrestrial-phase Amphibians

Terrestrial-phase adult CRLFs also consume frogs. RQ values representing direct exposures of paraquat to terrestrial-phase CRLFs are used to represent exposures of paraquat to frogs in terrestrial habitats. The T-HERPS model was therefore employed as a refinement tool to explore amphibian-specific food intake on potential exposure to terrestrial-phase amphibian food items for the CRLF. The T-HERPS model incorporates the same inputs as T-REX with equations adjusted for poikilotherm food intake. As described in Section 5.2.1.2, the RQs for small terrestrial-phase amphibians did not exceed the listed species LOC (0.1) for any use of paraquat. Reduction in amphibian prey items, specifically other frogs is not affected from paraquat use. Other items in the prey base all had RQs that exceeded the listed species LOC for numerous uses of paraquat.

**Based on this evidence, a May Affect and is Likely to Adversely Affect (LAA) determination is made for indirect effects via reductions in prey base to the terrestrial-phase CRLF.**

### 5.2.3 Indirect Effects (via Habitat Effects)

#### 5.2.3.1 Aquatic Plants (Vascular and Non-vascular)

Aquatic plants serve several important functions in aquatic ecosystems. Non-vascular aquatic plants are primary producers and provide the autochthonous energy base for aquatic ecosystems. Vascular plants provide structure as attachment sites and refugia for many aquatic invertebrates, fish, and juvenile organisms, such as fish and frogs. In

addition, vascular plants also provide primary productivity and oxygen to the aquatic ecosystem. Rooted plants help reduce sediment loading and provide stability to nearshore areas and lower streambanks. In addition, vascular aquatic plants are important as attachment sites for egg masses of CRLFs.

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production were assessed using RQs from freshwater aquatic vascular and non-vascular plant data. Indirect effects of paraquat to the aquatic-phase CRLF (tadpoles) are present in the reduction of non-vascular aquatic plants in the aquatic-phase CRLFs diet. The Agency's LOC (1.0) for non-vascular plants is exceeded for all uses of paraquat in California. The non-vascular aquatic plant RQs range from 138 for airports, commercial/industrial/public health uses to 4.1 for use on melon (Section 5.1.1.2).

Indirect effects of paraquat to the aquatic-phase CRLF (tadpoles) are also found via the reduction in vascular aquatic plants in the aquatic-phase CRLFs diet. The Agency's LOC (1.0) for vascular plants is exceeded for all uses of paraquat in California. The acute RQs range from 0.77 for airports, commercial/industrial areas, and public health areas to 0.02 for melons (Section 5.1.1.2).

An analysis of the fate characteristics of paraquat indicates that paraquat is expected to be persistent in aquatic environments. As a result, the primary food source for the aquatic-phase CRLF (both vascular and non-vascular aquatic plants) is expected to be adversely affected.

**Because of the non-vascular aquatic plant LOC exceedances for registered uses of paraquat, and verified non-target incidents resulting from paraquat use, the Agency concludes that there is a potential of indirect impact to the aquatic-phase of the CRLF from reduction of food items (algae). Therefore, paraquat May Affect and is Likely to Adversely Affect (LAA) the CRLF.**

#### 5.2.3.2 Terrestrial Plants

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

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production were assessed using RQs from monocot and dicot plant data. The RQs for monocots were below the Agency's LOC, whereas the dicot spray drift RQ exceeded the Agency's RQ (1.0), for all aerial applications of paraquat (Tables 5-15 and 5-16).

Twenty-one incidents have been reported for paraquat, listed under paraquat and paraquat dichloride, but they are one in the same. There were nine incidents from the misuse of paraquat that resulted in plant damage, with one incident of plant mortality (I014409-024), and one incident of plant discoloration (I005880-005). Of the reported misuses of paraquat; two from general misuse, six from accidental misuse, and one from the intentional misuse of paraquat (I014409-024, I013554-040, I005660-005, I005880-005, I007371-033, I007371-034, I007371-035, I007371-008, and I016940-005 respectively). There were a total of six incidents from the registered use of paraquat and all resulted in plant damage (I013884-038, I013636-029, I011838-055, I014034-099, I012684-010, I001131-001). The remaining six incidents were from undetermined legality of paraquat use and resulted in plant damage (I014409-001, I013884-014, I012366-023, I009573-009, I011838-091, and I011838-038).

**Based on LOC exceedances in spray drift RQs for dicots, and the twenty-one reported incidents that resulted in plant damage a variety of monocots, paraquat May Affect and is Likely to Adversely Affect (LAA) the CRLF indirectly via habitat degradation through reduction in terrestrial plants. Of particular concern is the risk from spray drift during/after aerial application.**

### 5.2.4 Effects to Designated Critical Habitat

#### 5.2.4.1 Aquatic-Phase PCEs

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

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

Conclusions for potential indirect effects to the CRLF via direct effects to aquatic and terrestrial plants are used to determine whether modification to critical habitat may occur. LOCs are exceeded for terrestrial riparian plants and for aquatic plants from exposure to paraquat from spray drift. Alteration of riparian and vascular plants may result in alteration of temperature, turbidity, and oxygen content.

Aquatic non-vascular plants used as a food source and habitat for CRLF may be potentially affected from all paraquat uses. A reduction in these aquatic based food

sources may occur from most use sites. Likewise, due to aquatic vascular and terrestrial plant communities being reduced from most use sites, there is potential for alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond.

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

**Based on acute LOC exceedances for aquatic plants paraquat may result in effects to aquatic-phase PCEs of designated critical habitat related to effects of alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.**

#### 5.2.4.2 Terrestrial-Phase PCEs

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

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

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

**There is a potential for habitat effects via impacts to terrestrial plants (Section 5.2.3.2) from paraquat use (aerial applications only).**

The risk estimation for terrestrial-phase PCEs of designated habitat related to potential effects on terrestrial plants is provided in Section 5.1.2.3. These results will inform the effects determination for effects to designated critical habitat for the CRLF.

The third terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of paraquat on this PCE, acute and chronic toxicity endpoints for terrestrial invertebrates, mammals, and terrestrial-phase frogs are used as measures of effects. RQs for these endpoints were calculated in Section 5.1.2.2. **There is potential for habitat effects via indirect effects to terrestrial-phase CRLFs via reduction in prey base (Section 5.2.2.4 for terrestrial**

**invertebrates, Section 5.2.2.5 for mammals, and 5.2.2.6 for frogs) from paraquat use.**

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. Direct acute and chronic RQs for terrestrial-phase CRLFs are presented in Section 5.2.1.2. **There is potential for habitat effects via direct (Section 5.2.1.2) and indirect effects (Sections 5.2.2.4, 5.2.2.5, and 5.2.2.6) to terrestrial-phase CRLFs from paraquat use. Paraquat use may result in habitat effects based on effects to the terrestrial PCE related to alteration of chemical characteristics necessary for normal growth and viability.**

### 5.2.5 Spatial Extent of Potential Effects

A May Affect determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the CRLF or its designated critical habitat. To determine this area, the footprint of paraquat's use pattern is identified, using land cover data that correspond to paraquat's use pattern. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by spray drift. The identified direct and indirect effects are anticipated to occur only for those currently occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that overlap with the initial area of concern plus at least 1,000 feet from its boundary. It is assumed that non-flowing waterbodies (or potential CRLF habitat) are included within this area.

In addition to the spray drift buffer, the downstream dilution extent analysis results in a distance of **300 kilometers** for forest land cover, **285 kilometers** for cultivated crop, orchard/vineyard, and pasture/hay land cover and **88.7 kilometers** for developed land cover. If any of these streams reaches flow into CRLF habitat, there is potential to affect either the CRLF or modify its habitat. These lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of paraquat sufficient to result in a May Affect determination or effects to critical habitat.

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

#### 5.2.5.1 Spray Drift

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

For paraquat use with the maximum application rate relative to the terrestrial-phase CRLF, the results of the screening-level risk assessment indicate that spray drift for aerial

applications, using both the Tier I and Tier II mode, exceeds the 1,000 foot range of the AgDrift model . For the Tier I ground mode (no higher tier modeling for ground applications is available in AgDrift), the spray drift buffer distance is found to be >1,000 feet for non-listed plants as well. A summary of the modeled distances by application method is presented in Table 5-15.

Since the maximum application rate resulted in distances exceeding the range allowed by the AgDRIFT model, the lowest application rate was also run for comparison purposes. For the Tier I and Tier II mode for the aerial application, the spray drift buffer distance was found to be >1,000 feet for non-listed plants. For the Tier I ground application mode, the spray drift buffer distance was found to be >1,000 feet for the non-listed plants (no higher tier modeling for ground applications is available in AgDrift). See Table 5-16 for a summary of the modeled distances by application method.

In order to characterize the spatial extent of the effects determination that is relevant to the CRLF (i.e. NLAA versus LAA), an analysis was conducted using the most sensitive non-listed terrestrial plant $EC_{25}$ of 0.014 lbs cation/acre. Typically the NOAEC is used when there is an obligate relationship between the species being assessed and endangered plants (or other taxa). However, there is no obligate relationship between the CRLF and any endangered plant; therefore the LAA/NLAA determination is based on the area defined by the non-listed species LOC (i.e., $EEC/EC_{50}$).

**Table 5-20 Summary of AgDrift Predicted Terrestrial Spray Drift Distances Using Maximum Application Rate**

| Tier I Ground Application | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Risk Class | Risk Description | Application Rate (lb cation/acre) | Toxicity Value Used | Fraction of applied | Nonvolatile Rate (lb/a) | Minimum Spray Volume Rate (gal/a) | Active Rate (lb ai/a) | Distance |
| Non-Listed Plants | Potential for effects to non-target, non-listed plants from exposures | 1 | $EC_{25}$ = 0.014 lb cation/A | 0.000004 | Does not apply | Does not apply | Does not apply | >1,000 feet |
| **Tier I Aerial Application** | | | | | | | | |
| Risk Class | Risk Description | Application Rate (lb cation/acre) | Toxicity Value Used | Fraction of applied | Nonvolatile Rate (lb/a) | Minimum Spray Volume Rate (gal/a) | Active Rate (lb ai/a) | Distance |
| Non-Listed Plants | Potential for effects to non-target, non-listed plants from exposures | 1 | $EC_{25}$ = 0.014 lb cation/A | 0.000004 | Does not apply | Does not apply | Does not apply | >1,000 feet |
| **Tier II Aerial Application** | | | | | | | | |
| Risk Class | Risk Description | Application Rate (lb cation/acre) | Toxicity Value Used | Fraction of applied | Nonvolatile Rate (lb/a) | Minimum Spray Volume Rate (gal/a) | Active Rate (lb ai/a) | Distance |
| Non-Listed Plants | Potential for effects to non-target, non-listed plants from exposures | 1 | $EC_{25}$ = 0.014 lb cation/A | 0.000004 | 0.683 | 0.317 | 1 | >1,000 feet |

**Table 5-21 Summary of AgDrift Predicted Aquatic Spray Drift Distances Using Minimum Application Rate**

| Tier I Ground Application | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Risk Class | Risk Description | Application Rate (lb cation/acre) | Toxicity Value Used | Fraction of applied | Nonvolatile Rate (lb/a) | Minimum Spray Volume Rate (gal/a) | Active Rate (lb ai/a) | Distance |
| Non-Listed Plants | Potential for effects to non-target, non-listed plants from exposures | 0.3 | $EC_{25}$ = 0.014 lb cation/A | 0.000012 | Does not apply | Does not apply | Does not apply | >1,000 feet |
| **Tier I Aerial Application** | | | | | | | | |
| Risk Class | Risk Description | Application Rate (lb cation/acre) | Toxicity Value Used | Fraction of applied | Nonvolatile Rate (lb/a) | Minimum Spray Volume Rate (gal/a) | Active Rate (lb ai/a) | Distance |
| Non-Listed Plants | Potential for effects to non-target, non-listed plants from exposures | 0.3 | $EC_{25}$ = 0.014 lb cation/A | 0.000012 | Does not apply | Does not apply | Does not apply | >1,000 feet |
| **Tier II Aerial Application** | | | | | | | | |
| Risk Class | Risk Description | Application Rate (lb cation/acre) | Toxicity Value Used | Fraction of applied | Nonvolatile Rate (lb/a) | Minimum Spray Volume Rate (gal/a) | Active Rate (lb ai/a) | Distance |
| Non-Listed Plants | Potential for effects to non-target, non-listed plants from exposures | 0.3 | $EC_{25}$ = 0.014 lb cation/A | 0.000012 | 0.683 | 0.317 | 0.3 | >1,000 feet |

#### 5.2.5.2 Downstream Dilution Analysis

To complete this assessment, the greatest ratio of aquatic RQ to LOC was estimated. Using an assumption of uniform runoff across the landscape, it is assumed that streams flowing through treated areas (i.e. the initial area of concern) are represented by the

modeled EECs; as those waters move downstream, it is assumed that the influx of non-impacted water will dilute the concentrations of paraquat present.

Using a NOAEC value of 0.158 ug/L for vascular aquatic plants (the most sensitive species) and a maximum peak EEC for applications to airports/commercial/public health areas (non-agricultural use) of 892 ug/L yields an RQ/LOC ratio of 5424 (5424/1), and guava (agricultural use) of 26 ug/L yields an RQ/LOC ratio of 158 (158/1). Using the downstream dilution approach (described in more detail in Appendix J) results in a distance of **300 kilometers** for forest land cover (which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern), **285 kilometers** for cultivated crop, orchard/vineyard, and pasture/hay land cover and **88.7 kilometers** for developed land cover. Similar to the spray drift buffer described above, the LAA/NLAA determination is based on the area defined by the point where concentrations exceed the $EC_{50}$ value.

#### 5.2.5.3 Overlap between CRLF habitat and Spatial Extent of Potential Effects

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

For paraquat, the use pattern in the following land cover classes (forest land cover, cultivated crop, orchard/vineyard, pasture/hay land cover, and developed land cover) also include areas beyond the initial area of concern that may be impacted by spray drift overlaps with CRLF habitat. Appendix D provides maps of the initial area of concern, along with CRLF habitat areas, including currently occupied core areas, CNDDB occurrence sections, and designated critical habitat. It is expected that any additional areas of CRLF habitat that are located at least 1,000 ft (to account for offsite migration via spray drift) and **300 kilometers** for forest land cover (to account for the maximum continuous distance of downstream dilution from the edge of the initial area of concern) outside the initial area of concern may also be impacted and are part of the full spatial extent of the LAA/effects to critical habitat effects determination.

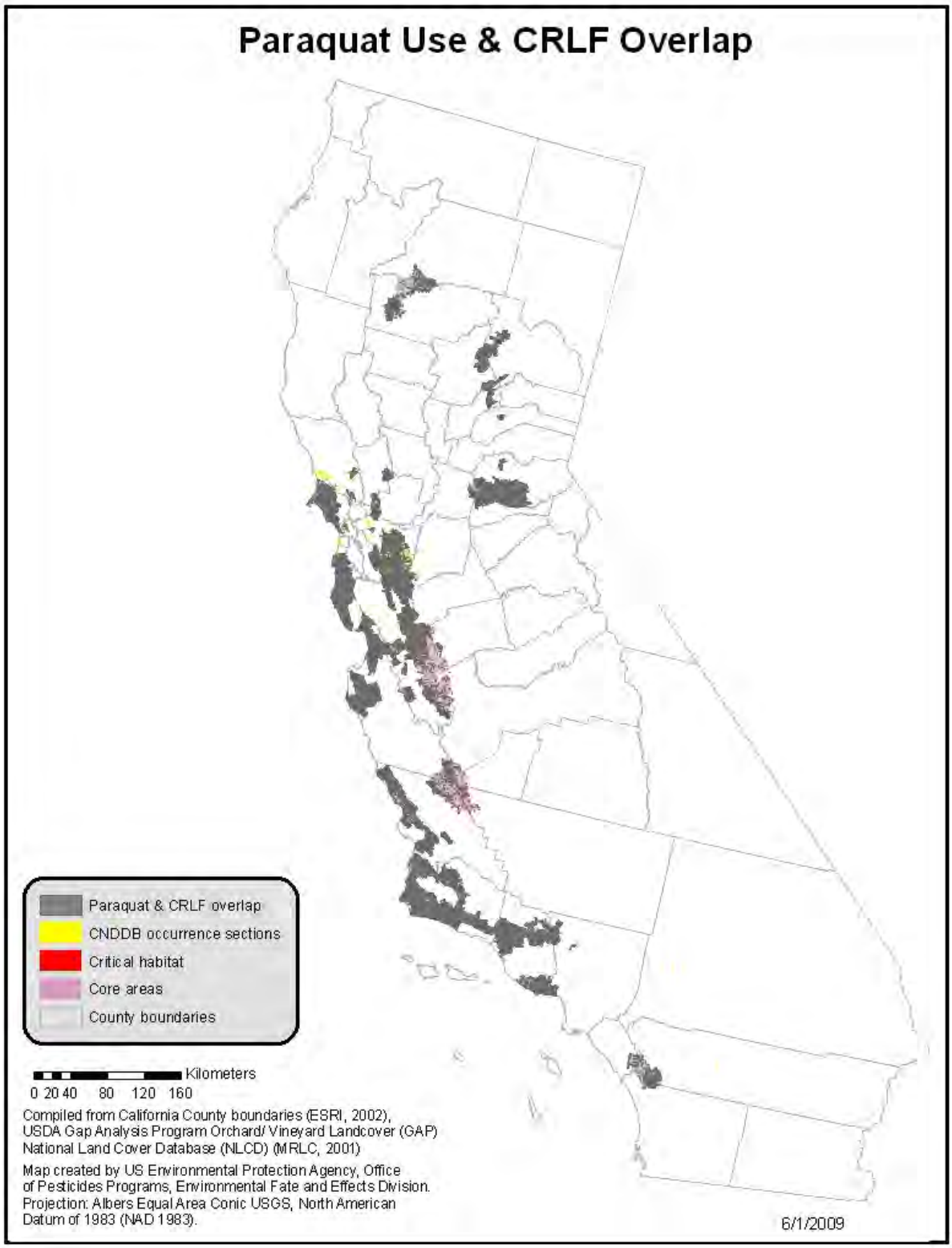



**Figure 5-1. Overlap Map: CRLF Habitat and Paraquat Initial Area of Concern**

# 6.0 Uncertainties

## 6.1 Exposure Assessment Uncertainties

### 6.1.1 Maximum Use Scenario

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

### 6.1.2 Crops Not Grown in California

Crops that are not currently grown in California according to CDPR PUR data, as well as the USDA NASS database, are listed on current labels. As these crops are not currently grown in California and are not expected to be grown in California in the future, use of paraquat was not assessed for these crops. The following uses will not be assessed because they are not grown in California: cocoa, coffee, banana, plantain, pineapple, and soybeans. If the use patterns indicate that these crops are grown in CA in the future, the conclusions of this assessment may need to be revisited.

### 6.1.3 Aquatic Exposure Modeling of Paraquat

GENEEC2 is a Tier I computer program, that 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. This first tier is designed as a coarse screen and estimates conservative pesticide concentrations in surface water from a few basic chemical parameters and pesticide label use and application information. Tier I is used to screen chemicals to determine which ones potentially pose sufficient risk to warrant higher level modeling. It calculates acute as well as longer-term estimated environmental concentration (EEC) values. It considers reduction in dissolved pesticide concentration due to adsorption of pesticide to soil or sediment, incorporation, degradation in soil before washoff to a water body, direct deposition of spray drift into the water body, and degradation of the pesticide within the water body. It is designed to mimic a PRZM-EXAMS simulation.

The standard ecological water body scenario (pond) used to calculate potential aquatic exposure to pesticides is intended to represent conservative estimates, and to avoid underestimations of the actual exposure. The standard scenario consists of application to a 10-hectare field bordering a 1-hectare, 2-meter deep (20,000 $m^3$) pond with no outlet. Exposure estimates generated using the 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 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 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 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 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).

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

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

likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

In order to account for uncertainties associated with modeling, it is preferred to compare available monitoring data to GENEEC2 estimates of peak EECs for the different uses. However, as discussed above, only CDPR had looked for paraquat, and only detected one positive concentration of approximately 1 ppb. It is believed the positive detection was a result of runoff from agricultural use areas. Yet, the specific use patterns (*e.g.* application rates and timing, crops) associated with the agricultural areas are unknown, but they are assumed to be representative of potential paraquat use areas.

Due to the lack of detections from the CDPR data, 399 samples and only one detect, it is believed that the GENEEC2 EECs provide a conservative measure of exposure. Moreover, due to the chemical properties of paraquat, it is believed that the larger the clay content in the soil, the greater the likelihood that paraquat will adsorb to the clay surface and will remain. Therefore, paraquat would become decreasingly mobile in areas with increased clay content, and this would decrease the probability of paraquat finding its way to water bodies due to run-off. If paraquat is found in aquatic environments, paraquat will bind quickly to clay found within the water body due to its cationic properties; it is a double charged cation.

Although the potential impact of discharging ground water on CRLF populations is not explicitly delineated, it should be noted that, in some areas of the country, ground water could provide a source of pesticide to surface water bodies – especially low-order streams, headwaters, and ground water-fed pools. This is particularly likely if the chemical is persistent and mobile, the pesticide is applied to highly permeable soils overlying shallow unconfined ground water, and rainfall is sufficient to drive the chemical through the soil to ground water. Soluble chemicals that are primarily subject to photolytic degradation will be very likely to persist in ground water, and can be transportable over long distances. Similarly, many chemicals degrade slowly under anaerobic conditions (common in aquifers) and are thus more persistent in ground water. Under the right hydrologic conditions, this ground water may eventually be discharged to the surface – often supporting stream flow in the absence of rainfall. Continuously flowing low-order streams in particular are sustained by ground water discharge, which can constitute 100% of stream flow during baseflow (no runoff) conditions. Thus, it is important to keep in mind that pesticides in ground water may impact surface water quality during base flow conditions with subsequent impact on CRLF habitats. However, many smaller streams in CA are net dischargers of water to ground water that go dry during portions of the year and are not supplied by baseflow from ground water.

Although concentrations in a receiving water body resulting from ground water discharge cannot be explicitly quantified, it should be assumed that significant attenuation and retardation of the chemical will have occurred prior to discharge. Nevertheless, where paraquat is applied to highly permeable soils over shallow ground water where there is a net recharge to adjacent streams, ground water could still be a consistent source of chronic background concentrations in surface water, and may also add to surface runoff

during storm events (as a result of enhanced ground water discharge typically characterized by the 'tailing limb' of a storm hydrograph).

### 6.1.4 Action Area Uncertainties

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

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

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

### 6.1.5 Usage Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. Eight years of data (1999 – 2006) were included in this analysis because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was provided by CDPR for these years only. No methodology for removing outliers was provided by CDPR for 2001 and earlier pesticide data; therefore, this information was not included in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been cancelled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide usage data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

### 6.1.6 Terrestrial Exposure Modeling of Paraquat

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.

### 6.1.7 Spray Drift Modeling

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

## 6.2 Effects Assessment Uncertainties

### 6.2.1 Acute to Chronic Ratio

Indirect acute effects to the aquatic-phase CRLF via effects to prey (invertebrates) in aquatic habitats are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. For chronic risks, 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive RQs. However, since freshwater invertebrate chronic toxicity values are not available at this time, the indirect

chronic toxicity values for the CRLF were unable to be calculated. As a result, there is uncertainty as to what degree paraquat may have chronic indirect effects on the CRLF.

### 6.2.2 Age Class and Sensitivity of Effects Thresholds

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

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

### 6.2.3 Use of Surrogate Species Effects Data

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

### 6.2.4 Sublethal Effects

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

There were numerous studies found within the ECOTOX database that reported on the sublethal effects observed after paraquat exposure. Potential sublethal effects on fish are evaluated qualitatively and not used as part of the quantitative risk characterization. Although one study did provide some information regarding different biochemical factors influenced by exposures to paraquat (E104191). Further details on ECOTOX studies are provided in Appendix G, and contain the rejection codes and other information as to why studies from ECOTOX were not used.

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

### 6.2.5 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.

## 7.0 Risk Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this endangered species risk assessment represents the best data currently available to assess the potential risks of paraquat 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 paraquat. The Agency has determined that there **is the potential for effects to** CRLF designated critical habitat from the use of the chemical. The direct effects and habitat modification determinations are summarized in Table 7.1 and Table 7.2 respectively. Given the LAA determination for the CRLF and potential effects to designated critical habitat, a description of the baseline status and cumulative effects for the CRLF is provided in Attachment II.

There are three exceptions to this determination. First, for the direct affects to the CRLF, the aquatic-phase CRLF (from surrogate fish species), a **No Effect (NE)** determination was made, as none of the EECs for any of the uses exceeded the listed species LOC (0.05). Second, for the indirect effects to the CRLF, the aquatic invertebrates, a **No Effect (NE)** determination was also made, as none of the EECs for any of the uses exceeded the listed species LOC (0.05). Third, also for the indirect effects to the CRLF, the terrestrial invertebrates were determined to **May Affect, But Not Likely to Adversely Affect (NLAA)** the CRLF, as there is a negligible potential impact to terrestrial invertebrates that the CRLF consumes. Likewise, none of the EECs for any of the uses exceeded the listed species LOC (0.05). All of the other direct and indirect effects to the CRLF were determined to **Likely to Adversely Affect (LAA)** the CRLF.

The LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the CRLF or its designated critical habitat. To determine this area, the footprint of paraquat's use pattern is identified, using land cover data that correspond to paraquat's use pattern. The spatial extent of the LAA effects determination also includes areas beyond the initial area of concern that may be impacted by spray drift. The identified direct and indirect effects are anticipated to occur only for those currently occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that overlap with the initial area of concern plus at least 1,000 feet from its boundary, see Section 5.2.5 for further information. It is assumed that non-flowing waterbodies (or potential CRLF habitat) are included within this area.

In addition to the spray drift buffer, the results of the downstream dilution extent analysis result in a distance of **300 kilometers** for forest land cover (which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern), **285 kilometers** for cultivated crop, orchard/vineyard, and pasture/hay land cover and **88.7 kilometers** for developed land cover. Please see Section 5.2.5 for a more detailed description. If any of these streams reaches flow into CRLF habitat, there is

potential to affect either the CRLF or modify its habitat. These lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of paraquat sufficient to result in LAA determination or effects to critical habitat.

Appendix D provides maps of the initial area of concern, along with CRLF habitat areas, including currently occupied core areas, CNDDB occurrence sections, and designated critical habitat. It is expected that any additional areas of CRLF habitat that are located at least 1,000 ft (to account for offsite migration via spray drift) and **300 kilometers** for forest land cover (to account for the maximum continuous distance of downstream dilution from the edge of the initial area of concern) outside the initial area of concern may also be impacted and are part of the full spatial extent of the LAA/effects to critical habitat effects determination.

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

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

| Assessment Endpoint | Effects Determination [1] | Basis for Determination |
|---|---|---|
| Survival, growth, and/or reproduction of CRLF individuals | **NE[1]** | **Potential for Direct Effects** |
| | | ***Aquatic-phase (Eggs, Larvae, and Adults)***:<br>The aquatic phase amphibian acute LOCs for listed species (0.05) are not exceeded for any uses of paraquat in California. The chronic EECs are all less than the estimated chronic value derived from the ACR. Therefore, there are no exceedances of chronic LOCs. |
| | **LAA[1]** | ***Terrestrial-phase (Juveniles and Adults)***:<br><br>Refined acute dietary-based RQs for CRLFs consuming small insects exceed the acute listed species LOC (0.1) for all uses of paraquat except melons, RQs ranged from 1.28 (Airport/public health use/guava) to 0.06 (melons). The Refined acute dietary-based RQs for CRLFs consuming large insects and 15g small insectivore mammals resulted in paraquat use on airports/public health use/guava exceeding the listed species LOC (0.1), with an RQ of 0.14 for both. The refined acute dietary-based RQs for CRLFs consuming small herbivore mammals (15g) resulted in all uses exceeding the listed species LOC, RQs ranged from 2.17 (Airport/public health use/guava) to 0.10 (melons) and for 35g small mammals all uses except melons exceed the listed species LOC, RQs ranged from 1.50 (Airport/public health use/guava) to 0.77 (melons). There are no exceedances for CRLFs consuming small terrestrial-phase amphibians.<br><br>Refined dose-based RQs for CRLF of varying weights (1.4g, 37g and 238g) consuming small insects exceed the acute endangered species LOC (0.1) for only the Airport/public health and Guava uses of paraquat for all weights of CRLF). There are no exceedances for small sized (1.4g) CRLF consuming large insects and CRLF this size are too small to consume small mammals or small terrestrial-phase amphibians. The RQs for small sized (1.4g) CRLF are 0.27 suggesting that small CRLF consuming small insects are potentially affected by acute exposures to paraquat. |

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|---|---|---|
| | | Refined dose-based RQs for medium sized (37g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat. There were also exceedances in the acute listed species LOC (0.1) for medium sized CRLF consuming small insectivore (15g) mammals for the airports/public health, guava, and ginger uses of paraquat. For medium sized CRLF consuming small insectivore (35g) mammals there were exceedances in the acute listed species LOC (0.1) for all uses of paraquat except carrots and melons. There are no exceedances for medium sized (37g) CRLF consuming large insects or small terrestrial-phase amphibians. Due to exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses, and exceedances of LOCs for CRLF consuming small insectivore mammals (either 15g or 35g) for a majority of paraquat uses indicate that the medium sized CRLF could potentially be affected by acute exposures to paraquat.<br><br>Refined dose-based RQs for large sized (238g) CRLF consuming small herbivore mammals (either 15g or 35g) exceed the acute listed species LOC (0.1) for all uses of paraquat except melons. There were no exceedances for large sized (238g) CRLF consuming large insects, small insectivore mammals (15g or 35g), or small terrestrial-phase amphibians. The exceedances of LOCs for CRLF consuming small herbivore mammals (either 15g or 35g) for all paraquat uses except melons, indicates that the large sized CRLF could potentially be affected by acute exposures to paraquat.<br><br>Refined chronic dietary-based RQs for CRLFs consuming small insects and small herbivore mammals (either15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for all uses of paraquat. Refined chronic dietary-based RQs for CRLFs consuming large insects and small insectivore mammals (either 15g or 35g) using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health, guava, and ginger uses of paraquat. The refined chronic dietary-based RQs for CRLFs consuming small terrestrial-phase amphibians using T-HERPS model exceed the chronic species LOC (1.0) for Airport/public health and guava uses of paraquat (the maximum uses). |
| | **LAA[1]** | **Potential for Indirect Effects**<br>***Aquatic prey items, aquatic habitat, cover and/or primary productivity***<br><br>LOCs for non-vascular plants are exceeded for all uses. The non-vascular plant RQs range from 138 for airports, commercial/industrial areas, and public health areas to 4.1 for melons.<br><br>LOCs for vascular plants are not exceeded for any uses. The vascular plant RQs range from 0.77 (airports, commercial/industrial areas, public health areas) to 0.02 (melons).<br><br>LOCs for aquatic invertebrates are not exceeded for any uses. The acute RQs range from 0.730 for airports, commercial/industrial areas, and public health areas to 0.004 for melons. When comparing chronic indirect effects, the estimated chronic value at 0.174 ppm is not exceeded for any use.<br><br>For fish/frogs none of the uses exceed the LOCs for listed species. The RQs range from 0.004 for airports, commercial/industrial areas, and public health areas to < 0.001 for melons. When comparing chronic direct effects, the estimated chronic value at 1.89 ppm is not exceeded for any use. |

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| | **LAA**[1] | ***Terrestrial prey items, riparian habitat***<br><br>RQs could not be calculated for terrestrial invertebrates as the endpoint was not definitive. The calculated EECs were compared to the toxicity endpoint, and it was determined that terrestrial invertebrates would not likely adversely affect the CRLF indirectly as food.<br><br>For small mammals the acute dose-based RQs exceed the Agency's LOC (0.1) for all uses of paraquat, the RQs ranged from 7.63 (airports/public health use/guava) to 0.34 (melons). The chronic dose-based RQs exceed the Agency's LOC (1.0) for all uses of paraquat, and range from 128.53 (airports/public health use/guava) to 5.78 (melons). The chronic dietary-based RQs exceed the Agency's LOC (1.0) for all uses except melons, and range from 14.81 (airports/public health use/guava) to 0.67 (melons).<br><br>The RQs for small terrestrial-phase amphibians did not exceed the listed species LOC (0.1) for any use of paraquat. Reduction in amphibian prey items, specifically other frogs is not affected from paraquat use.<br><br>The RQs for non-target terrestrial monocot and dicot plants inhabiting semi-aquatic and upland dry areas do not exceed the Agency's LOC (1.0) for any uses. All aerial applications of paraquat results in spray drift exceedances for dicots (only). These exceedances range from 3.57 (Agricultural fallow/ideland maximum aerial application rate) to 1.07 (Melons, minimum aerial application rate). |

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

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

| Assessment Endpoint | Effects Determination | Basis for Determination |
|---|---|---|
| Modification of aquatic-phase PCE | **May affect** | Due to aquatic non-vascular and terrestrial plant communities being reduced from a majority of use sites, there is potential for alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond. These plant communities provide shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs. In addition, there is potential for 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.<br><br>LOCs are exceeded for terrestrial riparian plants and for aquatic non-vascular plants from exposure to paraquat from spray drift. LOCs for non-vascular plants are exceeded for all uses of paraquat. |
| Modification of terrestrial-phase PCE | **May affect** | The use of paraquat at all sites may create the following effects to PCE: elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs, elimination and/or disturbance of dispersal habitat, reduction and/or modification of food sources for terrestrial phase juveniles and adults, and alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.<br>The RQs for vascular plants did not exceed the Agency's LOC (1.0) for any uses of paraquat in California. |

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| | | The RQs for non-target terrestrial monocot and dicot plants inhabiting semi-aquatic and upland dry areas do not exceed the Agency's LOC (1.0) for all uses. All aerial applications of paraquat results in spray drift exceedances for dicots (only).<br><br>The use of paraquat on most use sites will exceed the revised acute dietary- and dose-based LOC and chronic LOC for prey food items of small mammals, and invertebrates. Food sources for the CRLF are reduced, and the CRLF is indirectly affected from this reduction. |

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.

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