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

Pesticide Effects Determination

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

This ecological risk assessment evaluates the potential for the use of the insecticide methyl parathion (PC#053501) to directly or indirectly affect the California red-legged frog (*Rana aurora draytonii*), and/or modify its designated critical habitat. The California red-legged frog was Federally listed as a threatened species by USFWS effective June 24, 1996 (USFWS 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (USFWS 2002). Final critical habitat for the CRLF was designated by USFWS on April 13, 2006 (USFWS 2006; 71 FR 19244-19346). The frog is endemic to California and Baja California (Mexico) and historically inhabited 46 counties in California, including the Central Valley and both the coastal and interior mountain ranges (USFWS 1996). Its range has been reduced by approximately 70%, and it currently inhabits 22 counties in California (USFWS 1996). This assessment is being undertaken consistent with the settlement for the court case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)) and in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

Seven active registrations currently regulate the use of methyl parathion in California. Current registrations are limited to orchards (walnuts), agricultural crops, and grass used as hay, pasture, or forage. It is marketed in two formulations: a microencapsulated liquid formulation, and an emulsifiable concentrate. Methyl parathion can be applied aerially or by ground boom, and although chemigation is permitted in other locations, it is prohibited in California. Methyl parathion is a restricted use pesticide, and may only be used by certified applicators. There are no residential uses.

Based on data reported in the CDPR PUR database, use of methyl parathion in California has increased in the period (2002-2005) for which data are available. In this period, total use of approximately 292,000 lbs was reported. In all years, the dominant use was on walnuts (94% of all applied). The only other uses accounting for ≥1% of reported were corn (5%) and onions (1%). Of the total applied, 75% was used in only 4 counties (Tulare, San Joaquin, Stanislaus, and Kings), with an additional 7 counties accounting for another 24% of reported use.

Methyl parathion is an insecticide, acting via acetylcholinesterase inhibition. In general, it is acutely toxic to animals, and effects are evident soon after exposure. It is toxic via both ingestion and dermal contact. In cases where it does not cause mortality, sub-lethal effects include disorientation and behavioral changes that may increase susceptibility to predation and/or modify parenting patterns (*e.g.*, nest abandonment in birds). Based on available, acceptable data, methyl parathion is classified as moderately toxic to fish and very highly toxic to aquatic invertebrates on an acute basis. Based on acute oral and subacute dietary toxicity test results, it is classified as very highly toxic to birds and mammals on an acute and subacute exposure basis. It is also classified as highly toxic to bees on both an oral and contact basis.

Methyl parathion is mobile to relatively mobile in soil, but degrades rapidly ($t_{1/2}$ <5 days) in both soil and water. Photodegradation ($t_{1/2}$ = 49 hours) is a relatively rapid dissipation route in aquatic systems, but may be limited due to light attenuation with depth and turbidity in most natural waters. The major degradation product (>10% of applied) of methyl parathion is 4-nitrophenol. Methyl paraoxon is a minor (2.1% of applied), toxic degradate of methyl parathion, formed under oxidizing conditions in water and on leaf surfaces. The oxon appears to be as toxic to aquatic invertebrates as the parent, although the data are extremely limited. The transformation product, 4-nitrophenol, appears to be less toxic than either the parent or methyl paraoxon.

The Henry's Law constant (6.12×10^{-7}) value available for methyl parathion would indicate very limited volatility. However, the concentrations found in air and rainwater monitoring data may be sufficient to affect aquatic macroinvertebrates (Section 3.3.3).

Estimated environmental concentrations (EECs) for surface water were derived using PRZM-EXAMS and the Rice Water Quality Model. Peak 1-in-10 year EECs for methyl parathion ranged from 4.2 μg/L to 66.8 μg/L. Peak 1-in-10 year EECs for methyl paraoxon ranged from 0.09 μg/L to 1.40 μg/L. Available water monitoring data for California were analyzed. The highest measured concentration of methyl parathion (0.524 μg/L) was an order of magnitude lower than modeled peak or chronic concentrations. In the subset of samples analyzed for methyl paraoxon, none had concentrations above instrument detection limits, which ranged from 0.02-0.05 μg/L.

Risk quotients (RQs) were calculated for the three different land use classes evaluated (orchards, agricultural lands, and rangeland). For the aquatic phase, which considers effects on frog eggs, larvae, tadpoles, juveniles, and adults, there were no Level of Concern (LOC) exceedances for the surrogate taxa (fish) representing aquatic-phase amphibians except for direct applications to water for use on rice. In the evaluation of aquatic prey items, there were no LOC exceedances for fish/aquatic-phase amphibians except for use on rice. For aquatic invertebrates, both acute and chronic RQs exceeded LOCs for all land uses. Acute RQs for the invertebrates ranged from 9.7 to 69 (LOC= 0.05). Chronic RQs ranged from 13 to 35 (LOC=1.0). There were no LOC exceedances for aquatic plants. Based on the data available, it appears that detrimental effects on terrestrial plants are unlikely to occur at a distance >30 ft away from the application site, even at the highest application rate.

Evaluation of potential impacts on the terrestrial- phase CRLF included analysis of direct effects on the frog itself (juveniles and adults); and evaluation of indirect effects and/or modification of critical habitat on the terrestrial-phase frogs by a reduction in prey items (terrestrial invertebrates, small mammals, and frogs) or modification of the terrestrial plant community supporting the frog population. For all land uses, acute and chronic RQs for the frog itself exceeded acute and chronic risk LOCs. Acute RQs ranged from 15-88 (LOC=0.1) for direct effects to terrestrial phase CRLF. RQs for all prey items evaluated also exceeded the acute risk LOCs (RQ range 15-233, LOCs 0.05 for terrestrial invertebrates, 0.1 for all other organisms). Based on the data available, it appears that detrimental effects on terrestrial plants are unlikely to occur at a distance >30 ft away from the application site, even at the highest application rate.

Organophosphate pesticides, including methyl parathion, have been documented to cause sublethal effects including disorientation and behavioral modifications. Currently, no data are available to establish a lower bound for these types of effects relative to methyl parathion, thus the Agency has not attempted to delineate a zone of effects around the various land use classes.

After completing the analysis of the effects of methyl parathion on the Federally-listed threatened California red-legged frog in accordance with methods delineated in the Overview Document (USEPA 2004), the Agency concludes that the use of methyl parathion as currently registered may affect, and is likely to adversely affect (LAA) the California red-legged frog, based on direct effects on juvenile and adult frogs and indirect effects on both the aquatic and terrestrial prey base. The Agency also concludes these potential effects on prey base primary constitute elements and therefore, determines habitat modification (HM) to designated critical habitat. Rationale for each component assessed is provided in Table 1.

Table 1 Effects Determination for Methyl Parathion

Assessment Endpoint	Effects determination	Basis for Determination
Aquatic-Phase CRLF (Eggs, larvae, tadpoles, juveniles, and adults)[a]		
Direct Effects		
1. Survival, growth, and reproduction of CRLF	No effect (use on rice is an LAA)	No exceedances of acute or chronic LOCs for surrogate organisms representing the aquatic-phase CRLF except for use on rice where both acute and chronic risk LOCs are exceeded.
Indirect Effects and Critical Habitat Effects		
2. Reduction or modification of aquatic prey base	May affect Likely to adversely affect Modification of critical habitat	Acute and chronic exceedances for aquatic invertebrates for all land uses assessed. Anticipated effects on aquatic prey base.
3. Reduction or modification of aquatic plant community	No effect	No LOC exceedances for aquatic plants.
4. Degradation of riparian vegetation	May affect Not likely to adversely affect (Discountable)	Based on available data, detrimental effects of a sufficient magnitude to cause take of CRLF due to effects on these plants appear unlikely.
Terrestrial-Phase CRLF (Juveniles and Adults)		
Direct Effects		
5. Survival, growth, and reproduction of CRLF	May affect Likely to adversely affect	Acute and chronic LOC exceedances for both adults and juveniles based on both T-REX and T-HERPS estimates for all land use categories.
Indirect Effects and Critical Habitat Effects		
6. Reduction or modification of terrestrial prey base	May affect Likely to adversely affect Modification of critical habitat	Acute and chronic LOC exceedances for all prey categories for all land use categories.
7. Degradation of riparian and/or upland vegetation	May affect Not likely to adversely affect (Discountable)	Based on available data, detrimental effects of a sufficient magnitude to cause take of CRLF due to effects on these plants appear unlikely.

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.

2.0 Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (U.S. EPA 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS 1998) and EPA's methodologies as described in the Overview Document (U.S. EPA 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS 2004).

2.1 Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of methyl parathion on agricultural crops grown in the state of California. Crops for which methyl parathion is currently registered include walnuts, corn, onions, rice, and grass (for forage). This assessment also evaluates whether use on these crops is expected to result in the degradation of the species' critical habitat. This ecological risk assessment has been prepared consistent with a settlement agreement in the case *Center for Biological Diversity (CBD) vs. EPA et al.* (Case No. 02-1580-JSW(JL)) settlement entered in Federal District Court for the Northern District of California on October 20, 2006.

In this assessment, direct and indirect effects to the CRLF and potential modification of its critical habitat are evaluated in accordance with the methods described in the Agency's Overview Document (U.S. EPA 2004). Screening level methods include use of standard models such as Pesticide Root Zone Model-Exposure Analysis Model System (PRZM-EXAMS), Terrestrial Exposure (TREX) model, Terrestrial Plant model (TerrPlant), AgDrift, and AgDisp, all of which are described at length in the Overview Document. Additional refinements include a modification of TREX (THERPS) to evaluate effects on terrestrial-phase frogs, an analysis of the usage data, and a spatial analysis. 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 methyl parathion 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 OPP's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of methyl parathion may potentially involve numerous areas throughout the United States and its Territories.

However, for the purposes of this assessment, attention will be focused on the section of the action area, intersecting with 1) locations where CLRF is known to occur[1], 2) currently occupied core areas for the CLRF[2], and 3) designated critical habitat.

As part of the "effects determination," one of the following three conclusions will be reached regarding the potential use of methyl parathion 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 methyl parathion as it relates to this species and its designated critical habitat. If, however, direct or indirect effects to individual CRLFs are anticipated and/or effects may impact the PCEs of the CRLF's designated critical habitat, a preliminary "may affect" determination is made for the FIFRA regulatory action(s) regarding methyl parathion.

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

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

[1] As documented in the California Natural Diversity Database (CNDDB)
[2] As described in the recovery plan.

limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically-mediated processes. Activities that may destroy or modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of methyl parathion 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

Methyl parathion (CAS Registry # and 298-00-0), is an organophosphate insecticide currently registered in the U.S. for agricultural uses only, on a relatively small number of crops. An analysis of usage patterns in California indicates the dominant use is in walnut orchards. There are no homeowner, public health, or veterinary use registrations at the time of this assessment. Methyl parathion is formulated in two ways, as an emulsifiable concentrate, and in a microencapsulated form. Both are applied to crops as a liquid. Existing data indicate toxicity of the two forms is similar, and the most sensitive endpoints, regardless of formulation, are used in this assessment. In the environment, methyl parathion has two degradates that are of toxicological concern; methyl paraoxon, which has the same mode of action as the parent, and 4-nitrophenol, which acts as a polar narcotic. These degradates are considered in this assessment. The scope of this assessment includes exposure and effects modeling for the active ingredient methyl parathion.

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).

Methyl parathion has registered products that contain multiple active ingredients. Analysis of the available open literature and acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in Appendix G. The results of this analysis show that an assessment based on the toxicity of the single active ingredient of methyl parathion is appropriate. This current registration includes the active ingredient malathion, also an organophosphate insecticide. As both chemicals have a similar mode of action, toxicity for this formulation is expected to be additive (Appendix G).

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

Although current registrations for methyl parathion allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of methyl parathion in portions of the action area that are reasonably assumed to be biologically relevant to the CRLF and its designated critical habitat.[3]

2.3 Previous Assessments

The ecological risk assessment developed for the re-registration of methyl parathion concluded that acute and chronic effects on birds and mammals, acute effects on bees, and acute and chronic effects on aquatic invertebrates were likely to occur as a result of methyl parathion use. The 2004 evaluation of methyl parathion effects on Pacific salmonids concluded "some methyl parathion uses may affect 9 listed Pacific salmon and steelhead evolutionarily significant units (ESUs); may affect but are not likely to adversely affect 12 listed Pacific salmon and steelhead ESUs; and methyl parathion use will have no effect on the remaining five ESUs." (USEPA 2004a)

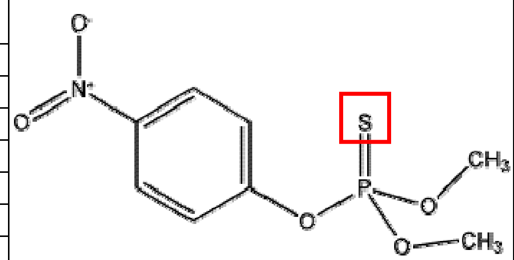
2.4 Stressor Source and Distribution

Methyl parathion has specific properties and uses which help delineate when and where the active ingredient and/or any impurities/degradates may co-occur temporally and spatially with the CRLF with sufficient intensity (sufficient concentration) to affect the CRLF. The parent methyl parathion, a highly toxic but minor (2.1% of applied) degradate, methyl paraoxon, and a major (~10% of applied) but less toxic degradate, 4-nitrophenol, are included in this risk assessment. Appendix A summarizes fate data discussed in the RED (USEPA 2006).

The basic physical and chemical properties and structure of methyl parathion are presented in Table 2. Methyl paraoxon differs structurally from methyl parathion by the substitution of a double-bonded oxygen to phosphorus in place of the double-bonded sulfur (identified by red box in chemical structure diagram) and has a slightly lower molecular weight of 247.19 g/mole. Throughout this assessment many of the properties of methyl parathion are assumed to apply to methyl paraoxon due to the similarities in chemical structure. These assumptions are necessary due to the dearth of information on methyl paraoxon relative to the amount of information available for methyl parathion.

[3] Technical labels also exist, which may include crops not listed on end use labels. Technical products are used to make formulated end use products. Because these technicals cannot be applied directly, use sites on these labels are not considered at part of the Federal action.

Table 2. Physical/chemical properties of methyl parathion.

Physical/Chemical Properties	Value/Description	Chemical Structure
Common Name	Methyl Parathion	
Chemical Name:	O,O-dimethyl O-p-nitrophenyl phosphorothioate	
CAS No.	298-00-0	
PC Code	053501	
Molecular formula	$C_8H_{10}O_5NPS$	
Molecular weight	265 g/mole	
Physical state	White crystalline solid	
Melting point	35-36 ^{o}C	
Boiling Point	decomposes rapidly above 100 degrees ^{o}C	
Bulk Density	1.358 g/mL at 25 ^{o}C	
Henry's Law Constant (20 ^{o}C)	6.12 x 10^{-7} atm. m^3/mole	
Solubility (20 ^{o}C)	60 mg/l water	

2.4.1 Environmental Fate Properties

The environmental fate assessment for methyl parathion is based on acceptable and supplemental data. Although the weight of evidence from supplemental data and open literature suggest that methyl paraoxon is not formed in aerobic soil environments, a common uncertainty in the metabolism studies was the inability to identify all degradation products of methyl parathion.

The major routes of dissipation for methyl parathion are microbial degradation, aqueous photolysis, hydrolysis, and partitioning onto soil organic matter. Methyl parathion degrades rapidly ($t_{1/2}$ < 5 days) in soil and water through (aerobic and anaerobic) microbial degradation. It also is expected to photodegrade ($t_{1/2}$ = 49 hours) in aquatic environments. Other degradation processes appear to be less important routes of methyl parathion dissipation. Methyl parathion slowly hydrolyzed ($t_{1/2}$ = 68 days at pH 5, $t_{1/2}$ = 40 days at pH 7, $t_{1/2}$ = 33 days at pH 9) in buffer solutions and slowly photodegraded ($t_{1/2}$ = 61 days) on soil surfaces.

The major (>10% of applied) degradation product of methyl parathion is 4-nitrophenol. This degradate is formed through the hydrolytic cleavage of nitrophenyl C-O-P bond. Other minor degradates (<10% of applied) that have been found in laboratory studies include methyl paraoxon, monodesmethyl parathion, phosphorothioic acid, O,S-dimethyl o-(4-nitrophenyl)ester, nitrophenyl phosphoric acid, mono (4-nitrophenyl) ester and CO_2. Of these, only methyl paraoxon is included in EPA Health Effects Division's (HED's) tolerance expression. Methyl paraoxon has only been detected (2.1% of applied) in an anaerobic aquatic metabolism study (MRID 41768901). (A later acceptable anaerobic aquatic metabolism study, MRID 46997601, did not identify methyl paraoxon, but was unable to characterize several degradates that were <4% of applied.) The oxon is formed through a desulfonation (P=S to P=O) reaction. It should be noted, however, that the amount of methyl paraoxon derived by aerobic soil metabolism is not clear at this time.

In addition, analyses for methyl paraoxon in two field dissipation studies (no oxon found) are questionable because of storage stability issues.

Methyl parathion is mobile to relatively mobile in soil. However, the low persistence of methyl parathion is expected to limit the extent of off-site movement. Supplemental data on parent methyl parathion indicate that it is very mobile to somewhat mobile [K_{oc}s = 230-to-670 l/kg] in mineral soils. There is uncertainty in these results since the soils used in the batch equilibrium experiment were sterilized by autoclaving. Another route of dissipation is the secondary movement through volatilization of methyl parathion from soil and leaf surfaces. Although laboratory studies seem to indicate that methyl parathion volatilization is not a major route of dissipation, methyl parathion has been detected in air and rain samples across the United States. These detections appear to be correlated to use on cotton, soybeans, wheat, and tobacco.

Methyl parathion, formulated as an emulsifiable concentrate (EC), dissipated rapidly (<1 day) in a field dissipation study performed in a cotton field in California. Methyl parathion was not detected below 4 inches.

Acceptable field studies have not been performed using the microencapsulated formulation Penncap-M.

2.4.2 Environmental Transport Mechanisms

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

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

In general, deposition of drifting or volatilized pesticides is expected to be greatest close to the site of application. Computer models of spray drift (AgDRIFT and AGDISP) are used to determine potential exposures to aquatic and terrestrial organisms. Methyl parathion is most toxic to terrestrial invertebrates (primarily insects), thus the distance of potential impact away from the use sites (action area) is determined by the distance required to fall below the LOC for these organisms.

2.4.3

2.4.3 Mechanism of Action

Methyl parathion is an acetylcholinesterase (AChE) inhibitor. AChE is the enzyme responsible for deactivating acetylcholinesterase, the enzyme which modulates the chemical signals across cholinergic nerve synapses. The specific reaction between the pesticide and the enzyme results in binding to the active site of the enzyme (a serine hydroxyl group), leaving the enzyme inactivated (Ecobichon 1996). For organophosphorus compounds, this reaction is close to irreversible, and normal response in the organism does not resume until new AChE has been synthesized. Absence of AChE results in continuous firing of the cholinergic nerve synapses. Typical symptoms of exposure include loss of coordination, dizziness, tremors, confusion, and depressed respiration (Kamrin 1997). Sublethal effects in wildlife may be exhibited as changes in behavior, including reduced predator avoidance, general disorientation, and decreased parental caretaking. Methyl parathion may affect organism via ingestion, inhalation, or dermal contact. Effects are transitory in nature, and organisms which survive often appear to recover. In mammalian systems, methyl parathion is metabolized and is then excreted by the kidneys. It does not bioaccumulate, and transformation is relatively rapid. (Kamrin 1997, Hill 1995).

2.4.4 Use Characterization

Based on a search of active registrations (all types) in EPA's data base (OPPIN, 9/20/07, PDB), and coordination with the Registration Division (RD) and the Special Review and Re-registration Division (SRRD), 7 active registrations were identified that currently regulate the use of methyl parathion in California (Table 1). Other restrictions may be levied at a state, county, or regional level, but those restrictions are not a part of the federal action, and are not considered in this assessment. One of the registrations is a formulation intermediate, and has no registered crop uses. Two labels are the subject of voluntary cancellation requests (VCR) by the registrants, and are included in the assessment, although their use is anticipated to be phased-out in the near future. Two formulations exist: a microencapsulated liquid formulation, and an emulsifiable concentrate.

Table 3 Active Registrations for Methyl Parathion

Registration Number (Type) Label Date	Name	Registrant	Form	Percent Active Ingredient	Additional Active Ingredients
4581-393 (Section 3) 9/24/07	Penncap-M Microencapsulated Insecticide	Cerexagri, Inc.	Microencapsulated	20.9%	No
4787-33 (Section 3)	Cheminova Methyl Parathion Technical	Cheminova A/S	Formulation Intermediate	77%	No
4787-48 (Section 3) 8/28/07	Declare	Cheminova A/S	Emulsifiable Concentrate	43.4%	No
5905-533 (Section 3) VCR 9/20/07	4 lb Methyl Parathion	Helena Chemical Co.	Emusifiable Concentrate	43.4%	No
5905-534 (Section 3) VCR 3/16/05	Malathion-Methyl Parathion Emusifiable Liquid	Helena Chemical Co.	Emusifiable Concentrate	38.44%	Malathion 39.94%
67760-43 (Section 3) 8/28/07	Cheminova Methyl Parathion 4EC	Cheminova, Inc.	Emusifiable Concentrate	43.8%	No
4581-393 (SLNCA000001) 9/24/07	Penncap-M Microencapsulated Insecticide	Cerexagri, Inc.	Microencapsulated	20.9%	No

Methyl parathion can be applied aerially or by ground boom, and although chemigation is permitted in other locations, it is prohibited in California. It is a restricted use pesticide, and may only be used by or under the direct supervision of a certified applicator. Current registrations are limited to agricultural crops, orchards (walnuts only) and grass used as hay, pasture, or forage. Agricultural crops for which it is registered include: corn, cotton, legumes (soybeans, dried peas), cereals (wheat, oats, barley, rye, rapeseed), sunflowers, onions, sugar beets, potatoes, rice, and alfalfa. Because agricultural crops, orchards, and rangeland (grass used as hay, pasture, or forage) are different land classes in the National Land Cover Data (NLCD) (http://landcover.usgs.gov/), and their proximity to CRLF habitat is somewhat different, they have been addressed separately. Application rates for agricultural crops range from 0.5 pounds of active ingredient per acre (lb a.i/A) for onions to 3.0 lb a.i/A for cotton, so these two crops are used in the assessment as lower and upper bound estimates for the agricultural lands.

The Office of Pesticides Programs' Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information using state-level usage data obtained from USDA-NASS[4], Doane[5], and the California's Department

[4] United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.usda.gov/nass/pubs/estindx1.htm#agchem.
[5] (www.doane.com; the full dataset is not provided due to its proprietary nature)

of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[6]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or proprietary databases used by EPA, and thus the usage data reported by county in this assessment were generated using CDPR PUR data. From the CDPR PUR data, BEAD generated summaries of average and total methyl parathion usage by year, county, and crop for the years 2002-2005 (the most recent and best available data). Total usage is shown in Figures 1-3.

Some uses reported in the CDPR PUR database may be different than those considered in the assessment. The uses considered in this risk assessment represent currently registered uses according to a review of all current labels by OPP/BEAD and OPP/SRRD. No other uses are relevant to this assessment. Any reported uses in the CA DPR database that do not reflect current labeled uses may represent either historic uses that have been canceled, misreported uses, or cases of misuse. Historic uses, misreported uses, and misuse are not considered part of the federal action and, therefore, are not considered in this assessment.

Based on data reported in the CDPR PUR database, use of methyl parathion in California has increased in the period (2002-2005). In this period, total use of approximately 292,000 pounds of active ingredient was reported. Use of approximately 56,000 lbs a.i was reported in 2002. Total pounds applied ranged from approximately 75,000-83,000 lbs a.i in 2003-2005. In all years, the dominant use was on walnuts (94% of all applied from 2002-2005). The only other uses accounting for ≥1% of reported were corn (5%) and onions (1%). Of the total applied, 75% was used in only 4 counties (Tulare, San Joaquin, Stanislaus, and Kings), with 7 other counties accounting for an additional 24% of reported use.

[6] 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.

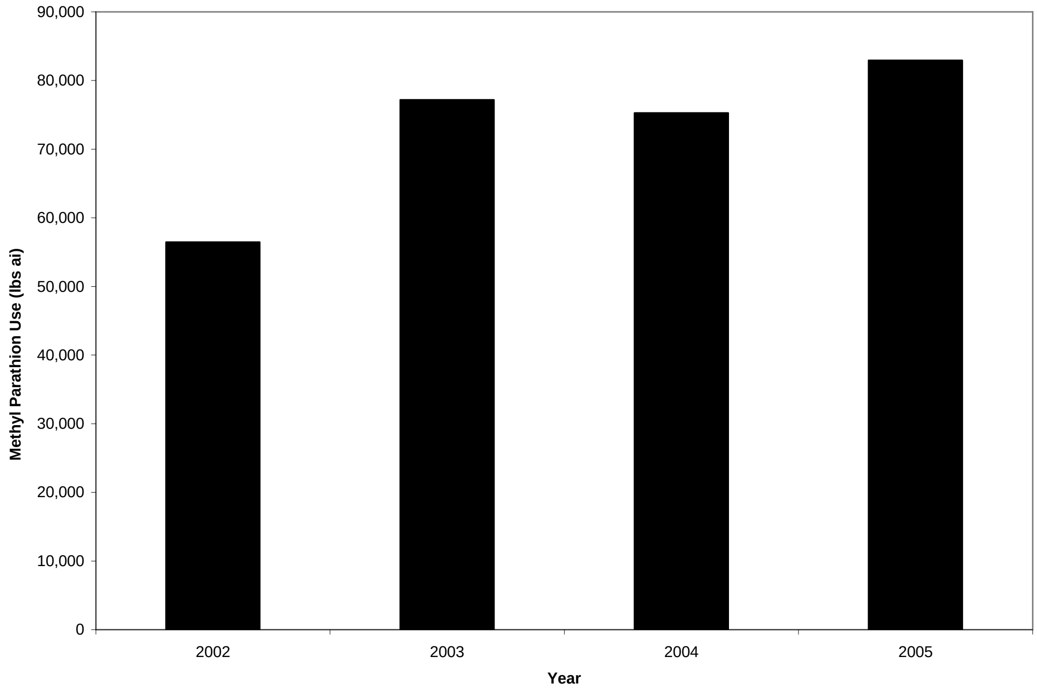


Figure 1 Methyl Parathion Usage in California by Year (Total Applied, 2002-2005)

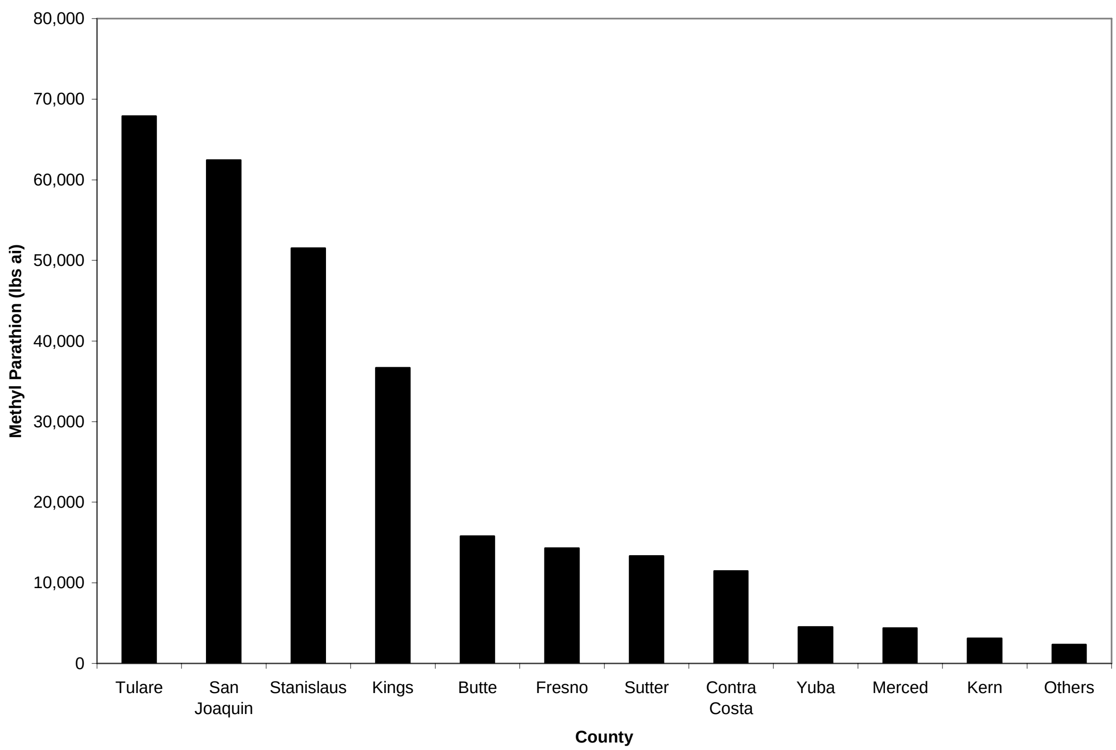


Figure 2 Methyl Parathion Usage in California by County (Total Applied, 2002-2005)

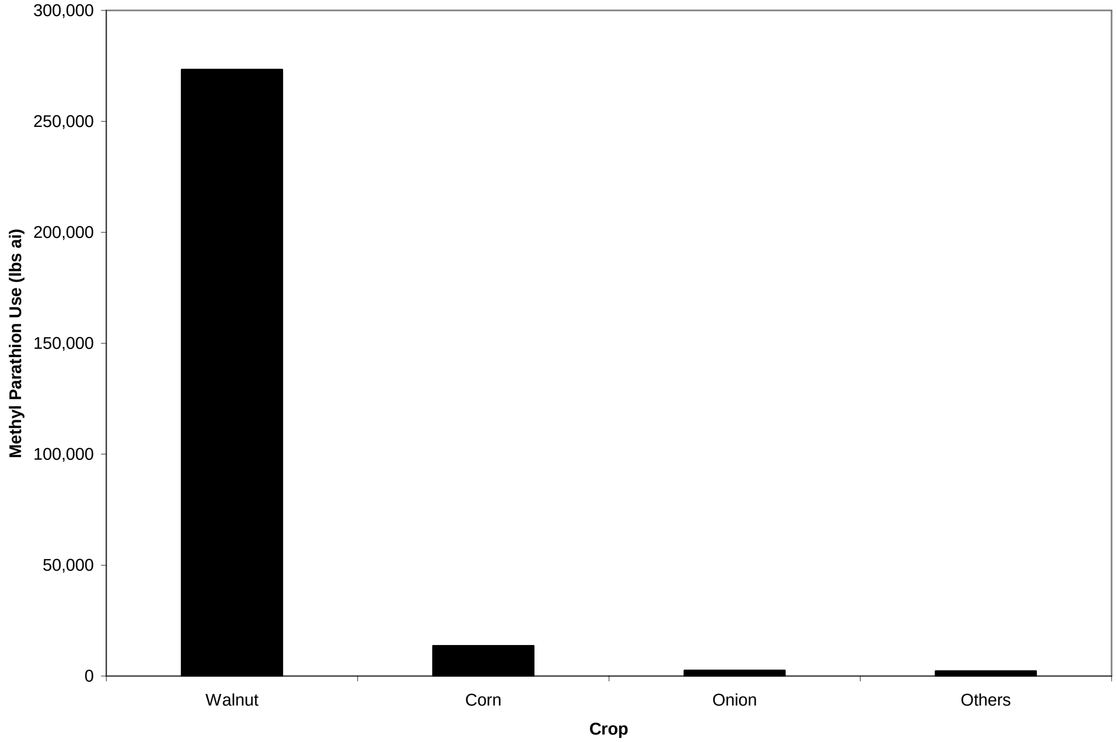


Figure 3 Methyl Parathion Usage in California by Crop (Total Applied, 2002-2005)

2.5 Assessed Species

The California red-legged frog was federally listed as a threatened species by USFWS effective June 24, 1996 (USFWS 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (USFWS 2002). Final critical habitat for the CRLF was designated by USFWS on April 13, 2006 (USFWS 2006; 71 FR 19244-19346). A brief discussion of distribution, reproduction, diet, and habitat requirements follows, with more detailed information provided in Attachment 1.

2.5.1 Distribution

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

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

The distribution of CRLFs within California is addressed in this assessment using four categories of location. Three of these categories were designated by the USFWS in the recovery plan (recovery units, core areas, and designated critical habitat). The fourth category is known occurrences as reported in the California Natural Diversity Database (CNDDB) (Figure 4). Recovery units are large areas defined at the watershed level that have similar conservation needs and management strategies. The recovery unit is primarily an administrative designation, and land area within the recovery unit boundary is not exclusively CRLF habitat. Core areas are smaller areas within the recovery units that comprise portions of the species' historic and current range and have been determined by USFWS to be important in the preservation of the species. Designated critical habitat is generally contained within the core areas, although a number of critical habitat units are outside the boundaries of core areas, but within the boundaries of the recovery units. Additional information on CRLF occurrences from the CNDDB is used to cover the current range of the species not included in core areas and/or designated critical habitat, but within the recovery units. For purposes of this assessment, designated critical habitat, currently occupied (post-1985) core areas, and additional known occurrences of the CRLF from the CNDDB are considered the range of the species.

2.5.1.1 Recovery Units

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

2.5.1.2 Core Areas

USFWS has designated 35 core areas in which to focus recovery efforts. The core areas, which are distributed throughout portions of the historic and current range of the species, are intended to provide for long-term viability of existing populations and reestablishment of populations within historic range. These areas were selected because they: 1) contain existing viable populations; or 2) they contribute to the connectivity of other habitat areas (USFWS 2002). Core area protection and enhancement are vital for maintenance and expansion of the CRLF's distribution and population throughout its range.

2.5.1.3 Designated Critical Habitat

Critical habitat was designated for the CRLF on April 13, 2006 (USFWS 2006; 71 FR 19244-19346). Critical habitat was selected for the species based on areas: 1) that are occupied by CRLFs; 2) where source populations of CRLFs occur; 3) that provide connectivity between source populations; and 4) that are ecologically significant. Designation of critical habitat is based on habitat areas that provide essential life cycle needs of the species or areas that contain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)) The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation (USFWS 2006):

- Aquatic breeding habitat
- Non-breeding aquatic habitat
- Upland habitat
- Dispersal habitat

Critical habitat does not include certain areas where existing management is sufficient for CRLF protection. For the CRLF, all designated critical habitat units contain all four PCEs and were occupied by the CRLF at the time of listing.

USFWS has established modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. For the CRLF specifically, these include, but are not limited to, the following:

- Alteration of water chemistry or temperature
- Increased sedimentation
- Alteration of channel or pond morphology
- Elimination of upland foraging areas
- Introduction of non-native species
- Degradation of prey base

The critical habitat designation 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.

2.5.1.4 Other Known Occurrences from the CNDBB

The CNDDB[7] provides location and natural history information on species found in California. It is the best available information for historical and current species location sightings.

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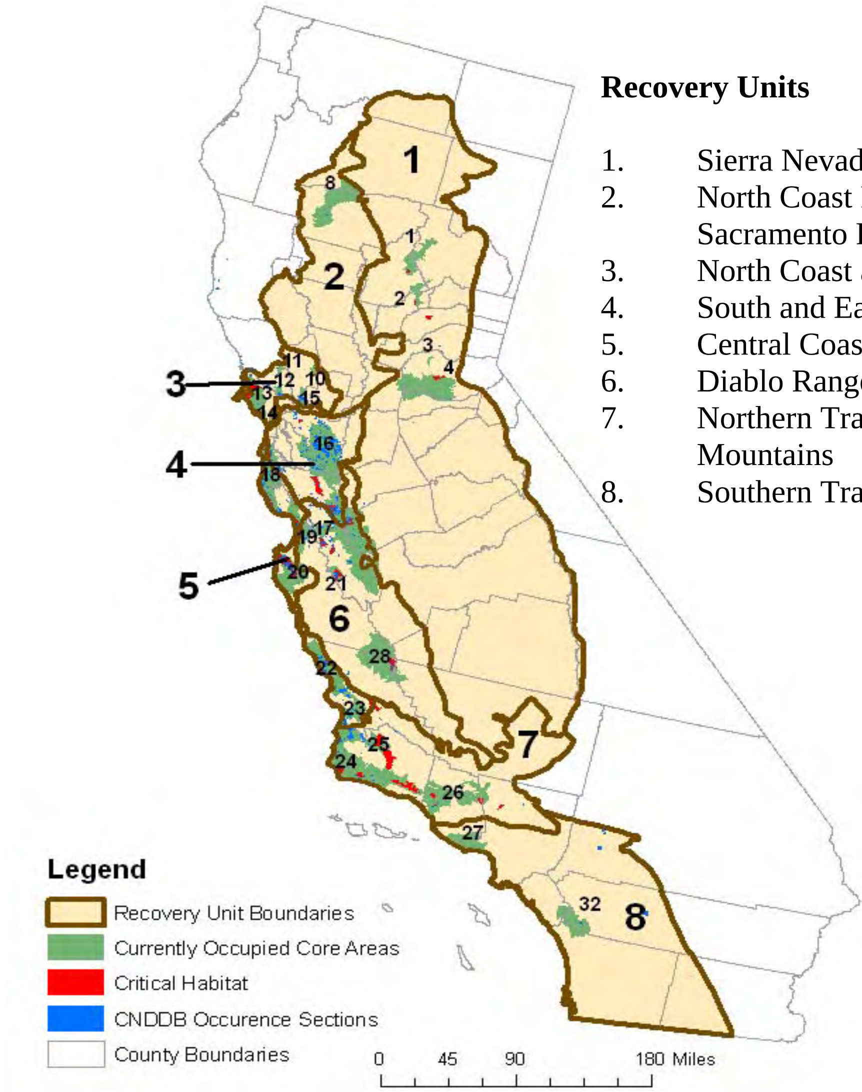
[7] See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.



Recovery Units

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

Core Areas

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

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

Figure 4 California Red-legged Frog Distribution

2.5.2 *Reproduction*

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers 2005a). According to the Recovery Plan (USFWS 2002), CRLFs breed from November through late April. Peaks in spawning activity vary geographically; Fellers (2005b) reports peak spawning as early as January in parts of coastal central California. Eggs are fertilized as they are being laid. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto 1984). Egg masses contain approximately 2000 to 6000 eggs ranging in size between 2 and 2.8 mm (Jennings and Hayes 1994). Embryos hatch 10 to 14 days after fertilization (Fellers 2005a) depending on water temperature. Egg predation is reported to be infrequent and most mortality is associated with the larval stage (particularly through predation by fish); however, predation on eggs by newts has also been reported (Rathburn 1998). Tadpoles require 11 to 28 weeks to metamorphose into juveniles (terrestrial-phase), typically between May and September (Jennings and Hayes 1994, USFWS 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers 2005b, USFWS 2002). Males reach sexual maturity at 2 years, and females reach sexual maturity at 3 years of age; adults have been reported to live 8 to 10 years (USFWS 2002). Figure 5 depicts CRLF annual reproductive timing.

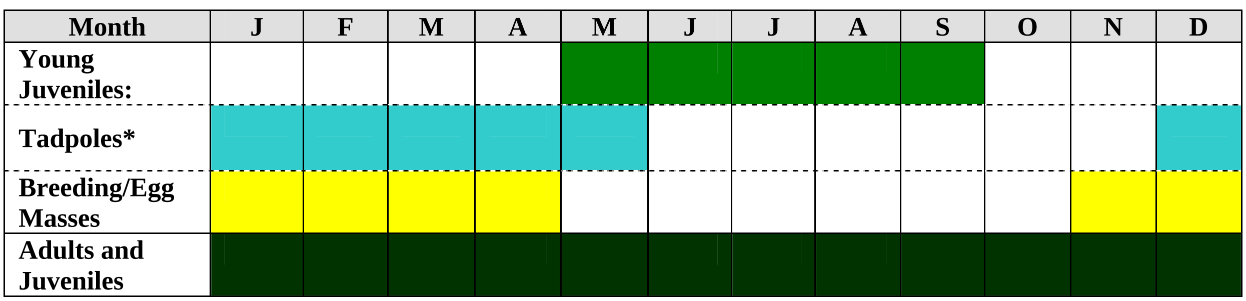


Figure 5. CRLF Reproductive Events by Month *except those that over-winter.

2.5.3 *Diet*

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus (USFWS 2002). Tadpoles filter and entrap suspended algae (Seale and Beckvar, 1980) via mouthparts designed for effective grazing of periphyton (Wassersug, 1984, Kupferberg *et al.*; 1994; Kupferberg, 1997; Altig and McDiarmid, 1999).

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

2.5.4 Habitat

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

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

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

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

2.6 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). In the Overview Document, EPA defined exceedances of the pre-established OPP levels of concern (LOCs) as effects (USEPA 2004). The initial area of concern is delineated by the registered use sites, or some reasonable surrogate, such as a land use type. For this assessment, land use type has been used, with agricultural land use representing agricultural crops, orchard land use representing use on walnuts, and rangeland representing use on grass for hay, pasture, and forage. The extent of the action area is determined by the taxa for which LOCs are exceeded farthest away from the use site. This offset is added to the edge of the merged use sites and the total area is considered the action area. For methyl parathion, the most sensitive taxa for spray drift effects are the terrestrial invertebrates (represented in this assessment by honeybees). For aquatic organisms, the offset is determined by the distance downstream required for the most sensitive endpoint to drop below the LOC. The most sensitive taxa for downstream effects are aquatic invertebrates. Because of the potential for atmospheric transport of methyl parathion, and the low aquatic concentration ($\geq$ 0.05 μg/L), that would exceed the endangered species LOC, several analyses examining methyl parathion movement into surface water from atmospheric transport alone were conducted (Section 3.2.3) In several of these analyses, risk quotients for aquatic invertebrates generated solely on the basis of atmospheric input exceeded the endangered species LOCs, thus for the purpose of this assessment the entire action area is defined as the state of California. Action areas by land use categories are shown in relation to CRLF locations in Figures 6 – 10. Figures 11 – 13 depict high use counties in relation to CRLF locations.

It is recognized by the Agency that the overall action area for the national registration of methyl parathion includes any locations where registered uses might result in ecological effects. However, the scope of this assessment limits consideration to the areas in which application of the pesticide may have direct or indirect effects on California red-legged frog or its designated critical habitat.

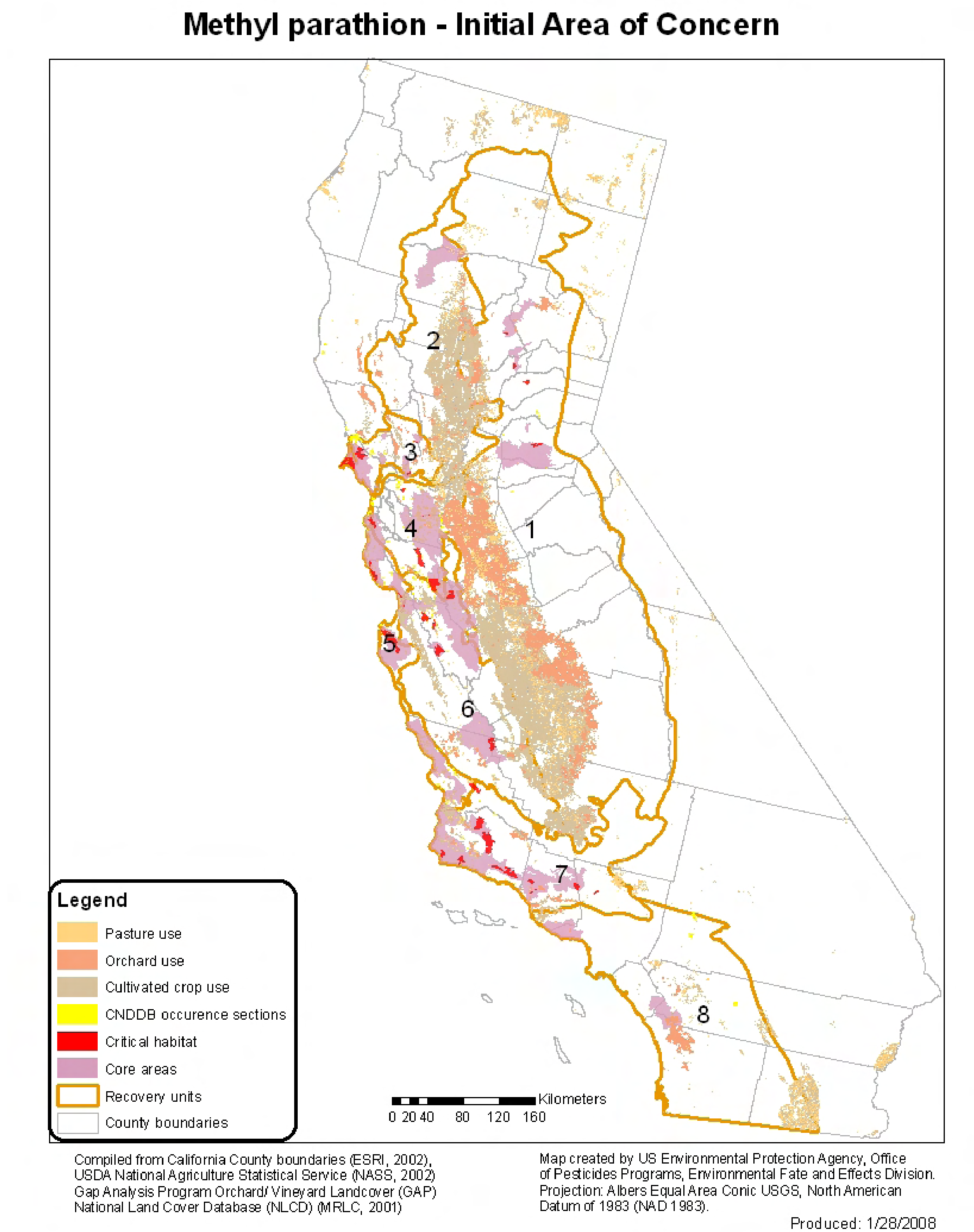


Figure 6 Land Use Categories in Relation to CRLF Locations

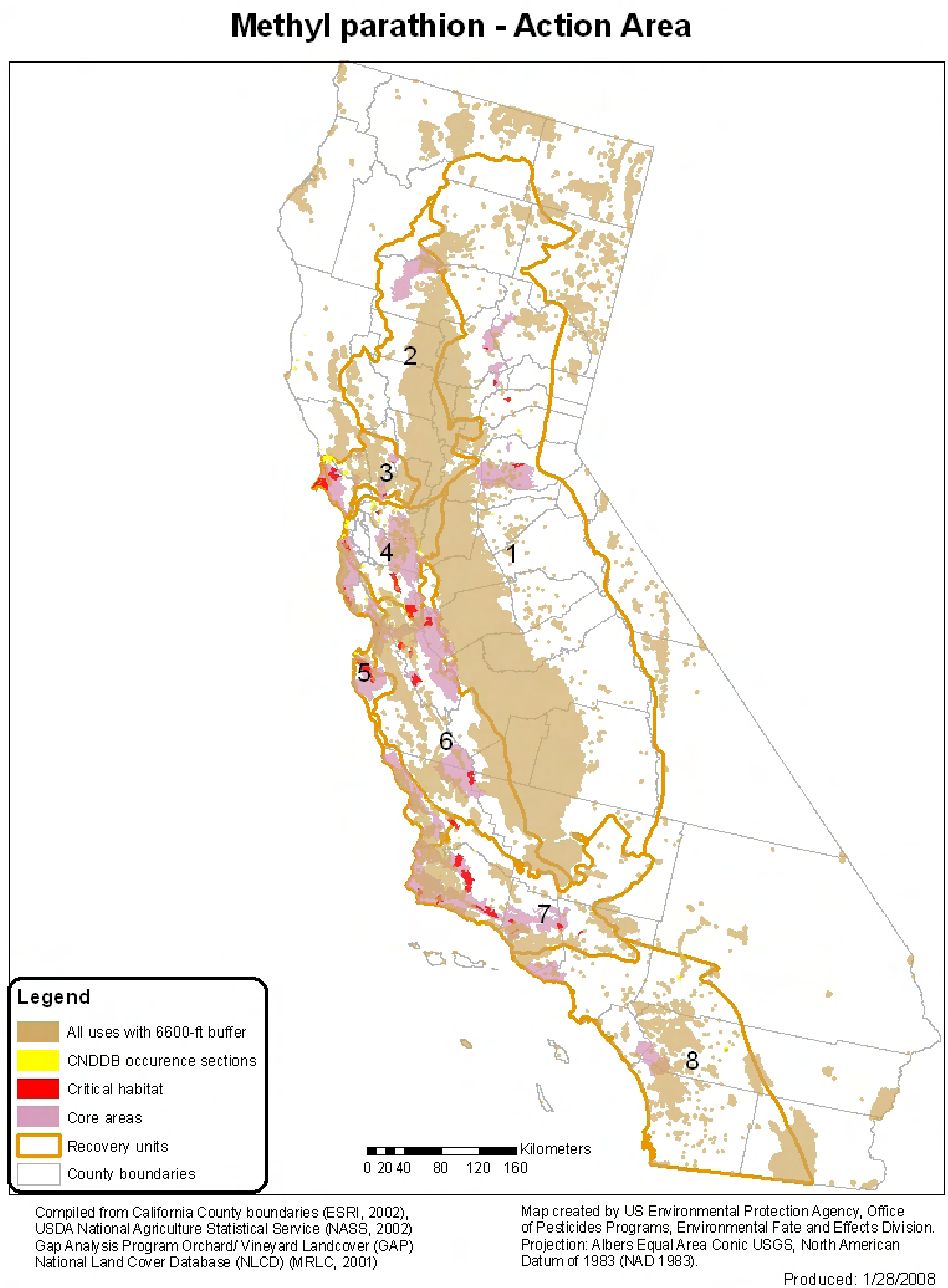
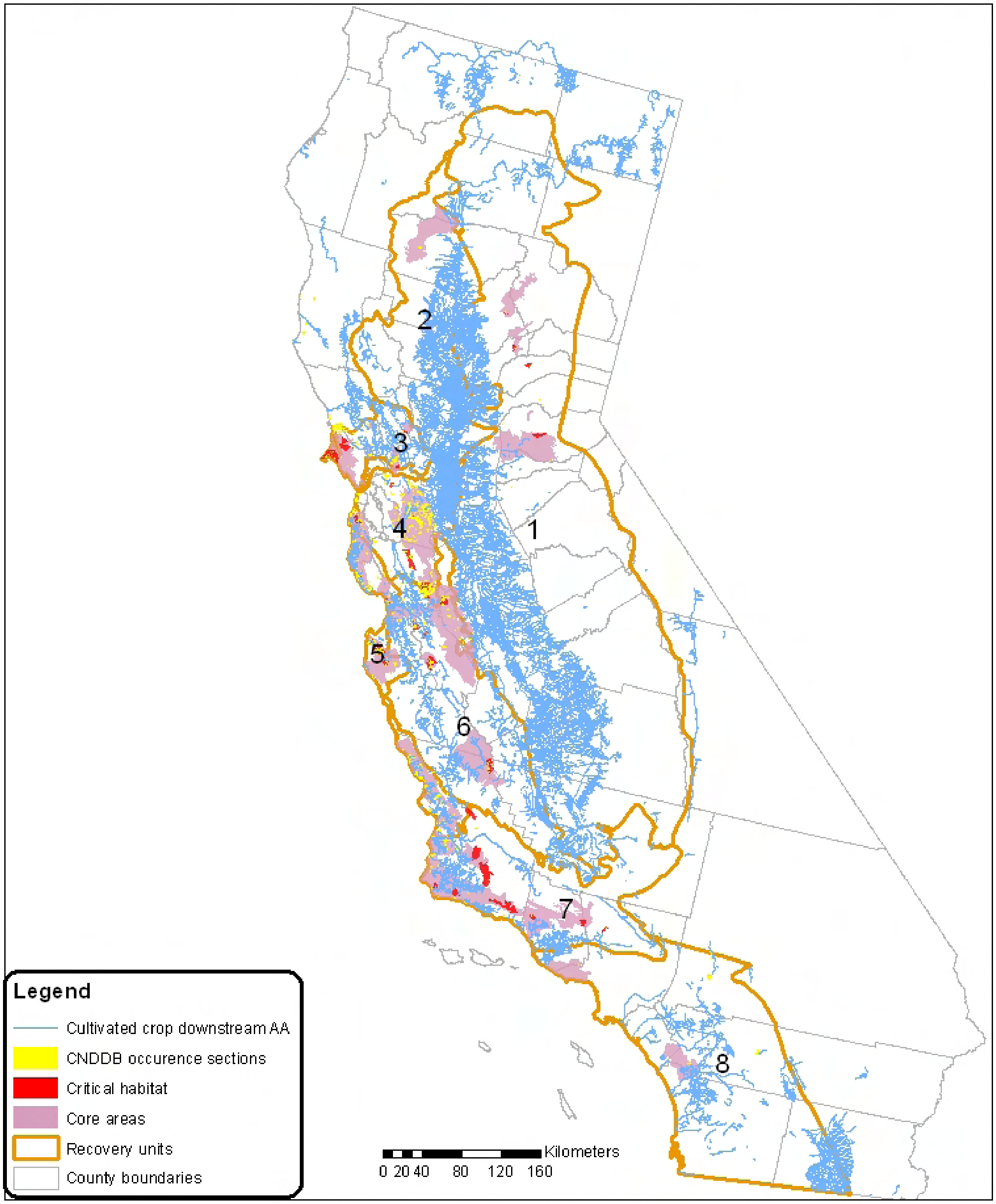


Figure 7 Combined Land Use Categories plus Spray Drift Buffer in Relation to CRLF Locations

Methyl parathion - Cultivated Crop Downstream Action Area



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

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

Produced: 1/28/2008

Figure 8 Extent of Potential Downstream Effects Based on Agricultural Uses

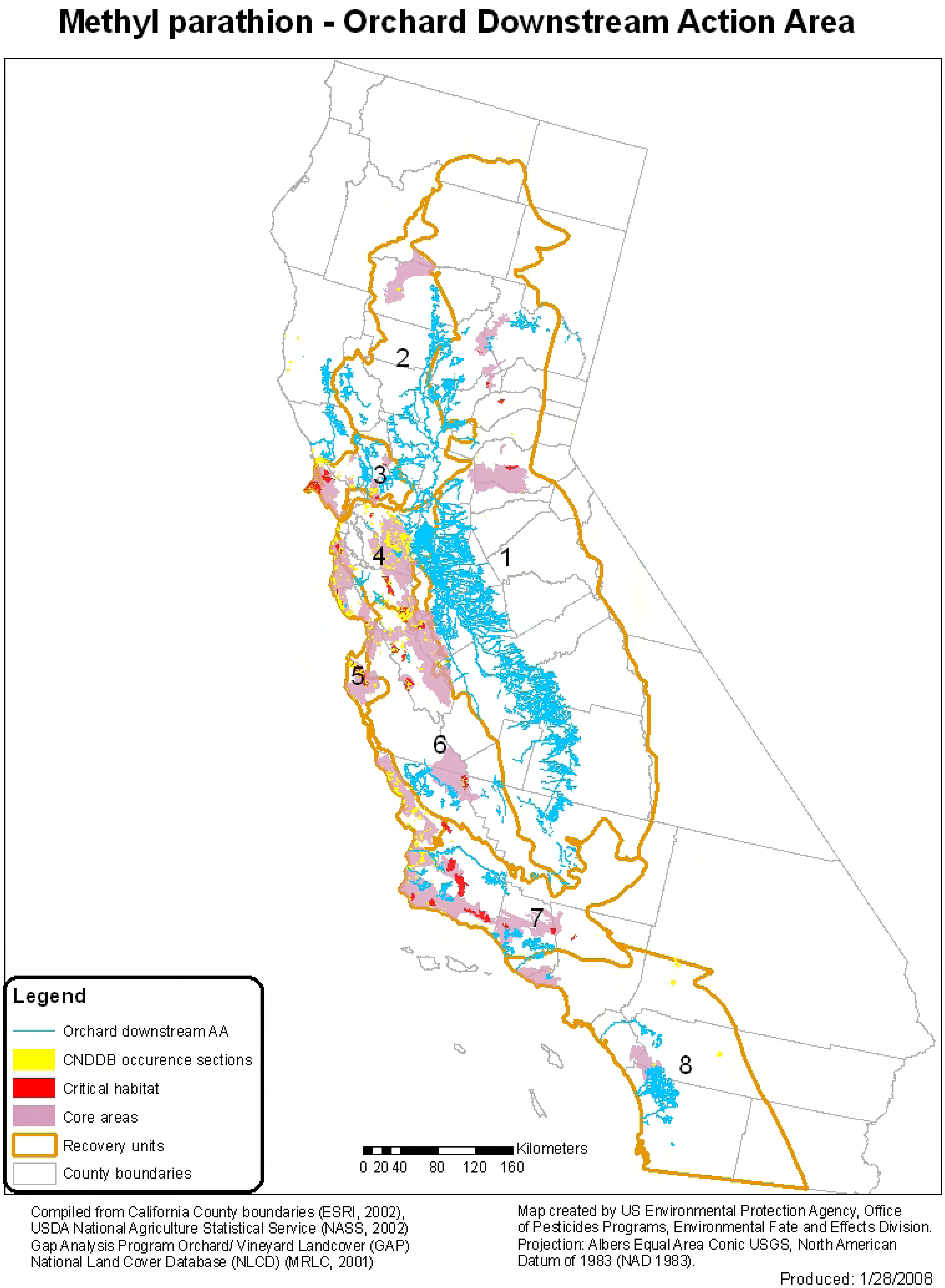


Figure 9 Extent of Potential Downstream Effects Based on Orchard Uses

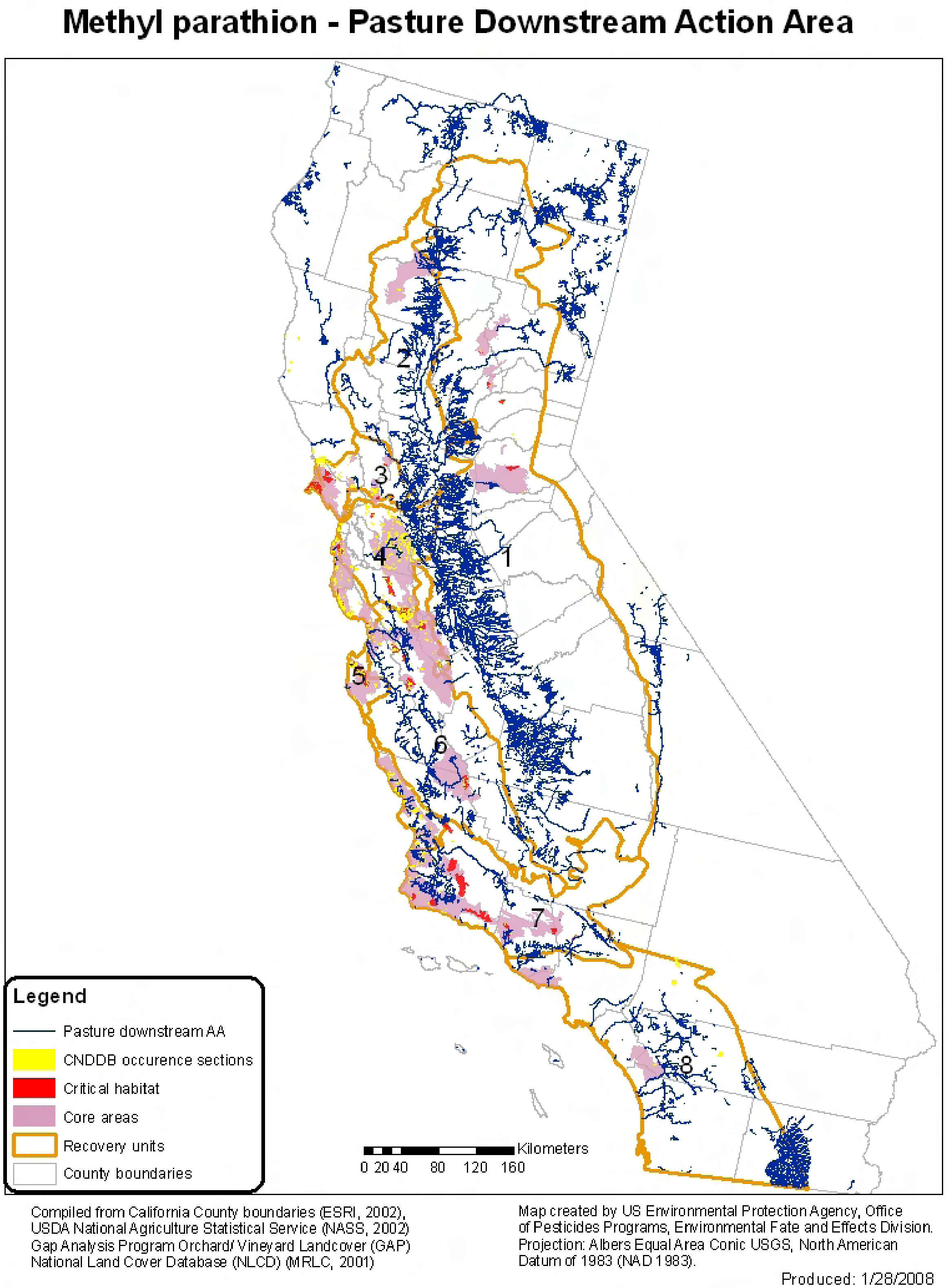


Figure 10 Extent of Downstream Effects Based on Rangeland Uses

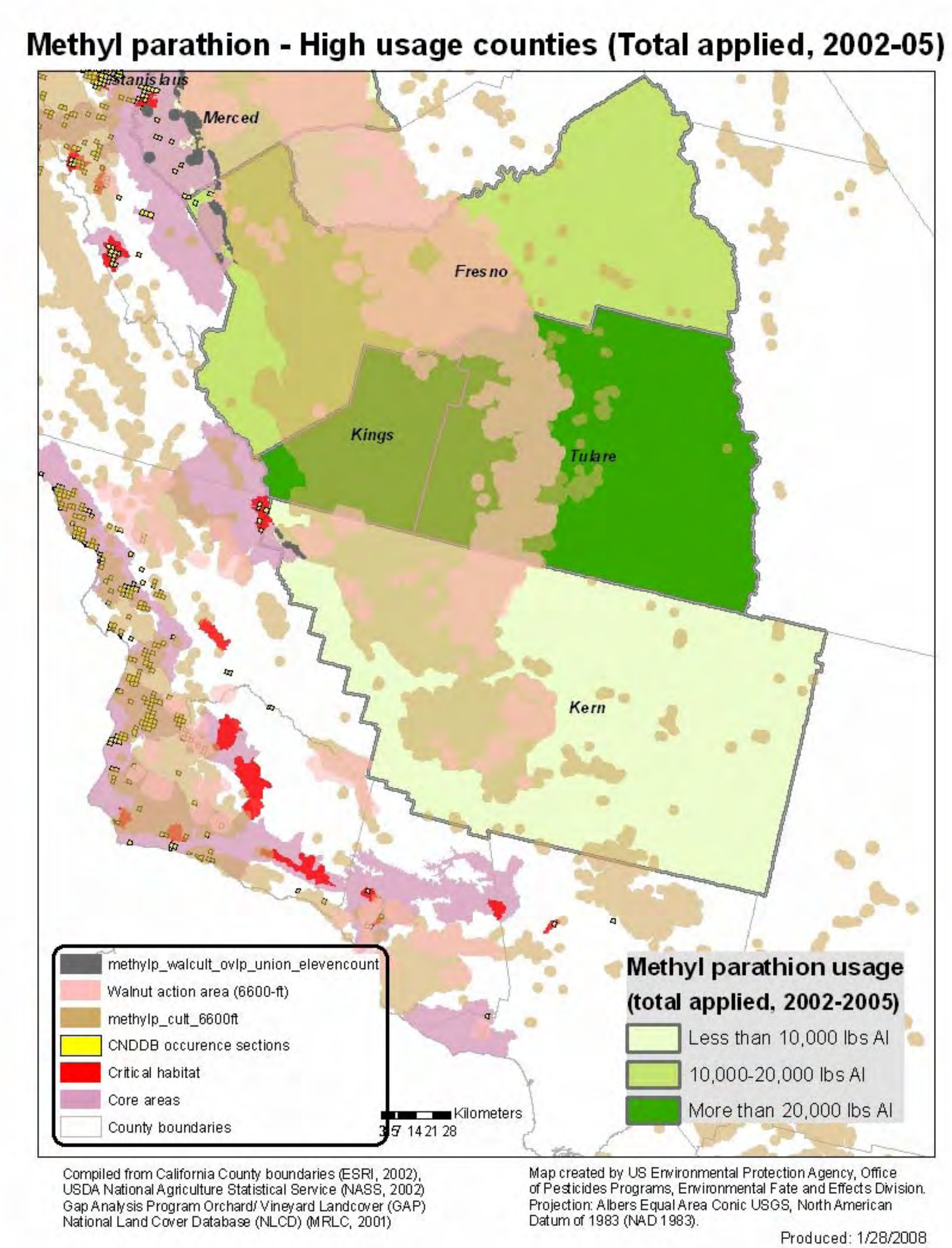


Figure 11 High Usage Counties (CA DPR PUR) in Relation to CRLF Locations (Fresno, Kings, Kern, and Tulare Counties)

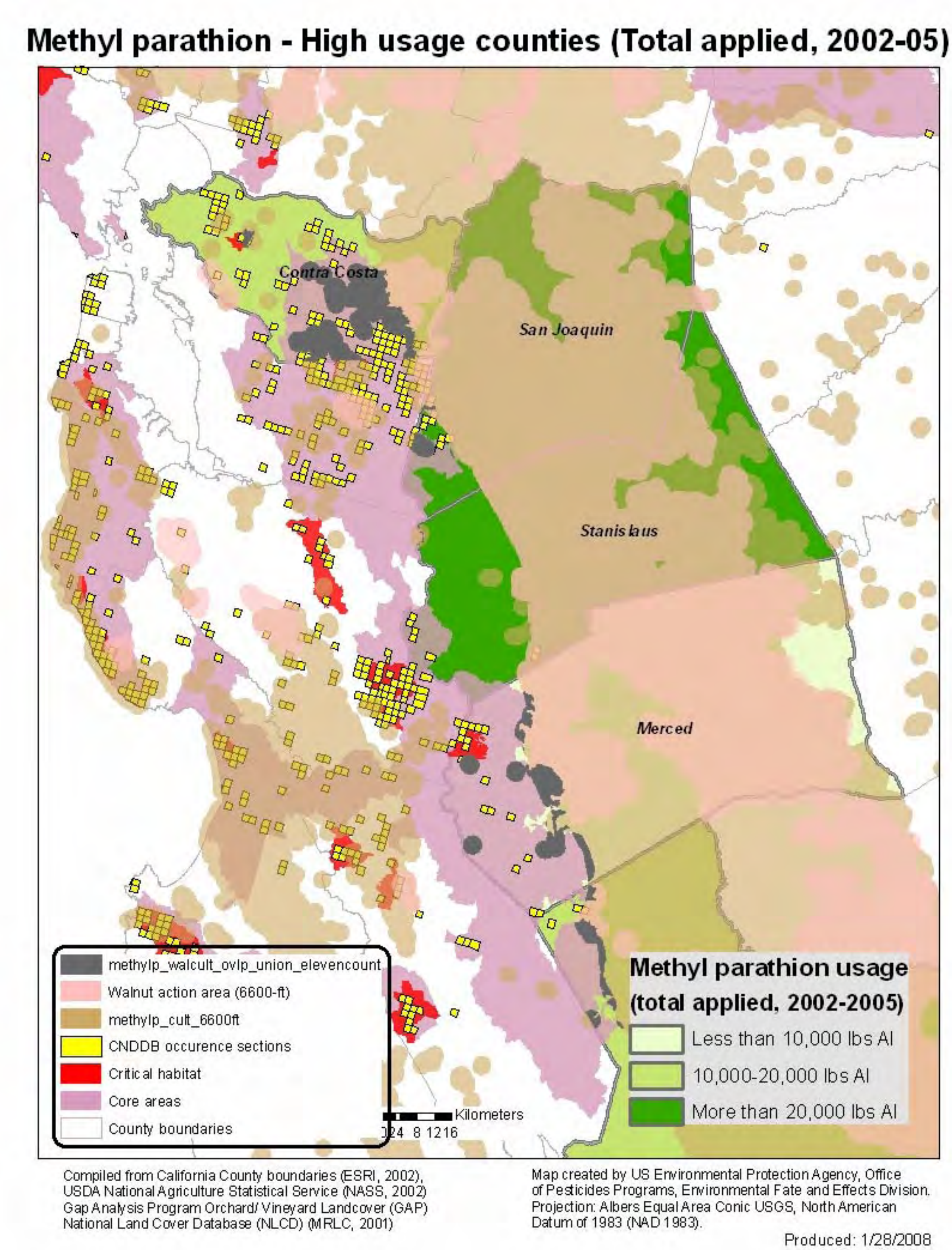


Figure 12 High Usage Counties (CA DPR PUR) in Relation to CRLF Locations (Merced, San Joaquin, and Stanislaus Counties)

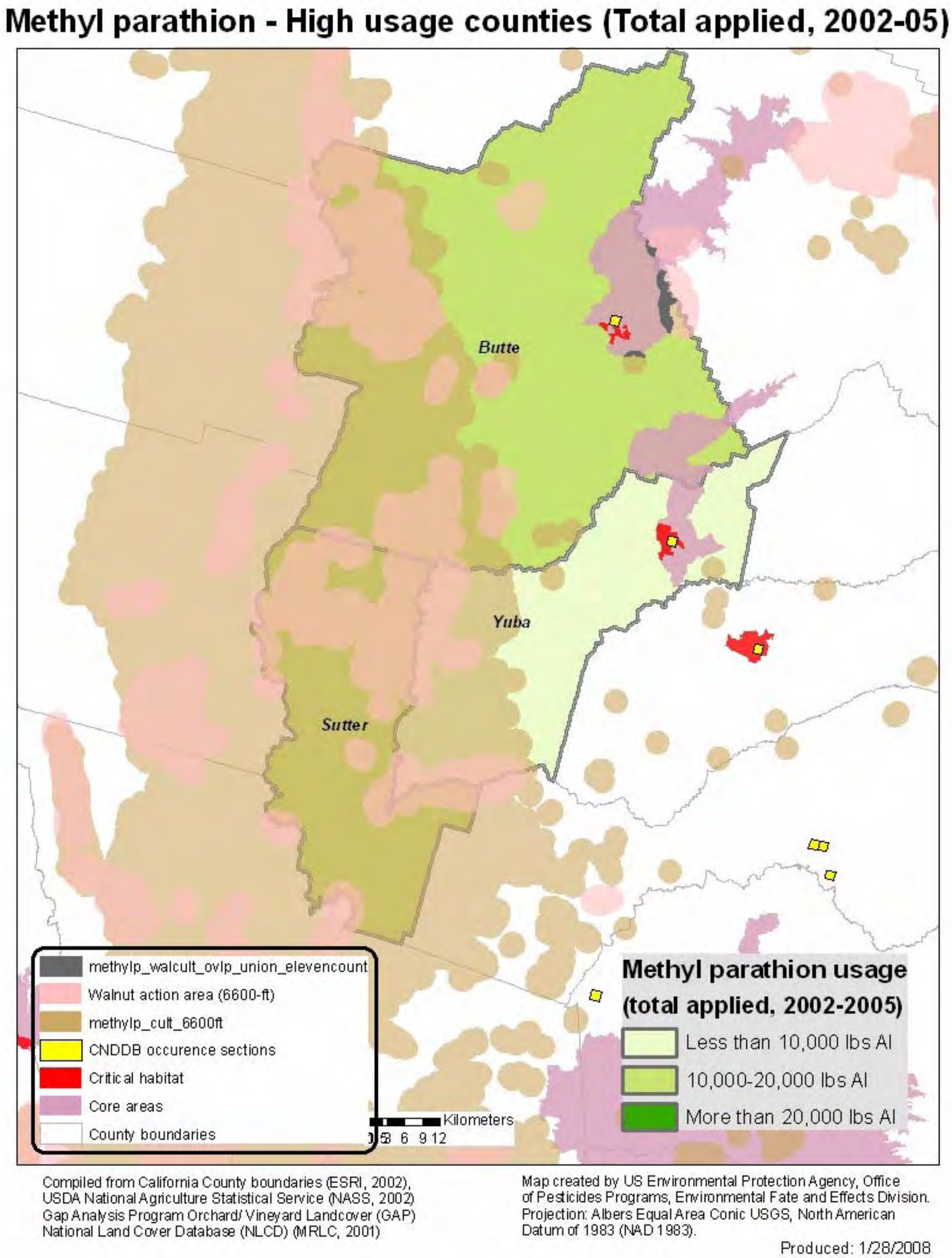


Figure 13 High Usage Counties (CA DPR PUR) in Relation to CRLF Locations (Butte, Sutter, and Yuba Counties)

2.7 Assessment Endpoints and Measures of Ecological Effect

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected."[8] 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 methyl parathion (*e.g.,* runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to methyl parathion *(e.g.,* direct contact, *etc.).*

2.7.1. Assessment Endpoints for the CRLF

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

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in Section 4 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to methyl parathion is provided in Table 4.

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

Table 4 Assessment Endpoints and Measures of Ecological Effects

Assessment Endpoint	Measures of Ecological Effects[9]
Aquatic-Phase CRLF (Eggs, larvae, tadpoles, juveniles, and adults)[a]	
Direct Effects	
1. Survival, growth, and reproduction of CRLF via direct effects on aquatic phase individuals	1a. Cutthroat trout acute LC_{50} 1b. Rainbow trout chronic NOAEC
Indirect Effects and Critical Habitat Effects	
2. Survival, growth, and reproduction of CRLF individuals via indirect effects on aquatic prey food supply (*i.e.,* fish, freshwater invertebrates, non-vascular plants)	2a. Cutthroat trout acute LC_{50} 2b. Rainbow trout chronic NOAEC 2c. Water flea acute EC_{50} 2d. Water flea chronic NOAEC. 2e. Non-vascular plant (freshwater algae) acute EC_{50}
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.,* aquatic plant community)	3a. Non-vascular plant acute EC_{50} (freshwater algae) [c]
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation	Appropriate data not available. Effects to plants not anticipated based on mode of action.
Terrestrial-Phase CRLF (Juveniles and adults)	
Direct Effects	
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Bobwhite quail acute oral LD_{50} 5b. Bobwhite quail chronic NOAEC
Indirect Effects and Critical Habitat Effects	
6. Survival, growth, and reproduction of CRLF individuals via effects on terrestrial prey (*i.e.,* terrestrial invertebrates, small mammals , and frogs)	6a. Honey bee acute contact LD_{50} 6b. Rat acute oral LD_{50} 6b. Rat chronic NOAEC 6b. Bobwhite quail acute oral LD_{50} 6b. Bobwhite quail dietary LC_{50} 6b. Bobwhite quail chronic NOAEC
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.,* riparian and upland vegetation)	Appropriate data not available. Effects to plants not anticipated based on mode of action.

[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 than exposure pathways on land.
[b] Birds are used as surrogates for terrestrial-phase amphibians.
[c].Vascular aquatic plant data not available for methyl parathion, thus data for non-vascular aquatic plants were used to assess all potential effects on aquatic plants.

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

Measures of effect and assessment endpoints defined for indirect effects also apply to critical habitat. Assessment endpoints used for the analysis of designated critical habitat are based on the modification standard established by USFWS (2006).

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

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

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.

2.8 Conceptual Model

2.8.1 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 methyl parathion to the environment. The following risk hypotheses are presumed for this endangered species assessment:

- Labeled uses of methyl parathion within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- Labeled uses of methyl parathion within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;
- Labeled uses of methyl parathion within the action area may indirectly affect the CRLF and/or modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the current range of the species and designated critical habitat, thus affecting primary productivity and/or cover;
- Labeled uses of methyl parathion within the action area may indirectly affect the CRLF and/or modify designated critical habitat by reducing or changing the composition

of the terrestrial plant community (*i.e.*, riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;

- Labeled uses of methyl parathion within the action area may modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- Labeled uses of methyl parathion within the action area may modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- Labeled uses of methyl parathion within the action area may modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- Labeled uses of methyl parathion within the action area may modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.
- Labeled uses of methyl parathion within the action area may modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

2.8.2 Diagrams

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor (*i.e.*, methyl parathion), release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial phases of the CRLF are shown in Figure 14 and Figure 15 and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in Figure 16 and Figure 17.

Exposure routes shown in dashed lines (Figures 14 and 16 only) are not expected to be significant. Groundwater is not considered quantitatively as an exposure route because only 1 (0.00737 µg/L) of 509 filtered groundwater samples had a methyl parathion concentration above its respective detection limits (detection limits varied from 0.006 to 0.04 µg/L) and 0 of 246 filtered groundwater samples had a methyl paraoxon concentration above their respective detection limits (detection limits varied from 0.019 to 0.0299 µg/L). Ingestion of aquatic animals and plants is not considered quantitatively as an exposure route because methyl parathion shows little potential to bioaccumulate therefore; exposure to residues through either plant or animal food was not considered further.

The conceptual model for *direct* effects to the aquatic phase of the CRLF's life cycle from methyl parathion uses is shown in Figure 14. Groundwater transport is considered quantitatively through PRZM model, but is considered to be a relatively minor source due to the non-persistence of methyl parathion, even when its mobility in soil is considered.

The operative routes of exposure will be spray drift at the time of application, run-off due to precipitation within a few days of application, and long-range atmospheric transport.

The conceptual model for *indirect* effects to the aquatic phase of the CRLF's critical habitat from methyl parathion uses is depicted in Figure 15. For the same reasons identified for direct effects, indirect effects are considered likely through depletion of forage items and suitable cover.

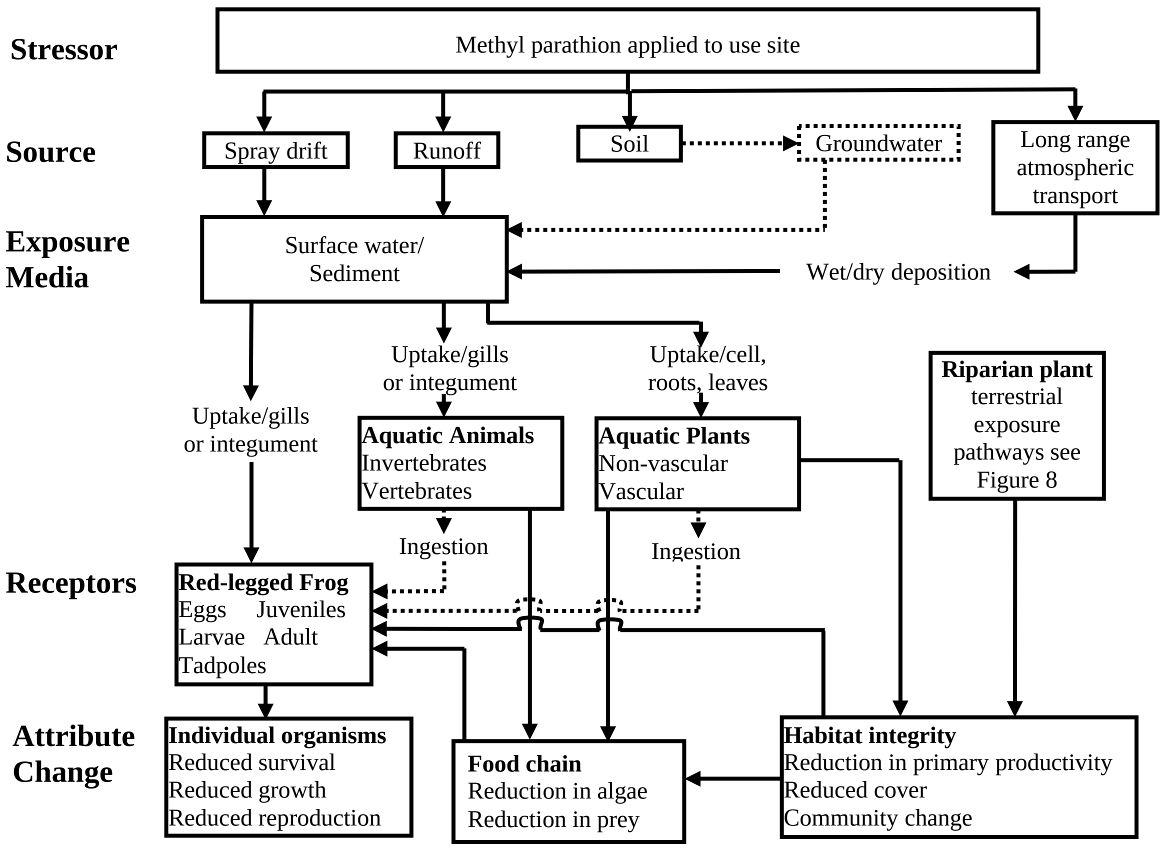


Figure 14 Conceptual Model: Direct Effects to Aquatic Phase of the California Red-Legged Frog

Compartments and pathways in dashed lines are considered possible but not of sufficient significance to warrant quantification in the assessment.

The conceptual model for *direct* effects to the terrestrial phase of the CRLF's life cycle from methyl parathion uses is shown in Figure 15. Again, the operative routes of exposure will be through direct application and spray drift at the time of application.

The conceptual model for *indirect* effects to the terrestrial phase of the CRLF's critical habitat from methyl parathion uses is depicted in Figure 16. Indirect effects are primarily driven by the depletion of forage items and suitable cover.

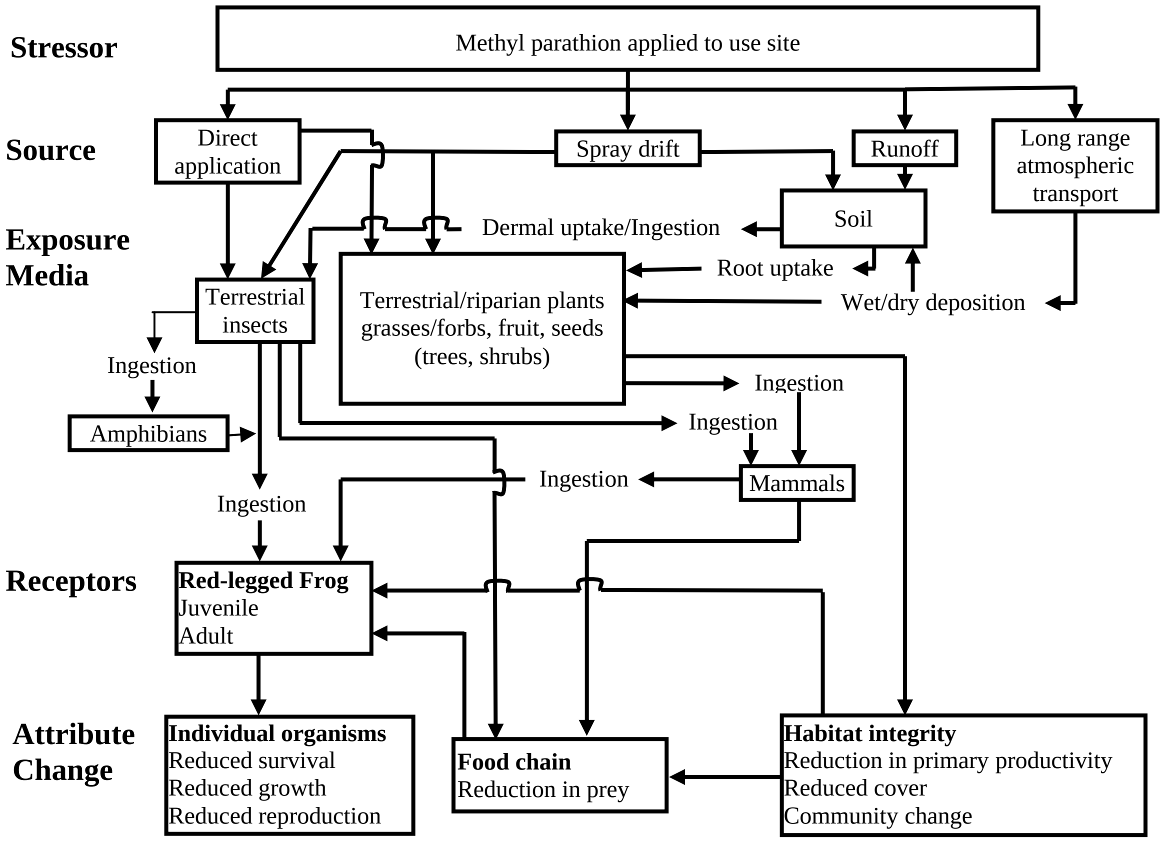


Figure 15 Conceptual Model: Direct Effects to the Terrestrial Phase of the California Red-legged Frog

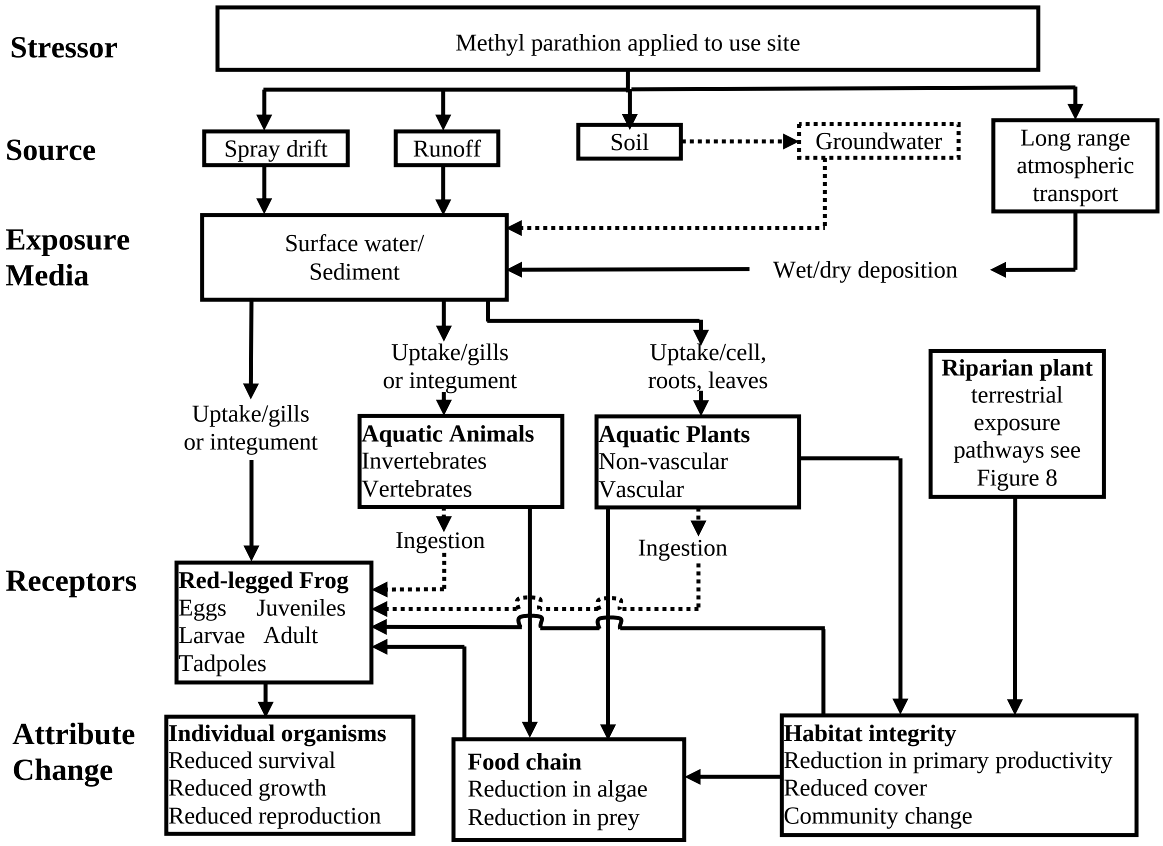


Figure 16 Conceptual model: aquatic component of CRLF critical habitat
Compartments and pathways in dashed lines are considered possible but not of sufficient significance to warrant quantification in the assessment.

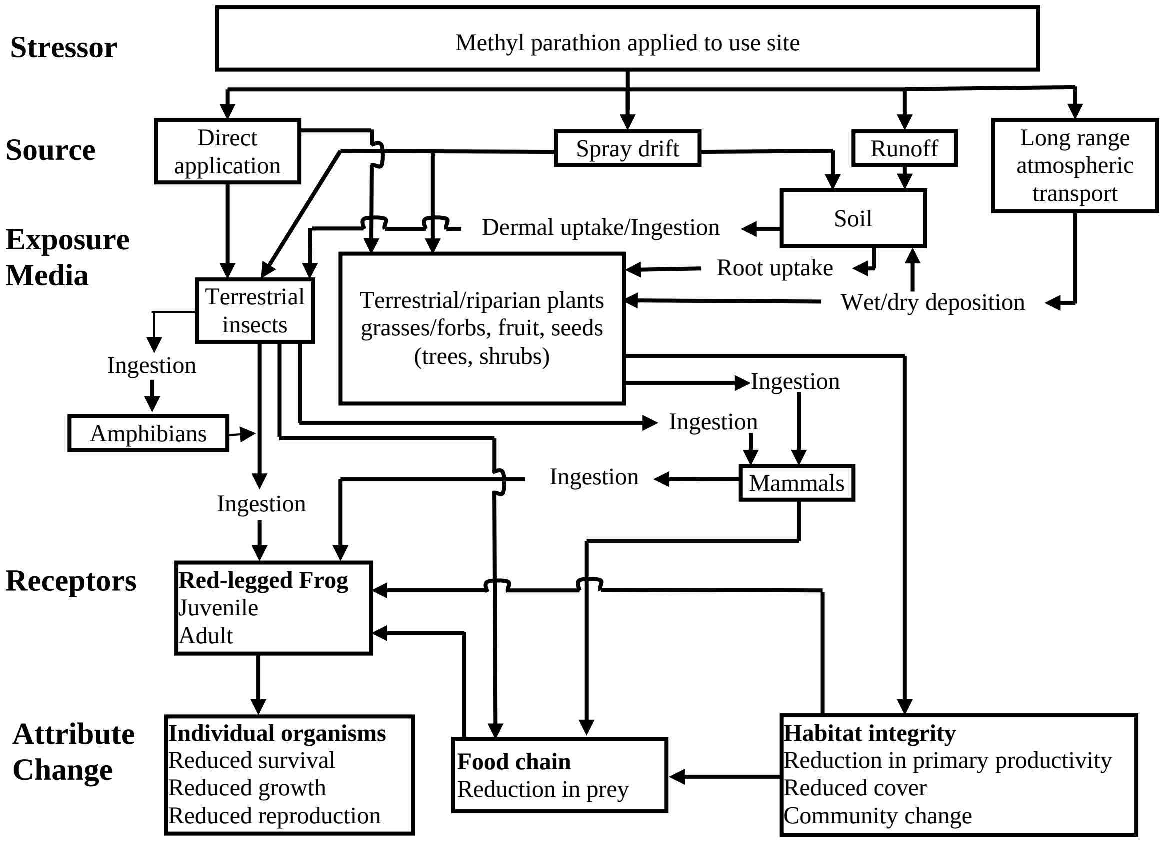


Figure 17. Conceptual model: terrestrial component of CRLF critical habitat.

2.9 Analysis Plan

The exposure and effects analysis is conducted in accordance with standard methods described in the Overview document (U.S. EPA 2004). Refinements specific to this assessment include the use of an amphibian/reptile-specific terrestrial exposure model (T-HERPS), evaluation of potential effects on terrestrial invertebrates using honey bees as the surrogate, the use of AgDrift to estimate clearance distances for both plants and animals, and the use of partitioning-based estimates to consider atmospheric inputs into water bodies. All refinements have been approved within EFED and are described in the appropriate section.

Crops for which methyl parathion is currently registered can be spatially represented by three land use classes: orchards (walnuts), pasture (grass for forage, pasture and hay), and agricultural land (all other crops). EECs and RQs are presented for each of these land uses in their respective tables, and for agricultural land, values are presented for crops with the highest (cotton) and lowest (onion) application rates. EECs presented in the body of the document are based on multiple applications at the maximum rate in the shortest interval.

3.0 Exposure Assessment

3.1 Label Application Rates and Intervals

Based on the existing labels, a number of crop groups were modeled for this assessment. These crop groups included alfalfa, cereals, corn, cotton, grass, legumes, potatoes, rice, root and tuber vegetables, seeds, and walnuts. A total of 3 land use groupings were identified: agricultural, rangeland and orchard. While the agricultural land use grouping includes many different uses, this assessment modeled those uses that represent the highest and lowest application rates among the agricultural uses. Thus, cotton and onions serve as surrogates for modeling the highest and lowest agricultural land cover uses, respectively. For rangeland and orchard land uses, only the maximum application rate is assessed; hay and walnuts serve as the surrogate crops within each of the two land use categories. Land uses and representative crops along with their respective use information are presented in Table 5.

Use of methyl parathion on rice was not considered fully in the assessment of agricultural crop uses. Because rice is a direct application to water, it will produce estimated environmental concentrations (EECs) and, therefore, aquatic risks to the CRLF that are much higher than other uses (Appendix E lists the rice EECs and Risk quotients). However, according to the California Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database methyl parathion use on rice totaled 132 lbs. in the years 2000 through 2005, which is <0.03% of the total methyl parathion applied over this time period in California (444,819 lbs). Therefore, efforts were focused on the other agricultural crop uses in California. Because other methyl parathion uses in California produce sufficient aquatic risks to the CRLF that result in a finding of "likely to adversely affect", the omission of rice does not materially affect this finding (a fuller consideration of rice would only have provided additional support for that determination).

For each of these groups, both a single application and the maximum number of multiple applications were modeled. Detailed label information, modeling parameters (*e.g.*, application rates, application intervals, and maximum number of applications, selection of application dates) and results from all modeling runs are included in Appendix E. The highest application rate for each crop and the corresponding maximum number of applications and minimum intervals were used for modeling. In cases where one label did not specify the number of applications or interval, assumptions were made based on information contained in other labels. In the many cases, a specific application interval was not provided, and EFED conservatively assumed 5 days as the application interval.

Table 5 shows modeling parameters and scenarios used for the two crops used as bounding estimates for the agricultural land, and the crops used for rangeland and orchard uses.

Table 5 Application Rates for Modeling

Crop Group Modeled (Scenario)	Surrogate For	Max Rate Lb a.i/A	Max # of Apps/year	Interval	Label
Agricultural Land Use					
Cotton (CA cotton RLF)	Cotton (Highest Agricultural Rate)	3	5	Not specified (Assume 5 days)	67760-43 5905-533
Root &Tuber Vegetables (CA Onion STD)	Onions (Lowest Agricultural Rate)	0.5	6 [a]	Not specified (Assume 5 days	5905-533
Rangeland Use					
Grass (CA range/hay RLF)	Hay Pasture Forage	0.75	6	Not specified (Assume 5 days)	5905-533
Orchard Land Use					
Tree Nuts (CA almonds RLF)	Walnuts	2	4	21 days	4581-533 (SLN)

[a] Rates in label given as per season, and were converted to a yearly rate based on crop cycle information developed by BEAD (Kaul 2007).

3.2 Aquatic Exposure Modeling

Typically, the Agency conducts modeling using scenarios intended to represent use sites in areas that are highly vulnerable to either runoff, erosion, or spray drift. Runoff estimates predicted by the Pesticide Root Zone Model (PRZM) are linked to the Exposure Analysis Modeling System (EXAMS). For ecological risk assessment, the Agency relies on a standard water body to receive the edge-of-field runoff estimates. The standard water body is of fixed geometry and includes the processes of degradation and sorption expected to occur in ponds, canals, and low-order streams (*e.g.* first and second order streams). The water body is static (no outflow). The CLRF inhabits a range of water bodies, but generally prefers perennial or near perennial waters in order to complete its lifecycle (Jennings *et al.*, 1997). Generally it inhabits watersheds and drainages of 4th order or lower streams (Hayes and Jennings 1998).

Environmental fate input parameters for methyl parathion were obtained from the methyl parathion RED, and registrant-submitted environmental fate studies. Methyl paraoxon concentrations were estimated as 2.1% of the methyl parathion concentrations based on anaerobic aquatic metabolism studies conducted under laboratory conditions. As a initial conservative EEC estimate for 4-nitrophenol (which is several orders of magnitude less toxic than either the parent methyl parathion or the methyl paraoxon degradate), EECs of the degradate were assumed to be equivalent to the parent.

Table 6 Input Parameters for Methyl Parathion PRZM Modeling

Parameter	Value	Comments	Source
Molecular Weight (grams/mole)	265	None	RED
Solubility (mg/L)	60	None	RED
Vapor Pressure (torr)			
Henry's Constant (atm m^3/mol)	6.12E-7	None	RED
K_{oc} (L/kg)	486	None	MRID 40999001
Aerobic Soil Metabolism Half-life (days)	11.25	3 X 3.75 [a]	MRID 41735901
Aerobic Aquatic Metabolism Half-life (days)	12.3	3 X 4.1 [a]	MRID 00103361 MRID 00128789 MRID 42069601
Anaerobic Aquatic Metabolism Half-life (days)	33.3	3 X 11.1 [a]	MRID 46997601
Photodegradation in Water (hours)	49	None	MRID 40809701
Hydrolysis Half-life (days)	40 at pH7	None	MRID 0013275 MRID 40784501
Spray Drift Fraction	1% 5%	Ground Aerial	Default value

[a] single measured half-life multiplied by 3 in accordance with PRZM/EXAMS input parameter guidance.

Peak 1-in-10 year EECs for methyl parathion ranged from 4.2 μg/L to 66.8 μg/L. The 21-day average EECs ranged from 2.9 μg/L to 42.2 μg/L, and the 60-day average EECs ranged from 2.0 μg/L to 25.7 μg/L

Table 7 Methyl Parathion EECs in the Standard EXAMS Water Body

Crop (lb a.i/A)	Application Timing (month/day - month/day)	Application Technique[a]	1 in 10 year EEC (μg/L)		
			Peak	21 day average	60 day Average
Agricultural Land Use					
Cotton[b] (3.0)	6/17 – 7/6	Ground	23.6	13.4	7.3
	9/12 – 10/1	Aerial	66.8	42.2	25.7
Onions[c] (0.5)	5/27 – 6/21	Ground	6.5	4.4	2.3
	9/24 – 10/19	Aerial	15.3	11.5	7.7
Rangeland Use					
Grass (0.75)	1/25 – 2/19	Ground	30.4	21.3	12.5
	4/22 – 5/17	Aerial	9.4	7.2	4.6
Orchard Land Use					
Walnuts (2.0)	5/27 – 7/29	Ground	4.2	2.9	2.0
	6/21 – 8/23	Aerial	9.5	5.8	4.8

[a] Both aerial and ground applications were modeled. Aerial applications typically result in higher aquatic EECs (due to greater spray drift), thus the aerial EECs are used as bounding estimates for each crop group in those cases. For grass, differences in application dates (and thus rainfall) resulted in higher EECs for ground application, and these higher EECs were used to calculate risk quotients.
[b] Used as the "highest" bounding estimate for developing risk quotients
[c] Used as the "lowest" bounding estimate for developing risk quotients. Although some estimates for ground applications are lower, the application rate is a function of the crop, not the application method, thus it is more conservative to use the aerial EECs.

Concentrations of methyl paraoxon were estimated based on a formation rate of 2.1% of total applied. Peak 1-in-10 year EECs for methyl paraoxon ranged from 0.09 μg/L to 1.40 μg/L. The 21-day average EECs ranged from 0.06 μg/L to 0.89 μg/L, and the 60-day average EECs ranged from 0.04 μg/L to 0.54 μg/L.

Table 8 Methyl Paraoxon EECs in the Standard EXAMS Water Body

Crop (lb ai/A)	Application Timing (month/day – month/day)	Application Technique[a]	1 in 10 year EEC (μg/L)		
			Peak	21 day average	60 day Average
Agricultural Land Use					
Cotton[b]	6/17 – 7/6	Ground	0.50	0.28	0.15
	9/12 – 10/1	Aerial	1.40	0.89	0.54
Onions[c]	5/27 – 6/21	Ground	0.14	0.09	0.05
	9/24 – 10/19	Aerial	0.32	0.24	0.16
Rangeland Use					
Grass	1/25 – 2/19	Ground	0.64	0.45	0.26
	4/22 – 5/17	Aerial	0.20	0.15	0.10
Orchard Land Use					
Walnuts	5/27 – 7/29	Ground	0.09	0.06	0.04
	6/21 – 8/23	Aerial	0.20	0.12	0.10

[a] Both aerial and ground applications were modeled. Aerial applications typically result in higher aquatic EECs (due to greater spray drift), thus the aerial EECs are used as bounding estimates for each crop group in those cases. For grass, differences in application dates (and thus rainfall) resulted in higher EECs for ground application, and these higher EECs were used to calculate risk quotients.
[b] Used as the “highest” bounding estimate for developing risk quotients
[c] Used as the “lowest” bounding estimate for developing risk quotients. Although some estimates for ground applications are lower, the application rate is a function of the crop, not the application method, thus it is more conservative to use the aerial EECs.

3.3 Monitoring Data

Available surface water, ground water, air monitoring, and rainwater data were evaluated and are summarized below. All of the data summarized in this section were collected in California with the exception of some of the rainwater data as noted below. Surface and ground water data were not targeted for monitoring spatial and/or temporal input from agricultural sites; in other words, the data may not have been collected in close proximity to when and/or where methyl parathion was applied.

3.3.1 Surface Water Monitoring Data

An evaluation of the surface water monitoring data was conducted to assess the occurrence of methyl parathion, methyl paraoxon, and 4-nitrophenol in California surface waters. Surface water data were obtained from the California Department of Pesticide Regulation (CaDPR) (http://www.cdpr.ca.gov/docs/sw/surfdata.htm) and USGS NAWQA data warehouse (http://water.usgs.gov/nawqa/data). The CaDPR surface water data set is a compilation of data from multiple sources and may include some of the USGS California data.

3.3.1.1 Summary of Individual samples

Methyl parathion. The CaDPR data set contained monitoring data for methyl parathion from 4477 samples from 219 sites in California (collected between 2/25/1991 and 6/7/2005). Instrument detection limits varied by sample and ranged from 0.005 to 1 µg/L. The maximum concentration measured above the instrument detection limit is 0.524 µg/L. Of the 13 CaDPR surface water samples with methyl parathion concentrations measured above their respective sample's instrument detection limits, all fell below the maximum detection limit in the entire data set of 1 µg/L (75 samples have instrument detection limits that exceed the maximum above-the-detection-limit sample concentration of 0.524 µg/L). The minimum above-the-detection-limit sample concentration measured was 0.006 µg/L. Of the 4477 samples in the CaDPR data set, 4466 samples (>99% of samples) have instrument detection limits that exceed the minimum above-the-detection-limit sample concentration of 0.006 µg/L.

This variation in instrument detection limits makes it difficult to conclude much about the distribution of methyl parathion in surface waters from the CaDPR data set. Considering only the 75 samples with detection limits of 1 µg/L, the potential exists that 75 samples have almost twice the maximum observed above-the-detection-limit concentration in this data set or that 75 samples have virtually no methyl parathion. Assuming the highest, lowest, or some mid-range values for these samples can greatly bias interpretations based on the data set. Therefore, it is important to appreciate the uncertainty caused by variation in detection limits when interpreting such data, especially in data sets that are compilations from different data sources with very different instrument detection limits.

The USGS surface water data set contained monitoring data for 5 sample types of methyl parathion, 2 sample types of methyl paraoxon, and 3 sample types of 4-nitrophenol. The methyl parathion sample types are filtered surface water samples (158 samples from 82 sites in California – USGS sampling dates not readily available), unfiltered surface water samples (8 samples from 7 sites in California), solids recoverable (none from California), suspended sediment data (none from California), and bed sediment (none from California). Of the 2 USGS methyl parathion sample types that had data from California, only in filtered surface water samples was methyl parathion detected above the instrument detection limits which ranged from 0.005 to 0.3 µg/L. Six of the 7 above-detection-limit filtered surface results are below the maximum detection limit (0.3 µg/L). Again, the variation in instrument detection limits makes it difficult to interpret the USGS filtered surface water data set. All 8 of the USGS *unfiltered* methyl parathion surface water samples were below detection limits (instrument detection limits ranged from 0.015 – 0.06 µg/L).

The highest methyl parathion surface water sample concentration was the same for both the CaDPR and USGS data sets (0.524 µg/L). It appears likely that this is the same sample and is a USGS sample that was compiled into the CaDPR data set. The CaDPR data set records this sample as being from "Orestimba Creek at River Road (trib. to SJR)" in Stanislaus County, CA, collected on 6/26/2002. The USGS data set describes this sample as being from "Orestimba Cr At River Rd Nr Crows Landing Ca" at USGS site number 11274538 in Stanislaus County, CA.

Methyl paraoxon. The CaDPR data set contained monitoring data from 202 samples from 17 sites in California (collected between 3/15/1993 and 8/8/1995) for methyl paraoxon. There were no samples measured above the instrument detection limits in the CaDPR methyl paraoxon data set. The instrument detection limit for all CaDPR methyl paraoxon samples was 0.05 µg/L.

The only USGS methyl paraoxon sample type is filtered surface water (21 samples from 18 sites in California). All of the filtered methyl paraoxon surface water sample concentrations fell below the instrument detection limits, which ranged from 0.019 to 0.0299 µg/L.

4-nitrophenol. Only the USGS data set contained monitoring data for 4-nitrophenol. Of the 3 types of surface water samples collected (filtered water, unfiltered water, and suspended sediment), no samples were collected in the state of California.

3.3.1.2 Summary by Sites

Because concentrations are expected to vary greatly over time at each site, concentration data were summarized (Figure 18) for methyl parathion only from the CaDPR and USGS (filtered surface water) data sets based on the maximum concentration occurring at each site. Again, the highest methyl parathion surface water site concentration is likely the same for both the CaDPR and USGS data sets (0.524 µg/L) because this USGS sample was likely also compiled into the CaDPR data set. A similar analysis of methyl parathion degradation products and other types of methyl parathion surface water samples (unfiltered, suspended solids, etc.) was not conducted because there were limited data on the methyl parathion degradation products and other methyl parathion surface water sample types.

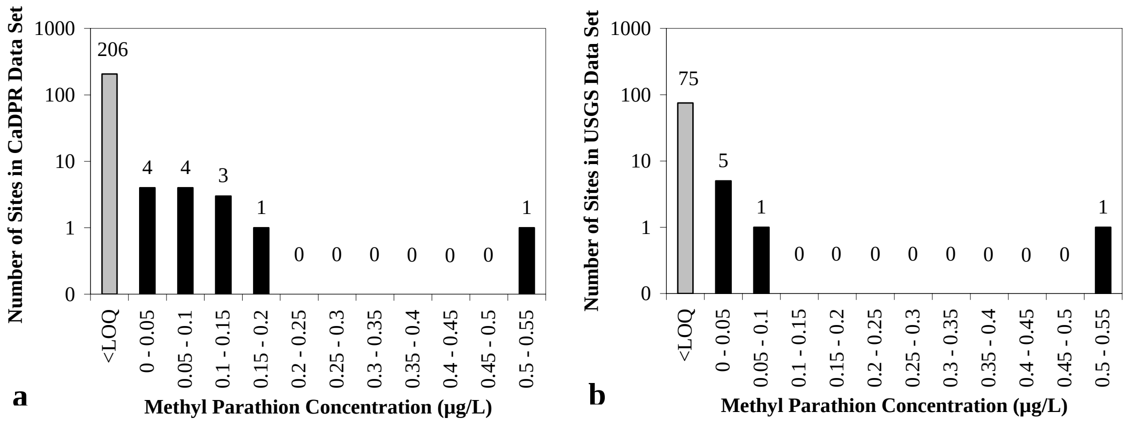


Figure 18 Frequency distribution of maximum surface water methyl parathion concentrations for each site sampled in the CaDPR (a) and USGS (b) data sets.

Risk quotients (RQs) were calculated for aquatic effects of methyl parathion for the highest observed non-targeted methyl parathion concentration (Table 9). This analysis shows that methyl parathion has been observed in surface water at concentrations that exceed levels of concern for acute and chronic risks to freshwater aquatic invertebrates.

Table 9. Aquatic risk quotients (RQs) based the highest observed non-targeted methyl parathion concentration in surface water.

Surface water Concentration (µg/L)	Acute Frog 1850 µg/L	Chronic Frog 10 µg/L	Acute Invertebrate 0.97 µg/L	Chronic Invertebrate 0.25 µg/L	Aquatic Plants 2900 µg/L
0.524	<0.01	0.05	**0.54**	**2.10**	<0.01

It is difficult to directly compare non-targeted surface water monitoring data to the PRZM/EXAMS EECs generated for this assessment because the surface water sites in the CaDPR and USGS data sets are likely to be dissimilar to the surface water site modeled in PRZM/EXAMS. The CaDPR and USGS data sets are likely to be representative of ditches, streams, and rivers (flow-through systems) farther downstream from any agricultural sites treated with methyl parathion, while the PRZM/EXAMS pond (no through-flow) is situated directly downstream and downwind of a field treated with methyl parathion at its maximum application rates and minimum reapplication intervals. Additionally, PRZM/EXAMs assumes that the entire watershed is planted in the crop and that 100% of the watershed is treated simultaneously.

The maximum measured methyl parathion concentration (0.524 µg/L) in the monitoring surface water data is one-fourth the minimum 60-day EEC (2.0 µg/L, ground application to walnuts) and less than 1/100th the maximum peak EEC (66.8 µg/L, aerial application to cotton) shown in Table 7. Because methyl parathion degrades relatively rapidly in the environment, its concentration in surface waters would be expected to be lower at the non-targeted surface water sites relative to the EECs in water bodies directly receiving runoff from the application site. Therefore at this gross level of analysis, the concentrations in the surface water monitoring and EECs do not appear to be inconsistent.

Another relatively firm conclusion that can be drawn from the methyl parathion surface water data from California is that surface water concentrations greater than the maximum detection limit (1 µg/L) have been rare at the type of sites sampled in the CaDPR and USGS data sets. Therefore, the off-site movement of methyl parathion from its use sites must be limited enough that the types of sites monitored in the USGS and CaDPR data sets that widespread incidence of concentrations in excess of 1 µg/L have not been reported.

3.3.2 Ground Water Monitoring Data

An evaluation of the ground water monitoring data was conducted to assess the occurrence of methyl parathion, methyl paraoxon, and 4-nitrophenol in California ground waters. Ground water data were obtained from the USGS NAWQA data warehouse (http://water.usgs.gov/nawqa/data).

Methyl parathion. There are 3 kinds of sampling matrices for methyl parathion in ground water represented in the USGS data set – filtered (509 samples from 430 sites in California), suspended solids (none in California), and unfiltered (none in California). Of the 509 filtered ground water samples in the USGS data set, only one sample collected in Riverside, CA (USGS station ID 340033117204001) had a methyl parathion concentration (0.00737 µg/L) above its respective detection limit. The individual sample detection limits ranged from 0.006 to 0.04 µg/L. Because 133 samples (26%) had detection limits higher than the sole above-the-detection-limit sample, it is difficult to conclude much about the distribution of methyl parathion in ground water based on the USGS data. However based on the USGS data, it does appear that methyl parathion concentrations exceeding the maximum detection limit in this data set (0.04 µg/L) have been rare at the types of sites monitored in the USGS data set.

Methyl paraoxon. There are 2 kinds of methyl parathion in ground water samples in the USGS data set – filtered (246 samples from 226 sites in California) and suspended solids (none in California). Of the 246 filtered ground water samples in the USGS data set, none had a methyl paraoxon concentration above its respective detection limit. The individual sample detection limits ranged from 0.019 to 0.0299 µg/L. Because all sample concentrations were below their respective detection limits, it appears that methyl paraoxon concentrations exceeding the maximum detection limit in this data set (0.0299 µg/L) have been rare at the types of sites monitored in the USGS data set.

4-nitrophenol. Only unfiltered ground water samples of 4-nitrophenol occur in the USGS data set, and none of these were collected in California.

3.3.3 Long-range Transport

Two methods were used to assess potential impacts from long-range transport of methyl parathion and methyl paraoxon. The first method used air monitoring data from California to estimate aquatic EECs and effects to aquatic organisms and habitat. The second method used rainwater monitoring data from several sources to estimate aquatic and terrestrial EECs and effects to aquatic and terrestrial organisms and habitat. Both methods have considerable uncertainty associated with their estimates of potential risks.

3.3.3.1 Air Monitoring

An evaluation of air monitoring data was conducted to assess the occurrence of methyl parathion and methyl paraoxon in air (no air monitoring data for 4-nitrophenol was found). Kollman (2002) summarizes two California air monitoring studies – an ambient air quality monitoring study (monitoring air quality at public places some distance from the site of application) for both methyl parathion and methyl paraoxon and an application site monitoring study (monitoring air quality near a site of application) for methyl parathion only. The ambient study of 5 sites (4 near rice fields and 1 control site) was conducted between 5/12/1986 and 6/12/1986, a time coinciding with methyl parathion application to rice for the control of tadpole shrimp (*Triops longicaudatus*). The maximum air concentrations observed were 30.1 and 7.79 ng/m^3 for methyl parathion and methyl paraoxon, respectively. The application site monitoring study from May of 1989 monitored 6 sites around a rice field before, during, and for 72 hours after application and found a maximum air concentration of 548 ng/m^3 (methyl paraoxon was not monitored in this study).

The potential impact of methyl parathion and methyl paraoxon air concentrations on surface water quality was assessed for the standard PRZM/EXAMS water body, which has a surface area of 1 ha (10,000 m^2) and a volume of 2 x 10^7 L. This analysis attempts to estimate 1) the mass of methyl parathion and methyl paraoxon in a column of air (referred to as an “air mass”) hovering over the standard EXAMS pond; and 2) the number of air masses that need to pass over the standard EXAMS pond during a storm (depositing some fraction of each air mass’s contaminants into this pond) in order to reach the aquatic toxicity endpoints identified in the effects assessment (Section 4). If this number of air masses is low enough to reasonably pass over the EXAMS pond in a single rain event, it would indicate that there is potential for long-range transport to affect the CRLF. If the number of air masses is high, it would indicate that there is little potential for long-range transport to affect the CRLF.

To estimate the mass of methyl parathion in each air mass, it is assumed that the application site monitoring concentration extends to a vertical height of 100 m above the standard pond and ambient air monitoring concentrations apply to 900 m of the air mass (above 100 m and extending to a vertical height of 1000 m). Therefore, the mass of methyl parathion in an air mass ($M_{MPthion}$) based on the maximum ambient (30.1 ng/m^3) and application site monitoring (548 ng/m^3) data in the aforementioned studies would potentially be:

$$
\begin{aligned}
M_{MPthion} &= \left(30.1\text{ng/m}^3 \times 900\text{m} \times 10^4\,\text{m}^2 + 548\text{ng/m}^3 \times 100\text{m} \times 10^4\,\text{m}^2\right)/10^6\,\text{ng/mg} \\
&= 819\text{mg}
\end{aligned}
$$

This is an estimate of the mass of methyl parathion in a single air mass passing over the standard PRZM/EXAMS pond, which can be expressed as 819 mg/air mass.

To provide some indication whether the potential exists for atmospheric concentrations of methyl parathion to impact frog populations, the number of air masses ($Num_{AirMasses}$) required to provide enough $M_{MPthion}$ to reach the relevant ecological endpoints (*Endpt*) is calculated using the following equation assuming 100% (full), 50%, and 25% washout.

$$Num_{AirMasses} = \frac{\dfrac{Endpt(\mu\text{g/L})}{819\text{mg/air mass} \times 10^3\ \mu\text{g/mg}}}{2 \times 10^7\ \text{L}} \times WashOut$$

where: 2 x 10^7 L is the volume of the standard PRZM/EXAMS pond and *WashOut* is the proportion of the $M_{MPthion}$ deposited in the pond as the air masses pass over the pond (Table 10).

Table 10. Number of air masses needed to attain most sensitive toxicity endpoints in the aquatic toxicity profile for methyl parathion assuming different levels of deposition or rainfall washout.

Washout	Acute Frog 92.5 µg/L[1]	Chronic Frog 10 µg/L[2]	Acute Invertebrate 0.0485 µg/L[1]	Chronic Invertebrate 0.25 µg/L[2]	Aquatic Plants 2900 µg/L[3]
Full	2259	244	1.2	6.1	70,827
50%	4518	488	2.4	12	141,653
25%	9037	977	4.7	24	283,307

[1] Acute endpoint × the listed species LOC (0.05).
[2] Chronic endpoint × the chronic LOC (1.0).
[3] Aquatic plant endpoint × the aquatic plant LOC (1.0).

The number of air masses needed to exceed the acute and chronic invertebrate endpoints are both relatively low and could potentially occur within a single rain event. (Though, chronic endpoints are typically compared to 21-day exposures.) Therefore, the air monitoring analysis seems to indicate that long-range transport of methyl parathion has the potential to indirectly impact CRLFs through impacts to aquatic invertebrates.

Because no methyl paraoxon monitoring data are available for application site monitoring concentrations, methyl paraoxon application site air concentration ($C_{AppSiteOxon}$) was estimated as the methyl parathion application site monitoring concentration corrected for the ratio of the ambient methyl paraoxon concentration to ambient methyl parathion concentration:

$$C_{AppSiteOxon} = 548\text{ng/m}^3 \times \frac{7.79\text{ng/m}^3}{30.1\text{ng/m}^3} = 142\text{ng/m}^3$$

Therefore, the mass of methyl paraoxon in a single air mass over the standard PRZM/EXAMS pond (M_{MPoxon}) based on the maximum ambient methyl paraoxon monitoring data (7.79 ng/m^3) and an estimated maximum application site methyl paraoxon air concentration (142 ng/m^3) would potentially be:

$$M_{MPthion} = \left(7.79\text{ng/m}^3 \times 900\text{m} \times 10^4\text{m}^2 + 142\text{ng/m}^3 \times 100\text{m} \times 10^4\text{m}^2\right)/10^6\text{ng/mg}$$
$$= 212\text{mg}$$

The $Num_{AirMasses}$ required to exceed the relevant ecological endpoints for methyl paraoxon would be:

$$Num_{AirMasses} = \frac{\dfrac{Endpt(\mu\text{g/L})}{212\text{mg/air mass} \times 10^3\,\mu\text{g/mg}}}{2 \times 10^7\,\text{L}} \times WashOut$$

The number of air masses required to exceed the methyl paraoxon endpoints under different assumptions of the fraction washed out of the air masses passing over the standard PRZM/EXAMS pond are recorded in Table 11.

Table 11. Number of air masses needed to attain most sensitive toxicity endpoints in the aquatic toxicity profile for methyl paraoxon assuming different levels of deposition or rainfall washout.

Washout	Acute Frog 89 µg/L[1]	Chronic Frog (No Endpoint Identified)	Acute Invertebrate 0.115 µg/L[1]	Chronic Invertebrate 1 µg/L[2]	Aquatic Plants (No Endpoint Identified)
Full	8392	NA	11	94	NA
50%	16784	NA	22	189	NA
25%	33567	NA	43	377	NA

[1] Acute endpoint × the listed species LOC (0.05).
[2] Chronic endpoint × the chronic LOC (1.0).

Comparing the number of air masses required to exceed the relevant methyl parathion (Table 10) and methyl paraoxon (Table 11) endpoints, fewer air masses are required to exceed the methyl parathion endpoints (Table 10). Therefore, methyl paraoxon seems to contribute little to the long-range air transport risk from methyl parathion applications according to the air monitoring data analysis.

3.2.3.2 Rainwater monitoring

Three estimates of maximum methyl parathion concentrations in rainwater were obtained from literature. Majewski *et al* 2005 (http://pubs.usgs.gov/of/2005/1307/) report a maximum methyl parathion concentration in rainwater of 0.194 µg/L from 13 sites sampled between 2002 and 2004 in the southern central valley of California. However, the monitoring for this study appears to have occurred during a time of year (mid-December through early April) when relatively little methyl parathion would be applied.

A second estimate of maximum methyl parathion concentrations in rainwater of 2.77 µg/L was obtained from Majewski and Capel (1995). This maximum value was obtained from a review of 130 studies from the U.S. and Canada.

A third estimate of maximum methyl parathion concentrations in rainwater of 22.9 µg/L was obtained from Coupe et al (2000). This maximum value was obtained from a study of weekly wet deposition samples at 2 sites in Mississippi collected between April and September of 1995.

In an attempt to estimate the amount of methyl parathion potentially deposited into aquatic and terrestrial habitats from rainwater after long-range atmospheric transport, the 3 estimates of maximum methyl parathion concentrations in rainwater were considered in combination with California-specific precipitation data and runoff estimates from PRZM. Precipitation and runoff data associated with several California PRZM scenarios were used to determine 1-in-10 year peak runoff and rain events. The scenarios included were: CA almond, CA lettuce, CA wine grape, CA row crop, CA fruit, CA nursery, and CA onion. The corresponding meteorological data were from the following locations in California: Sacramento, Santa Maria, San Francisco, Monterey County, Fresno, San Diego, and Bakersfield, respectively.

Aquatic environment. To estimate concentrations of methyl parathion in the aquatic habitat resulting from wet deposition, the daily PRZM-simulated volume of runoff from a 10 ha field is combined with an estimate of daily precipitation volumes over the 1 ha EXAMS pond. This volume is multiplied by the 3 estimates of maximum methyl parathion concentration in precipitation (reported above) to create low medium and high estimates for each use scenario (based on maximum methyl parathion concentrations in rainwater of 0.194, 2.77, and 22.9 µg/L, respectively). The results are daily mass loads of methyl parathion into the standard EXAMS pond. This mass is then divided by the volume of water in the standard EXAMS pond (2.0×10^7 L) to achieve a daily estimate of methyl parathion concentration in the standard EXAMS pond, which represents the aquatic habitat. From the daily values, 1-in-10 year peak estimates of the concentration of methyl parathion in the aquatic habitat are determined for each PRZM scenario (Table 12).

Table 12. One-in-10 year peak estimates of methyl parathion concentrations in aquatic and terrestrial habitats resulting from deposition of methyl parathion at low (0.194 µg/L), medium (2.77 µg/L), and high (22.9 µg/L) concentration in rain estimates.

		Concentration in aquatic habitat (µg/L)			Deposition on terrestrial habitat (lbs a.i./A)		
Met Station	**Scenario**	**Low[1]**	**Medium[2]**	**High[3]**	**Low[1]**	**Medium[2]**	**High[3]**
Sacramento	CA almond	0.036	0.516	4.269	0.0001	0.0017	0.0144
Santa Maria	CA lettuce	0.039	0.556	4.595	0.0001	0.0014	0.0113
San Francisco	CA wine grape	0.034	0.486	4.018	0.0001	0.0016	0.0129
Monterey Co.	CA row crop	0.031	0.446	3.688	0.0001	0.0017	0.0144
Fresno	CA fruit	0.014	0.202	1.669	0.0001	0.0010	0.0082
San Diego	CA nursery	0.026	0.375	3.098	0.0001	0.0013	0.0106
Bakersfield	CA onion	0.010	0.149	1.229	<0.0001	0.0007	0.0056

[1] Based maximum rainwater methyl parathion concentration in Majewski *et al* 2005 (http://pubs.usgs.gov/of/2005/1307/).
[2] Based maximum rainwater methyl parathion concentration in Majewski and Capel (1995).
[3] Based maximum rainwater methyl parathion concentration in Coupe *et al* (2000).

The highest scenario's rainwater EECs based on the low, medium, and high maximum rainwater estimates are 1/100th, 1/8th, and approximately equal to, respectively, the lowest peak PRZM/EXAMS generated EEC in Table 7 (4.2 µg/L, ground applications to walnuts). These same rainwater EECs are 1/2000th, 1/120th, and 1/15th, respectively, the highest peak PRZM/EXAMS generated EEC in Table 7 (66.8 µg/L, aerial applications to cotton). Because of the large variation in rainwater methyl parathion concentration estimates, no rainwater methyl parathion contribution to EECs is included in the EECs reported in Table 7 or in the use scenarios modeled in the remainder of the document. However, it is important to note that not including any rainwater methyl parathion contribution could affect the interpretation of methyl parathion's potential to impact CRLFs for those scenarios that generate relatively lower PRZM/EXAMS' EECs.

Risk quotients (RQs) were calculated for aquatic effects of methyl parathion from the scenarios that produced the highest and lowest EECs (Table 13). Similar to the air monitoring analysis, the rainwater monitoring data analysis shows that there is potential for acute and chronic risk to freshwater aquatic invertebrates and, therefore, the potential for indirect effects to the CRLF from long-range atmospheric transport of methyl parathion.

Table 13. Aquatic risk quotients (RQs) solely due to long-range atmospheric transport and subsequent deposition of methyl parathion in rainwater.

Maximum Rainwater Concentration	Acute Frog 1850 µg/L	Chronic Frog 10 µg/L	Acute Invertebrate 0.97 µg/L	Chronic Invertebrate 0.25 µg/L	Aquatic Plants 2900 µg/L
Highest Scenario: CA Lettuce (Sacramento Meteorological Station)					
Low (0.194 µg/L)[1]	<0.01	<0.01	0.04	0.16	<0.01
Medium (2.77 µg/L)[2]	<0.01	0.06	**0.57**	**2.22**	<0.01
High (22.9 µg/L)[3]	<0.01	0.46	**4.74**	**18.38**	<0.01
Lowest Scenario: CA Lettuce (Sacramento Meteorological Station)					
Low (0.194 µg/L)[1]	<0.01	<0.01	0.01	0.04	<0.01
Medium (2.77 µg/L)[2]	<0.01	0.01	**0.15**	0.60	<0.01
High (22.9 µg/L)[3]	<0.01	0.12	**1.27**	**4.92**	<0.01

[1] Based maximum rainwater methyl parathion concentration in Majewski *et al* 2005 (http://pubs.usgs.gov/of/2005/1307/).
[2] Based maximum rainwater methyl parathion concentration in Majewski and Capel (1995).
[3] Based maximum rainwater methyl parathion concentration in Coupe *et al* (2000).

Similarly, RQs were calculated for aquatic effects of methyl paraoxon from the scenarios that produced the highest and lowest methyl parathion EECs (Table 14). Methyl paraoxon EECs from long-range transport were estimated by assuming the maximum methyl paraoxon concentration is 2.1% of the deposited methyl parathion EECs (2.1% is based on the highest fraction of methyl paraoxon observed in any of the fate studies). This analysis shows that there is little potential for acute and/or chronic risks to freshwater aquatic invertebrates and, therefore, little potential for indirect effects to the CRLF from long-range atmospheric transport of methyl paraoxon.

Table 14. Aquatic risk quotients (RQs) solely due to long-range atmospheric transport and subsequent deposition of methyl paraoxon in rainwater.

Maximum Rainwater Concentration	Acute Frog 1780 µg/L[1]	Chronic Frog (No Endpoint Identified)	Acute Invertebrate 2.3 µg/L[1]	Chronic Invertebrate 1 µg/L[2]	Aquatic Plants (No Endpoint Identified)
Highest Scenario: CA Lettuce (Sacramento Meteorological Station)					
Low (0.194 µg/L)[1]	<0.01	N.A.	<0.01	<0.01	N.A.
Medium (2.77 µg/L)[2]	<0.01	N.A.	0.01	0.01	N.A.
High (22.9 µg/L)[3]	<0.01	N.A.	0.04	0.10	N.A.
Lowest Scenario: CA Lettuce (Sacramento Meteorological Station)					
Low (0.194 µg/L)[1]	<0.01	N.A.	<0.01	<0.01	N.A.
Medium (2.77 µg/L)[2]	<0.01	N.A.	<0.01	<0.01	N.A.
High (22.9 µg/L)[3]	<0.01	N.A.	0.01	0.03	N.A.

[1] Based maximum rainwater methyl parathion concentration in Majewski *et al* 2005 (http://pubs.usgs.gov/of/2005/1307/).
[2] Based maximum rainwater methyl parathion concentration in Majewski and Capel (1995).
[3] Based maximum rainwater methyl parathion concentration in Coupe *et al* (2000).

Terrestrial environment. To estimate deposition of methyl parathion on the terrestrial habitat resulting from wet deposition, the daily volume of water deposited in precipitation on 1 acre of land is estimated. This volume is multiplied by the 3 estimates of maximum methyl parathion concentration in precipitation (reported above) to create low medium and high estimates for each use scenario (based on maximum methyl parathion concentrations in rainwater of 0.194, 2.77, and 22.9 µg/L, respectively). The results are mass loads of methyl parathion per acre (converted to units of lbs a.i. /A). From these daily values, 1-in-10 year peak estimates of the deposition of methyl parathion on the terrestrial habitat are estimated for each PRZM scenario (Table 12).

For terrestrial insects, the acute effects endpoint is 0.28 µg/bee. Based on this endpoint, EFED would consider any application rate in excess of 0.0008 lbs a.i./A to have potential to cause acute terrestrial effects at the endangered species LOC. All of the scenarios in Table 3 exceed this deposition rate if these scenarios are based on the high maximum rainfall methyl parathion concentration estimate (22.9 µg/L), and all of the scenarios except CA onions exceed this deposition rate if these scenarios are based on the medium maximum rainfall methyl parathion concentration estimate (2.77 µg/L). Therefore according to the rainwater monitoring data analysis, log-range atmospheric transport has the potential to harm terrestrial insects and, therefore, indirectly harm the CRLF through depletion of terrestrial insects that serve as forage items for terrestrial-phase CRLF.

3.3.3.3 Long-range Transport Summary

There are several simplifying assumptions associated with both approaches used to estimate potential effects due solely to atmospheric transport that contribute uncertainty to the interpretation of this assessment. The air monitoring data analysis assumes the air monitored is similar in concentration to the air masses passing over the simulated CRLF aquatic habitat during a rain event. For CRLF habitat near sites of methyl parathion application, it seems likely that the air concentrations would be relatively well estimated, but having a rain event of sufficient intensity to strip out much of the methyl parathion from the air may be rare in the part of California where, and at the time when, methyl parathion is typically applied. Conversely for CRLF habitat distant from sites of methyl parathion application, it is likely that the air concentrations would be over-estimated due to dilution with air of lower methyl parathion concentration. However, having a rain event of sufficient intensity to strip out much of the methyl parathion from the air may be more likely in the parts of California away from where, but at the same time as, methyl parathion is typically applied.

Similarly, the rainwater monitoring data analysis assumes: 1) the concentration of methyl parathion in the rain event is spatially and temporally homogeneous (*e.g.*, the average concentration measured over the 10-ha field and 1-ha pond for the entire rain event equals the measured concentration); 2) the entire mass of methyl parathion contained in the precipitation runs off of the field or is deposited directly into the pond; 3) there is no degradation of methyl parathion between the time it leaves the air and the time it reaches the pond; and 4) the measured maximum precipitation concentrations are representative of the pesticide concentrations in precipitation at the site and time of the 1-in-10 year rain/runoff event. However, none of the 3 maximum methyl parathion concentration in rainwater estimates obtained provided satisfactory estimates for maximum methyl parathion concentrations at the site and time of actual application. The monitoring data from Majewski *et al* (2005) was from the time of the year when methyl parathion applications, typically, do not occur, while the other 2 estimates were not from California.

Neither of the long-range transport analyses presented suggests that risks to the CRLF can be dismissed. Although it is difficult at this time to spatially delineate where long-range transport of methyl parathion may cause effects, it should be assumed that the impacts of methyl parathion on CRLFs would likely extend beyond the downstream effects and spray drift impact zones alone.

3.4 Terrestrial Exposure

3.4.1 Bird and Mammal Exposure (TREX)

The Agency estimates exposure of birds and mammals to pesticides using the Terrestrial Exposure Model (T-REX). T-REX uses the Kenaga nomogram, as modified by Fletcher *et al.* (1994) to determine pesticide residues on several categories of food items, then calculates the potential dose an organism might receive from ingesting contaminated items using allometric equations. Unless toxicological endpoints for terrestrial amphibians or reptiles are available, toxicological endpoints for birds are used as a surrogate. For the frog, exposure via ingestion of contaminated food items is estimated using the EECs for a small bird (20 g) consuming small insects. For mammalian prey items, it is estimated for a small mammal consuming short grass. Assumed foliar dissipation half-life can have a significant impact on exposure estimates, especially for pesticides re-applied at relatively short intervals. Willis and McDowell (1987) is a compilation of foliage half-lives for pesticides. In this publication, a total of 10 foliar half-lives based on total dislodgeable residues are listed, ranging from 0.1-2.3 days. The most conservative estimate (2.3 days) has been used in the T-REX modeling. T-REX also incorporates a scaling factor developed by Mineau et al (1996) to improve interspecies toxicity extrapolation. The publication lists a scaling factor of 1.17 for parathion (slightly higher than the default value of 1.15). Although the publication does not specify whether the value is for ethyl parathion or methyl parathion, the more conservative estimate has been used in modeling

Table 15 Input Parameters for T-REX

Parameter	Value	Source
Percentage active ingredient	100%	Labels, application rate already adjusted
Number of applications	Cotton 5 Onions 6 Grass 6 Walnuts 4	Labels
Application interval	Cotton 5 Onions 5 Grass 5 Walnuts 21	Labels
Dissipation half-life[1]	2.3 days	Willis and McDowell 1987
Mineau scaling factor	1.17	Mineau *et al.,* 1996

Table 16 EECs for Dietary- and Dose-based Exposures

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
Agricultural				
Cotton (3 lb a.i/A)	520	592	924	881
Onions (0.5 lb a.i/A)	87	99	154	147
Orchards				
Walnuts (2 lb a.i/A)	270	308	481	458
Rangeland				
Grass (0.75 lb a.i/A)	130	148	231	220

3.4.2 Terrestrial Invertebrate Exposure

Exposure of terrestrial invertebrates was estimated using the dietary-based EECs produced by TREX for the two insect categories (small and large). The value produced by TREX, mg a.i./kg insect, is equivalent to µg a.i./g insect. The methyl parathion residue for a bee (µg a.i./bee) was calculated by multiplying the residue concentration by the assumed weight of a honey bee (0.128 g) to establish a dose per bee. This method assumes that contact is the relevant route of exposure, rather than ingestion. EECs are presented based on the TREX estimates for small insects and large insects to address the range of organisms potentially affected.

Table 17 Terrestrial Invertebrate Exposure

Application Rate (lb a.i/A)	Insect Size Category	EECs (mg a.i/kg insect)	Dose per Bee (μg a.i/bee)
Agricultural Highest (Cotton 3 lb a.i/A)	Small insects	520	67
	Large insects	58	7.4
Agricultural Lowest (Onions 0.5 lb a.i/A)	Small insects	87	11
	Large insects	9.6	1.2
Orchards (Walnuts 2 lb a.i/A)	Small insects	270	35
	Large insects	30	3.9
Pasture (Grass 0.75 lb a.i/A)	Small insects	130	17
	Large insects	14	1.8

4.0 Effects Assessment

Toxicity data were derived from guideline tests and open literature (ECOTOX). Data for the parent compound used in the RED (USEPA 2006) were re-reviewed. In some cases, data had been derived from sources which no longer meet data quality criteria for EFED. Based on the initial database reports from ECOTOX, studies which had similar or lower endpoints were reviewed. These reviews, along with tables documenting all toxicity data located, are included in Appendix B.

In general, methyl parathion is acutely toxic to animals, and effects are noted soon after exposure. It is toxic via both ingestion and dermal contact. In cases where it does not cause outright mortality, sub-lethal effects include disorientation and behavioral changes that may increase susceptibility to predation and/or modify parenting patterns (*e.g.*, nest abandonment in birds). Based on acceptable data, methyl parathion is classified as moderately toxic to fish and very highly toxic to aquatic invertebrates on an acute exposure basis. Based on acute oral and subacute dietary toxicity tests, it is classified as very highly toxic to birds and mammals on an acute oral and subacute dietary exposure basis. It is also classified as highly toxic to bees on both an oral dose and contact exposure basis. In many chronic effects evaluations, mortality occurs at the same concentrations at which reproductive endpoints are noted.

4.1 Aquatic Toxicity Profile

Table 18 shows assessment endpoints used to evaluate effects on the aquatic-phase CRLF. Data available for methyl paraoxon is shown in Table 19. Toxicity data from the RED document for 4-nitrophenol (PC 056301; also known as paranitrophenol (EPA 1998a)) is shown in Table 20.

Table 18 Aquatic Toxicity Profile for Methyl Parathion

Assessment Endpoint	Surrogate Species	Toxicity Value Used	Source Citation	Comments
Direct Effects				
Acute Toxicity to Frog	Cutthroat trout[1]	LC_{50} = 1,850 µg/L 95% CI = 1,390-2,470 µg/L	MRID 40094602	No comments
Chronic Toxicity to Frog	Rainbow trout	NOAEC = <10 µg/L LOAEC = 10 µg/L	MRID 250628	Endpoint fry length and weight. Fry survivability affected at 20 µg/L
Indirect Effects and Critical Habitat Effects (Prey Reduction)				
Acute Toxicity to Aquatic Invertebrates	Water flea *(C. dubia)*	EC_{50} = 0.97 µg/L 95% CI = NR Slope = NR	ECOTOX 56473	*C. dubia* typically more sensitive than *D. magna*
Chronic Toxicity to Aquatic Invertebrates	Water flea *(D.magna)*	NOAEC = 0.25 µg/L LOAEC = 0.55 µg/L	MRID 128790	Growth affected at 0.55 µg/L, reproduction at 0.89 µg/L
Indirect Effects and Critical Habitat Effects (Habitat Modification)				
Acute Toxicity to Aquatic Plants	Green algae[2] *(Scenedesmus subspicatus)*	EC_{50} = 15,000 µg/L NOAEC = 8,000 µg/L	ECOTOX 4008	72-hour test (Static)

[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.
[1]Data for western chorus frog (*Pseudacris triseriata*), tested at the same laboratory, yielded a 96-hour LC_{50} of 3,700 µg/L. A bluegill LC_{50} of 3,700 µg a.i./L was also determined, but material tested appears to have been a formulation.
[2]Data for aquatic vascular plants validated for qualitative use only. 96-hour LC_{50}= 18,000 µg/Lfor aquatic mosquito fern (*Azolla pinnata*). Typically, non-vascular plants are more sensitive to toxicant effects than vascular plants.

4.1.1 Toxicity to Freshwater Fish

4.1.1.1 Acute Exposure (Mortality) Studies

Review of methyl parathion acute toxicity data based on guideline studies of freshwater fish (Mayer and Ellersieck 1986) and open literature meeting ECOTOX and OPP criteria resulted in approximately 40 different 96-hr LC_{50} values, representing over 25 different species of freshwater fishes. The LC_{50} values ranged from 1,850 µg/L for cutthroat trout (*Oncorhynchus clarki*) (Mayer & Ellersieck 1986) to 12,806 µg/L for Western mosquito fish (*Gambusia affinis;* ECOTOX 62030). In some cases, such as for cutthroat trout (*Oncorhynchus clarki*), rainbow trout (*Oncorhynchus mykiss*), bluegill (*Lepomis macrochirus*), and fathead minnow (*Pimephales promelas*), multiple LC_{50} values, often generated by different investigators, were reported. For cutthroat trout, LC_{50} values ranged from 1,850-4,880 µg/L (n=2, arithmetic mean 3,365 µg/L). For rainbow trout, LC_{50} values ranged from 2,200-3,700 µg/L (n=4, arithmetic mean 2,863 µg/L). For bluegill, LC_{50} values ranged from 2,434-6,900 µg/L (n=3, arithmetic mean 4,570 µg/L).

For fathead minnow, LC_{50} values ranged from 7,200-8,900 µg/L (n=3, arithmetic mean 7,867 µg/L). The most sensitive value (1,850 µg/L, cutthroat trout) was used as the acute toxicity assessment endpoint.

4.1.1.2 Chronic Exposure (Growth/Reproduction) Studies

The most sensitive chronic endpoint was from a registrant-submitted guideline study of rainbow trout (MRID 250628, also referenced as Bailey 1983 in RED (USEPA 2006)). This study was conducted on the microencapsulated formulation (Penncap®-M). In the study, analytical concentrations for both filtered and unfiltered test water samples were reported. Filtered concentrations were used as the assessment endpoints to ensure the effects were associated with bioavailable methyl parathion. Effects were noted at the lowest concentration tested and a definitive NOAEC was not established. The study was classified by the reviewer as supplemental. Effects noted at the LOAEC of 10 µg/L included reductions in fry length and weight. Fry survivability was affected at 20 µg/L.

4.1.2 Toxicity to Aquatic-Phase Amphibians

4.1.2.1 Acute Exposure (Mortality) Studies

No guidelines currently exist for amphibian toxicity studies. However, five studies evaluating the acute effects (*i.e.*, mortality) of methyl parathion on frogs met the criteria for inclusion into ECOTOX (E9226, E12043, E52442, E65895, E66399). These studies were reviewed, and reviews are included in Appendix B. Two studies (E65895, E66399) were from the same group of researchers, who reported 96-hr LC_{50}s of 4,360 µg/L and 4,860 µg/L respectively, for tadpoles of the Indian bullfrog (*Rana tigrina*) tested with technical methyl parathion. [10]. Mayer and Ellersieck (1986) publication contained data for western chorus frog tadpoles (*Psuedacris triseriata*). The 96-hr LC_{50} for this frog was 3,700 µg/L. Indian researchers evaluated the end-product Metacid® 50, a product marketed in India that also contains some DDT. These authors reported the 96-hr LC_{50} for *Rana tigrina* tadpoles as 9,500 µg/L. Metacid® 50 is not registerd in the United States.

Another group of researchers conducted an experiment exposing adult *Rana cyanophlyctis* (skipping or skipper frog) to methyl parathion in solution. They reported 96-hr LC_{50} values of 4,000 µg/L for adult males and of 5,750 µg/L for adult females. The females were larger than the males (~20g as opposed to ~8g). In this study, authors noted avoidance behavior and "hyperactivity" in exposed frogs.

The limited data available suggest the sensitivity range for tadpoles and adult frogs exposed in the aquatic phase are similar to fish. Differences in the species sensitivity distributions of fish and amphibians are not well understood. Because of this fact, EFED has elected to use most sensitive LC_{50} for fish (cutthroat trout 1,850 µg/L); this value

[10] Paper is unclear as to whether value presented is in terms of solution (50% w/w emulsifiable concentrate, or technical. Reviewer has assumed reporting is in terms of EC, and corrected for percent technical.

appears to be protective for amphibians that, based on available data, do not appear to be any more sensitive than fish.

4.1.2.2 Studies Reporting Sub-lethal Endpoints

Sub-lethal effects data included evaluation of changes in glycogen reserves of adult *Rana cyanophlyctis* (female NOAEC 2,500 μg/L[11], E52442); increases in nitrogen excretion in *Rana tigrina* tadpoles (LOAEC 486 μg/L, NOAEC not established, E65895), and increases in oxygen consumption in *Rana cyanophlictis* tadpoles (LOAEC 2,500 μg/L, NOAEC not established).

4.1.3 Toxicity to Freshwater Invertebrates

Both registrant-submitted guideline studies and open literature toxicity data were available for freshwater invertebrates. Data evaluation records (DERs) and/or studies for endpoints reported in the RED (USEPA 2006) were located and reviewed. In some cases, reported data were from government laboratory toxicity tests reported in Mayer and Ellersieck 1986 and/or Johnson and Finlay 1980. If the raw data were available in EFED files, it was reviewed to confirm acceptability. In cases where the raw data were not available, and the LC_{50} values were questionable in comparison to other data for the same or similar species, the values were not used in the assessment (in accordance with EFED policy regarding use of such data.)

4.1.3.1 Acute Exposure (Mortality) Studies

Including registrant-submitted guideline studies and data included in ECOTOX, approximately 30 LC_{50} values were located for a range of aquatic invertebrates. Test duration ranged from 24-120 hours. Guideline tests for aquatic invertebrates require a 48-hr exposure, thus data from this exposure time period was considered first in determining an assessment endpoint. A total of 11 acceptable 48-hr LC_{50} values for aquatic invertebrates were located, from 7 different sources, including guideline studies for both technical methyl parathion and Penncap®-M. In the data set, there were LC_{50} values for 7 different species. LC_{50}s ranged from 0.97 μg/L (*Ceriodaphnia dubia* (water flea), E56473) to 40 μg/L (*Metapenaeus monoceros* (sand shrimp), E3674). Five separate LC_{50} values were available for *Daphnia magna*, one of the most commonly tested aquatic invertebrates. LC_{50} values ranged from 5.1-20 μg/L (n=5, arithmetic mean 7.6 μg/L.) The most sensitive value (0.97 μg/L, *Ceriodaphnia dubia)* was used as the assessment endpoint.

4.1.3.2 Chronic Exposure (Growth/Reproduction) Studies

Including registrant-submitted guideline studies and data included in ECOTOX, there were 3 acceptable 21-day (standard evaluation period) studies. All were conducted with *Daphnia magna*. The lowest NOAEC, derived from a registrant-submitted guideline study (MRID 128790) was 0.25 μg/L. Growth was the most sensitive endpoint, affected

[11] Paper is unclear as to whether value presented is in terms of solution (50% w/w emulsifiable concentrate, or technical. Reviewer has assumed reporting is in terms of EC, and corrected for percent technical.

at the LOAEC of 0.55 μg/L. In this study, reproductive parameters were affected at 0.89 μg/L. Another registrant-submitted guideline test (MRID 4303501) reported a NOAEC of 0.43 μg/L and a LOAEC of 0.85 μg/L. Endpoints affected in this study included survival, weight, and time to first brood. An open literature study (E6449) reported a NOAEC of 1.2 μg/L based on effects on reproduction and mortality (survival) to the test organisms.

4.1.4 Toxicity to Aquatic Plants

No guideline tests on freshwater aquatic plants were located. ECOTOX located 4 studies (E4008, E4335, E17302, E71939) reporting EC_{50}s for freshwater plants. Two of these studies (E4008, E4335) were written by the same group of researchers and included reported endpoints for a 10-day exposure in an experimental flow-through system as well as endpoints for a 72-hr static test conducted in accordance with OECD guidelines. Authors report the 72-hr EC_{50} for the green alga *Scendesmus subspicatus* as 15,000 μg/L, and the NOAEC as 8,000 μg/L. The 72-hr EC_{50} and NOAEC for another green alga, *Chlamydomonous reinhardi* were both reported as >100,000 μg/L. The authors noted that EC_{50}s for all chemical tested were 3-38 times lower in the flow-through system, but were unclear as to whether this may have been in response to the extended exposure or somehow associated with the test system itself. Given this uncertainty the most sensitive values from the static test *(S. subspicatus)* were used as assessment endpoints. Another study (E71939, not reviewed) reported EC_{50}s of 19,200 μg/L for the blue-green alga *Anabaena inaequalis* and of 290,900 μg/L for the green alga *Chlorella kessleri*. Only one study (E17302), using the endproduct Metacid® 50, a product marketed in India that also contains some DDT was located for freshwater vascular plants. This study reported an EC_{50} of 18,000 μg/L for the aquatic mosquito fern *(Azolla pinnata)* Metacid® 50 is not registerd in the United States..

No guideline toxicity data were available for methyl paraoxon. However, acceptable acute data for fish and chronic data for aquatic invertebrates were located in open literature and are presented in Table 19.

Table 19 Aquatic Toxicity Profile for Methyl Paraoxon

Assessment Endpoint	Surrogate Species	Toxicity Value Used	Source Citation	Comments
Direct Effects				
Acute Toxicity to Frog	No appropriate data located			
Chronic Toxicity to Frog	No data located			
Indirect Effects and Critical Habitat Effects (Prey Reduction)				
Acute Toxicity to Aquatic Invertebrate	Water flea *(D.magna)*	LC50 =2.3 μg/L 95% CI = 2.2-2.5 μg/L 24 hr exposure	ECOTOX 91481	24-hr exposure for both acute and chronic. Chronic effects noted following removal to clean medium. Chronic effects on reproduction, size and population growth rate.
Chronic Toxicity to Aquatic Invertebrate		NOAEC = 1.0 μg/L LOAEC = 1.5 μg/L		
Indirect Effects and Critical Habitat Effects (Habitat Modification)				
Acute Toxicity to Aquatic Plants (non-vascular)	No data located			
Acute Toxicity to Aquatic Plants (vascular)				

In the freshwater invertebrate study (ECOTOX 91481), the author exposed *D. magna* neonates to a 24-hour pulse of technical grade methyl paraoxon, then moved exposed animals to clean medium and analyzed survival, growth, reproduction, and biochemical endpoints for the exposed animals. Experimental conditions for the reproductive test were based on the OECD 1979 guideline for reproductive tests with *D. magna*. The author calculated an EC_{50}, based on survival following a 24-hr exposure and 48-hr recovery (used in assessment as a 24-hr exposure value); this value is 2.3 μg/L (95% CI 2.2-2.5). Although this exposure period is less than is typically acceptable (aquatic invertebrate guideline tests have a 48-hr exposure period), no other data regarding toxicity of the oxon to aquatic invertebrates were located. A longer exposure period could possibly lower the EC_{50} value, although the time-to-death data that are available from other studies indicate that in most cases death occurs rapidly following exposure to methyl parathion, and that organisms which survive the first 24 hours of the test often survive the entire test.

In the 24-hr exposure study with daphnids, the EC_{50} values decreased slightly with length of observation of the recovery time, with the an EC_{50} of 2.1 μg/L with a 24-hr exposure and 7 days of recovery and an EC_{50} of 2.0 μg/L with a 24-hr exposure and 14 days of recovery. Cholinesterase inhibition was noted at concentrations as low as 0.7 μg/L during day 1 (exposure to methyl paraoxon). Exposure to concentrations > 1.0 μg/L resulted in decreased size, and reduced number of offspring. Effects were statistically significant at 1.5 μg/L. These data indicate that the relatively short acute exposure (24 hr) resulted in long-term effects on growth and survival.

Based on data contained in the RED (USEPA 2006), 4-nitrophenol is slightly toxic to fish and aquatic invertebrates on an acute basis but is several orders of magnitude less toxic than the parent compound or its oxon intermediate.

Table 20 Aquatic Toxicity Profile for Degradate 4-nitrophenol

Assessment Endpoint	Surrogate Species	Toxicity Value Used	Source Citation	Comments
Direct Effects				
Acute Toxicity to Frog	Rainbow trout	LC_{50}=4,000 μg/L	MRID 94659	As cited in 4-nitrophenol RED (EPA 1998)
Chronic Toxicity to Frog	No data located			
Indirect Effects and Critical Habitat Effects (Prey Reduction)				
Acute Toxicity to Aquatic Invertebrates	Water flea	LC_{50}=5,000 μg/L	MRID 94659	As cited in 4-nitrophenol RED (EPA 1998)
Chronic Toxicity to Aquatic Invertebrates	No data located			
Indirect Effects and Critical Habitat Effects (Habitat Modification)				
Acute Toxicity to Plants (non-vascular)	No data located			
Acute Toxicity to Plants (vascular)				

Based on data contained in 4-nitrophenol RED (EPA 1998a; studies not reviewed), it is moderately toxic to both fish and aquatic invertebrates.

4.2 *Terrestrial Toxicity Profile*

Table 21 Terrestrial Toxicity Profile for Methyl parathion

Assessment Endpoint	Surrogate Species	Toxicity Value Used	Source Citation	Comments
Direct Effects				
Acute Toxicity to Frog	Bobwhite quail	LD_{50}= 9.8 mg/kg bw (dose) 9.5-10.2 mg/kg	ECOTOX 39539	Pen-reared birds. Authors also tested wild-caught birds and LD_{50}s were statistically indistinguishable.
	Bobwhite quail	LC_{50}= 28.2 mg/kg (dietary) 95% CI = 22.1- 35.3 mg/kg	MRID 102329	MP Technical, Penncap-M also tested, LC_{50}= 33.3 mg/kg bw
Chronic Toxicity to Frog	Bobwhite quail	NOAEC= 6.3 mg/kg diet LOAEC= 15.5mg/kg diet	MRID 41179302	Effects included treatment related mortality, reduction in eggs laid, and survival of offspring
Indirect Effects and Critical Habitat Effects (Prey Reduction)				
Acute Toxicity to Terrestrial Invertebrates	Honey bee *(A. mellifera)* (contact)	LD_{50} = 0.28 μg/bee	E91623	Authors also tested Thai honey bee *(A. cerana)*
Acute Toxicity to Mouse	Rat	LD_{50}=4.5 mg/kg bw (dose)	MRID 000168	Lowest endpoint for females, males higher in this test (6 mg/kg)
Acute Toxicity to Frog	American kestrel	LD_{50}= 3.1 mg/kg bw (dose) 95% CI = 2.3-4.2 mg/kg	ECOTOX 38447	Sub-lethal effects included hypothermia, inhibited brain and cholinesterase activity.
	Bobwhite quail	LC_{50}= 28.2 mg/kg (dietary) 95% CI = 22.1- 35.3 mg/kg	MRID 102329	MP Technical, Penncap-M also tested, LC_{50}= 33.3 mg/kg bw
Chronic Toxicity to Terrestrial Invertebrates	Honey bee	No acceptable data located		
Chronic Toxicity to Mouse	Rat	NOAEC= 5 mg/kg bw LOAEC= 25 mg/kg bw	MRID 005588	Changes in maternal body weight
Chronic Toxicity to Frog	Bobwhite quail	NOAEC= 6.3 mg/kg diet LOAEC= 15.5mg/kg diet	MRID 41179302	Effects included treatment related mortality, reduction in eggs laid, and survival of offspring
Indirect Effects and Critical Habitat Effects (Habitat Modification)				
Acute Toxicity to Terrestrial Plants	Monocot	NOAEL=0.202 lb ai/A	E89091	Bread wheat
	Dicot	NOAEL=0.445 lb ai/A	E91430	Sesame

[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 than exposure pathways on land.
[b] Birds are used as surrogates for terrestrial-phase amphibians.

4.2.1 Terrestrial Vertebrates (Birds and Mammals)

4.2.1.1 Birds

No registrant-submitted guideline studies were located for acute oral dose studies on birds. Two open literature studies were located by ECOTOX, one investigating sub-lethal effects on American kestrels *(Falco sparverius*,ECOTOX 38447, Rattner and Franson 1984), and one comparing toxicity effects of methyl parathion on pen-reared as opposed to wild-caught bobwhite quail (*Colinus virginianus*, ECOTOX 39539, Buerger et. al 1994). Both studies were reviewed, and author's reported endpoints were confirmed using the program TOXANAL and data as given in the paper. Reviews with accompanying statistics are included in Appendix B.

Acute Oral Dose
In the bobwhite study, authors dosed 64 pen-reared birds and 40 wild-caught birds (equal sexes) with methyl parathion at concentrations ranging from 9.1-11.1 mg/kg. Dose range was based on a previous range finding test. Controls were maintained for both sets of birds, and control mortality was zero. The author determined and the reviewer confirmed LD_{50} values for the pen-reared birds and wild-caught birds were 9.8 mg/kg (95% CI 9.5-10.2), and 10.22 mg/kg (95% CI 9.8-10.5), respectively. The groups were statistically inseparable. Acute symptoms noted during the tests included lethargy, ataxia, diarrhea, and muscle tremors. The authors also measured brain cholinesterase activity of both the birds that died, and those who survived (sacrificed at the end of a 14-day observation period). Brain cholinesterase activity in the birds that died (both groups) was approximately 25% that of the controls. Birds that survived exhibited decreased brain cholinesterase activity (approximately 70% that of controls) at the end of the observation period, indicating that while there is recovery, a period of impairment for birds receiving non-lethal doses may last days to weeks. The authors did not discuss whether there was any gender difference in response to the pesticide. The authors concluded there was no statistically significant difference in response between the pen-reared bobwhites and the wild-caught bobwhites for any of the parameters they measured.

The study on American kestrel was focused on physiological responses, and the authors report an estimated LD_{50} incidental to their main work. The authors did not note the source of birds; therefore, the previous exposure history to environmental contaminants in uncertain. Data used by the reviewer to estimate LD_{50} include data from three experiments reported in the same paper. It is unclear if author used data from all three experiments or just one experiment. The LD_{50} reported by author and confirmed by reviewer is 3.1 mg/kg bw, which is slightly above the highest dose tested (3.0 mg/kg). The upper bound for the 95% confidence interval could not be determined. Authors evaluated the kestrel's ability to thermoregulate following methyl parathion intoxication and the correlation of this effect with brain and plasma cholinesterase inhibition. Birds dosed with 2.0-3.0 mg/kg exhibited a drop in body temperature and plasma cholinesterase within 2 hrs of dosing. For birds that survived, both body temperature and cholinesterase levels showed recovery within the 10 hr post-dosing monitoring period. Body temperature declines appeared to be correlated with approximately a 50% reduction in brain and plasma cholinesterase activity. Plasma cholinesterase activity was inhibited in the lower dose (0.375 and 1.0 mg/kg) treatment groups as well, but the percent inhibition was not statistically different from the controls. Authors also tested the effect of exposure to lowered temperatures (5°C versus 22 °C) in birds treated with 2.25 mg/kg methyl parathion. The magnitude of the drop in body temperature to birds exposed to cold temperatures was similar to birds maintained at 22°C, but the consequences were more severe, with a 60% (3 out of 5) mortality rate in the cold-exposed birds. There was no mortality in the treated birds maintained at 22°C. The authors did not note weight of birds used in study; however, the average mass of an American kestrel is approximately 120 g (Yamamoto and Santolo 2000, Smallwood 1987, Bernstein *et al.*, 1979).

Based on the available acute oral toxicity data, methyl parathion is classified as very highly toxic to birds on an acute oral exposure basis.

Dietary Toxicity
A registrant-submitted study for bobwhite quail was located (MRID 102329 Supplemental). This study evaluated both technical methyl parathion and the Penncap®-M microencapsulated formulation. The LC_{50} value for the technical was reported as 28.2 mg/kg diet (95% CI 22.0-35.3 mg/kg diet). The LC_{50} value for Penncap®-M was reported as 33.3 mg/kg diet (95% CI 25.1 and 40.9 mg/kg diet). Based on the subacute dietary toxicity values, methyl parathion is classified as very highly toxic to birds on a subacute dietary exposure basis. Effects noted for all treated birds included ruffled feathers, diarrhea, wing droop, and withdrawal.

Chronic (Reproductive) Toxicity
A registrant-submitted guideline study for bobwhite quail, using technical grade methyl parathion, was located (MRID 41179302 Core). Birds were tested at feed concentrations (mean-measured) of 2.6, 6.27 and 15.5 mg/kg. Overt signs of toxicity were noted in the 15.5 mg/kg diet treatment group. No treatment-related mortality was noted in the 2.6 or 6.27 mg/kg diet treatment groups. The only statistically significant effects on reproductive performance were a reduction in egg laid per hen and eggs set per hen in the 15.5 mg/kg diet group. Based on this study, the NOAEC for bobwhite quail is 6.27 mg/kg diet and the LOAEC is 15.5 mg/kg diet.

4.2.1.2 Mammals

Registrant-submitted guideline studies were available for small mammals. These studies provided the most sensitive endpoint located, and are used as assessment endpoints.

Acute Oral Toxicity
Testing on laboratory mammals (typically rats or mice) is submitted to OPP's Health Effects Division (HED), where it is reviewed and evaluated for inclusion into the human health risk assessment. Three studies reporting acute oral LD_{50} values were located. In all cases, LD50s for male and female rats were reported separately. One study, conducted on a material reported as 80% methyl parathion (Accession # 243414), resulted in a male LD_{50} of 3.6 mg/kg bw (95% CI 1.6-7.9), and a female LD_{50} of 23.0 mg/kg (95% CI 13.7-38.6). Another study (cited as document # 000168 in HED

document 005588 (1986)) on a material reported as technical methyl parathion (not encapsulated) reported a male LD_{50} of 6-16 mg/kg bw, and a female LD_{50} of 4.5-24 mg/kg bw. Within experimental variability, these values are essentially the same and classify methyl parathion as highly toxic to very highly toxic to mammals on an acute oral exposure basis. Signs of acute toxicity in tested animals included excitability, twitching, loss of coordination, and convulsions. HED used the value reported in document #000168 in the human health assessment conducted for the RED (USEPA 2006), thus EFED has opted to use the same value in this ecological risk assessment.

Chronic Toxicity
A two-generation reproduction study was conducted with the Spargue-Dawley strain of Norway rats (*Rattus norvegicus*; MRID 00119087) to which methyl parathion was administered in the diet at concentrations of 0.5, 5, and 25 mg/kg diet. The parental (systemic) NOAEL was 5 mg/kg diet and the LOAEL was 25mg/kg diet based on decreased pre-mating body weight for F1 females and decreased maternal body weight during lactation in females of both generations. No parental reproductive toxicity was observed at any dose level, however, the offspring/developmental NOAEL was 5 mg/kg diet based on decreased pup survival in early lactation and on decreased body weight gain and increased food consumption in the period immediately following weaning. The developmental LOAEL was 25 mg/kg diet.

4.2.2 Terrestrial Invertebrates

A study by Atkins *et. al* (1976), (also referenced as MRID 00022220, Core) established a 48-hr acute contact LD_{50} of 0.291 µg/bee. This study, conducted on the technical, classifies methyl parathion as highly toxic to bees on an acute contact exposure basis. One study located by ECOTOX (E91623) evaluated variations in susceptibility to methyl parathion in honeybees (*Apis mellifera*) from different colonies. The LD_{50} for bees from the most sensitive colony was 0.28 µg/bee (95% CI 0.23-0.35 µg/bee). The LD_{50} for bees from the least sensitive colony was 0.54 µg/bee (95% CI 0.41-0.70 µg/bee). The authors also evaluated effect on the Thai honeybee (*Apis cerana).* Reported LD_{50} for these bees was 0.08 µg/bee (95% CI 0.06-1.0 µg/bee). The authors did not report weight of any of the bees tested, but *Apis cerana* are generally smaller than *Apis mellifera* (www.beesfordevelopment.org/info/info/species/honey-bee-species.shtml). Various strains of *Apis cerana* also vary in size. Given uncertainty associated with weight of the smaller bee, and to maintain consistency between CRLF assessments, the *Apis mellifera* endpoint was used to calculate RQ values.

The microencapsulated methyl parathion product, Penncap®-M, is similar in size to that of a pollen grain. It has been associated with a number of hive and colony kills because the bees transport it back to the hive, where the larvae that feed on stored pollen are exposed to it. Because of the potential toxicity of microencapsulated pesticides to honeybees, states have adopted regulations restricting the use of these formulations (http://dpr.clemson.edu/Acrobat/Bulletin%205%20protecting%20honeybees.pdf).

4.2.3 Terrestrial Plants

There were no registrant-submitted guideline studies for terrestrial plants, and ECOTOX located no studies determining an EC_{25}, which is the value typically used to evaluate potential effects on non-endangered plant species. ECOTOX did locate a number of studies (not reviewed) that described no observable adverse effects levels (NOAELs) for crop species. Authors generally evaluated effects in terms of growth (length) or population (biomass or abundance). For monocotyledonous plants (moncots), there were 12 studies (ECOTOX Reference Numbers E89091, E91471, E91429, E91647, E91672, E88845, E89090, E91914, E91390, E92124, E91584, E91626) evaluating effects on 4 different crop species (rice, barley, bread wheat, and grass). NOAELs ranged from 0.202-0.981 lb ai/A. For dicotyledonous plants (dicots), there were 2 studies, one on bell pepper (E91430) and one on sesame (E91627). NOAELs ranged from 0.445-17.84 lb ai/A.

Given that the application rate of 3.0 lb ai/A is currently registered for up to 5 applications only 5 days apart on dicots (cotton) and the application rate of 0.75 lb ai/A (grass, representing the more sensitive monocots) is currently registered for up to 6 applications only 5 days apart, it appears unlikely that even deposition of up to 0.75 lb ai/A has a low likelihood to cause detrimental effects on either monocots or dicots.

4.3 Use of Probit Slope Response Relationship

Generally, available toxicity data provide an LC_{50} or an EC_{50}. Because the Endangered Species Act (ESA) requires determination of potential effects at an individual level, this information must be extrapolated from existing data. The Agency uses the probit dose response relationship as a tool for deriving the probability of effects on a single individual (U.S. EPA, 2004). The individual effects probability associated with the acute RQ is based on the mean estimate of the probit dose response slope and an assumption of that probit model is appropriate for the data set. In some cases, probit is not the appropriate model for the data, and the Agency has low confidence in extrapolations from these types of data sets. Upper and lower-bound estimates of the effects probability are also provided. The upper and lower bounds of the effects probability are based on available information on the 95% confidence interval of the slope. 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). Probabilities of individual effects for the various assessment endpoints are provided in Table 22.

The methyl parathion probit slopes for assessment endpoints used in the analysis and from other studies reviewed in preparing the analysis ranged from approximately 10 to 40. A steep slope indicates that mortality (from 0% to 100%) occurs over a fairly small exposure range. Thus, the chance of an individual mortality effect below the LC_{50} is correspondingly also low ($<1 \times 10^{16}$). However, the potential for mortality of all individuals (LC_{100}) exposed at concentrations only slightly above the LC_{50} is high (not quantified by IECV1.1). The model is not used to evaluate the probability of individuals with sublethal effects.

In circumstances where a probit dose-response slope is not available, the Agency relies on a default slope of 4.5 (USEPA 2004).

Table 22 Probability of Individual Effects

Assessment Endpoint	Surrogate Species	LC_{50}/ LD_{50} and Slope	Fits Probit	Chance of Individual Effect
Aquatic-Phase (Eggs, larvae, tadpoles, juveniles and adults)				
Direct Effects				
Acute Toxicity to Frog	Cutthroat trout	1,850 µg/L and 14.8	Unknown[1]	<1 in 10^{16}
Chronic Toxicity to Frog	Rainbow trout	Evaluated based on no effects level, chance of effects evaluation not required		
Indirect Effects (Prey Reduction)				
Acute Toxicity to Prey	Water flea	0.97 µg/L and 4.5 (default slope)	Unknown[1]	1 in 4.2×10^{8}
	Cutthroat trout	1,850 µg/L and 14.8	Unknown[1]	<1 in 10^{16}
Chronic Toxicity to Prey	Water flea	Evaluated based on no effects level, chance of effects evaluation not required		
	Rainbow trout			
Indirect Effects (Habitat Modification)				
Acute Toxicity to Aquatic Plants	Chance of effects evaluation not required			
Acute Toxicity to Terrestrial Plants				
Terrestrial-Phase (Juveniles and adults)				
Acute Toxicity to Frog	Bobwhite quail	9.8 mg/kg and 12.6 (lower bound) 9.8 mg/kg and 26.8 (slope) 9.8 mg/kg and 41.0 (upper bound)	Yes	<1 in 10^{16} <1 in 10^{16} <1 in 10^{16}
Chronic Toxicity to Frog	Bobwhite quail	Evaluated based on no effects level, chance of effects evaluation not required		
Acute Toxicity to Prey	Honey bee	0.28 µg/bee and 4.5 (default slope)	Unknown[1]	1 in 4.2×10^{8}
	Bobwhite quail	9.8 mg/kg and 12.6 (lower bound) 9.8 mg/kg and 26.8 (slope) 9.8 mg/kg and 41.0 (upper bound)	Yes	<1 in 10^{16} <1 in 10^{16} <1 in 10^{16}
	Rat	0.28 µg/bee and 4.5 (default slope)	Unknown[1]	
	Bobwhite quail	Evaluated based on no effects level, chance of effects evaluation not required		
Acute Toxicity to Terrestrial Plants	Chance of effects evaluation not required			

[1]Raw data not available to calculate
ND Not determined

4.4 Incident Database Review

A total of 30 aquatic incidents for methyl parathion were listed in the OPP Ecological Incident Information System (EIIS) database. Of these, 73% occurred in the 1970's, and only 5 (16%) occurred more recently than 1990. In all cases where the species affected was reported, it was a fish kill, with the magnitude of the kill generally ranging from hundreds to thousands of fish. In a number of cases (43%), the legality of the application was listed as accidental misuse, with most of the other incidents listed as registered use or legality unknown. In 47% of the cases, certainty was described as probable to highly probable. Because methyl parathion is highly toxic to aquatic invertebrates, and death of such organisms is rarely reported unless they are economically important (*e.g.*, a shrimp fishery), incidents listed in the database may underestimate impact of methyl parathion on aquatic ecosystems and as such, the absence of more recent incidents should not be construed as the absence of incidents.

In the terrestrial category, 63 incidents were reported. Effects on plants are listed in the database separately, but only 2 plant incidents were listed, and one of them described the species affected as bees, so they have been included in the terrestrial description, bringing the total number of reported terrestrial incidents to 65. Of these incidents, the majority (94%) was reported in the time period following 1990, and they were heavily biased (95%) to reports regarding effects on pollinators (bees). The magnitude of effect was difficult to compare, as it was sometimes reported in terms of hives, and at other times in terms of colonies or sites. The likelihood that the incident was associated with a particular pesticide, *i.e.*, certainty, was classified as "probable" or "highly probable" for 80% of the reports. Whether the incident resulted from a labeled use of the pesticide, *i.e.*, legality of use, was uncertain, with 72% of the reports listing it as unknown. In 5 cases, it was listed as either accidental or intentional misuse. Only 3 reports listed species other than bees, and in all cases those were various bird species, with the magnitude of the kill ranging from 10 to approximately 1500 individuals.

5.0 Risk Characterizations

5.1 Risk Estimation

Risk is estimated by calculating the ratio of the expected environmental concentration and the appropriate toxicity endpoint. This value is the risk quotient, which is then compared to pre-established levels of concern for each category evaluated. The RQ methodology, LOCs, and specific details of the calculations are contained in Appendix D. The highest EECs (based on maximum application rates) and most sensitive endpoints are used to determine the screening-level RQ. Using these two values is intended to result in a conservative estimate of risk. Risk quotients are presented in Table 23 (aquatic-phase CRLF) and Table 24 (terrestrial-phase CRLF). Both tables contain risk quotients for the three types of land classes affected by use of methyl parathion (agricultural, orchards, and rangeland). For agricultural uses, which have a range of maximum rates, RQs for the highest rate (use on cotton) and the lowest rate (use on onions) are presented. T-HERPS was also run for each of the land uses (results in

Appendix E), and LOC exceedances followed the same pattern as those for the risk quotients generated by T-REX.

Appendix E indicates for freshwater fish, RQ values are below acute and chronic LOCs except for use on rice which exceeds the acute and chronic risk LOCs. Appendix E also indicates that even following a single application of methyl parathion, RQ values for freshwater invertebrates exceed the acute and chronic risk LOCs across all of the uses evaluated.

Table 23 Risk Quotients for Direct and Indirect Effects on Aquatic-Phase CRLF.

Assessment Endpoint	Organism or Life Stage	Concentration Estimate	RQ	LOC Exceedence[1]
Aquatic-Phase CRLF (Eggs, larvae, tadpoles, juvenile, and adults)[a]				
Direct Effects				
Acute Toxicity to Frog	Juveniles, adults	Agricultural (highest)	<0.05	No
		Agricultural (lowest)	<0.05	No
		Orchards	<0.05	No
		Rangeland	<0.05	No
Chronic Toxicity to Frog	Eggs, larvae, tadpole	Agricultural (highest)	<1.0	No
		Agricultural (lowest)	<1.0	No
		Orchards	<1.0	No
		Rangeland	<1.0	No
Indirect Effects and Critical Habitat Effects				
Acute Toxicity to Prey	Fish	Agricultural (highest)	<0.05	No
		Agricultural (lowest)	<0.05	No
		Orchards	<0.05	No
		Rangeland	<0.05	No
	Invertebrate	Agricultural (highest)	69	*Yes*
		Agricultural (lowest)	16	*Yes*
		Orchards	9.8	*Yes*
		Rangeland	9.7	*Yes*
Chronic Toxicity to Prey	Fish	Agricultural (highest)	<1.0	No
		Agricultural (lowest)	<1.0	No
		Orchards	<1.0	No
		Rangeland	<1.0	No
	Invertebrate	Agricultural (highest)	35	*Yes*
		Agricultural (lowest)	9.5	*Yes*
		Orchards	13	*Yes*
		Rangeland	16	*Yes*
Acute Toxicity to Aquatic Plants (Habitat, Food Source)	Green algae	Agricultural (highest)	<1.0	No
		Agricultural (lowest)	<1.0	No
		Orchards	<1.0	No
		Rangeland	<1.0	No
Acute Toxicity to Terrestrial Plants (Wetland & Upland)	Plant (based on more sensitive monocots)		No effect distance	
		Agricultural (highest)	140 ft	
		Agricultural (lowest)	10 ft	
		Orchards	100 ft	
		Rangeland	20ft	

[1] LOCs used in this assessment:
Aquatic animals acute risk endangered species 0.05
Aquatic animals chronic risk 1.0
Aquatic plants acute risk 1.0.

Table 24 Risk Quotients for Direct and Indirect Effects on theTerrestrial-Phase CRLF.

Assessment Endpoint	Organism or Life Stage	Concentration Estimate	RQ	LOC Exceedence[1]
Terrestrial-Phase CRLF (Juveniles and adults)				
Direct Effects				
Acute Toxicity to Frog	Small (20g)	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	88 15 46 22	*Yes* *Yes* *Yes* *Yes*
Chronic Toxicity to Frog	All sizes	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	83 14 43 21	*Yes* *Yes* *Yes* *Yes*
Indirect Effects and Critical Habitat Effects				
Acute Toxicity to Prey	Terrestrial Invertebrate	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	237 40 123 59	*Yes* *Yes* *Yes* *Yes*
	Mouse (15 g herbivore)	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	89 15 46 22	*Yes* *Yes* *Yes* *Yes*
	Frog (20 g)	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	88 15 46 22	*Yes* *Yes* *Yes* *Yes*
Chronic Toxicity to Prey	Terrestrial Invertebrate	No data for chronic evaluation		
	Mouse (herbivore all sizes)	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	9.2 1.5 4.8 2.3	*Yes* *Yes* *Yes* *Yes*
	Frog (all sizes)	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	83 14 43 21	*Yes* *Yes* *Yes* *Yes*
Acute Toxicity to Terrestrial Plants (Wetland & Upland)	Plant (based on more sensitive monocots)	Agricultural (highest) Agricultural (lowest) Orchards Rangeland	No effect distance 140 ft 10 ft 100 ft 20ft	

[1] LOCs used in this assessment:
Terrestrial plants acute risk 1.0
Terrestrial vertebrates acute risk endangered species 0.1
Terrestrial invertebrates acute risk endangered species 0.05

5.2 Risk Description

5.2.1 Direct Effects

Direct effects quantitatively considered in this assessment and used as the basis for the determination are survival, growth, and reproduction of both the aquatic and terrestrial-phase CRLF. Sublethal effects reported in some studies, such as disorientation, which may cause increased susceptibility to predation and/or behavioral modifications affecting the survival of either adult or juvenile frogs were not quantitatively evaluated. Because a lower endpoint for these types of effects is not available, the Agency has not attempted to spatially distinguish a zone of anticipated effects.

5.2.1.1 Aquatic Phase

The aquatic phase considers life stages of the frog that are obligatory aquatic organisms, including eggs, larvae, and tadpoles. It also considers juveniles and adults, which spend a portion of their time in water bodies which may receive runoff containing methyl parathion. No LOCs (acute or chronic risk) were exceeded for surrogate organisms (fish) representing the aquatic-phase frog except for direct applications to water for use on rice. The effects determination for this component is no effect except for use on rice where both acute and chronic risk LOCs are exceeded.

5.2.1.2 Terrestrial Phase (Adults and Juveniles)

For this ecological risk assessment, terrestrial-phase adults are defined as frogs weighing 100g or more, based on the evaluation categories available in the T-REX model. Acute and chronic LOCs are exceeded for all three land uses. Using T-HERPS, acute and chronic LOCs were exceeded for all three land uses. The effects determination for this component is may affect, likely to adversely affect.

For this ecological risk assessment, terrestrial-phase juveniles are defined as frogs weighing 20 g to 99 g, based on the evaluation categories available in the T-REX model. Acute and chronic risk LOCs are exceeded for all three land uses. Using T-HERPS, acute and chronic LOCs were also exceeded for all three land uses. The effects determination for this component is may affect, likely to adversely affect.

5.2.2 Indirect Effects and Critical Habitat Effects (Reduction in Prey Base)

A reduction in prey base may adversely affect the CRLF by reducing its survival, growth, or reproduction. It is difficult to quantitatively evaluate the effect a reduction in prey base may have on an individual frog or frogs. However, based on the fact that both acute and chronic risk LOCs are exceeded for aquatic invertebrates and all terrestrial prey types in all land use categories evaluated, it is reasonable to assume there may be a measurable reduction in prey items in areas treated with methyl parathion or adjacent to areas treated with methyl parathion. The effects determination for this component of the indirect effects evaluation is may affect, likely to adversely affect. The effects determination for this component of the critical habitat evaluation is modification of critical habitat.

5.2.2.1 Terrestrial Invertebrates

Quantitative evaluation of terrestrial invertebrate effects is based on acute data from honeybees. Acute risk LOCs for all land use categories evaluated are exceeded.

5.2.2.2 Terrestrial-Phase Amphibians

Small amphibians are a portion of the prey base for the CRLF. For this ecological risk assessment, small amphibians are defined as frogs weighing 20 g to 99 g, based on the evaluation categories available in the T-REX model. Acute and chronic LOCs are exceeded for all three land uses. Using T-HERPS, acute and chronic risk LOCs are also exceeded for all three land uses.

5.2.2.3 Aquatic Plants

Algae and detritus may be consumed by the aquatic-phase CRLF. No LOCs are exceeded for aquatic plants based on aquatic plant toxicity data for nonvascular plants.

5.2.2.4 Aquatic Invertebrates

Aquatic invertebrates are a portion of the prey base for the CRLF. Acute and chronic risk LOCs are exceeded for all land uses

5.2.2.5 Fish

Fish are a portion of the prey base for the CRLF. No acute or chronic risk LOCs are exceeded for fish.

5.2.3 Indirect Effects and Critical Habitat Effects (Habitat Degradation)

Plants, both aquatic and terrestrial, provide cover and foraging locations for adult and juvenile CRLF. Degradation of plant communities could results in increased exposure to predators and/or decrease in prey availability. The effects determination for this aquatic plant component of the indirect effects evaluation is no effect, and for the terrestrial plant component is may affect, not likely to adversely affect (discountable). The effects determination for this component of the critical habitat evaluation is no modification of critical habitat.

5.2.3.1 Aquatic Plants (Vascular and Non-vascular)

Aquatic plants were evaluated based on data available for nonvascular plants, i.e., green algae. No LOCs were exceeded for any land use category evaluated.

5.2.3.2 Terrestrial Plants

The application rate of 3.0 lb ai/A is currently registered for up to 5 applications only 5 days apart on dicots (e.g., cotton) and the application rate of 0.75 lb ai/A (grass, representing the more sensitive monocots) is currently registered for up to 6 applications only 5 days apart, it appears that even deposition of up to 0.75 lb ai/A has a low likelihood to cause detrimental effects on either monocots or dicots. Even at the highest application rate (3 lb ai/A), the deposition associated with aerial spray drift falls below this level at 30 ft away from the application site.

Based on the data available, it appears that detrimental effects on terrestrial plants of a sufficient magnitude to cause take of CRLF due to indirect effects on the shelter and foraging area provided by these plants are extremely unlikely to occur, i.e., discountable, thus this component of the determination is considered may effect, not likely to adversely affect..

5.3 Risk Conclusions

After completing the analysis of the effects of methyl parathion on the federally listed threatened California red-legged frog *(Rana aurora draytonii)* in accordance with methods delineated in the Overview document (USEPA 2004), EFED concludes that the use of methyl parathion (PC#053501) may affect, and is likely to adversely affect the California red-legged, based on direct effects on juvenile and adult terrestrial-phase frogs and indirect effects on both the aquatic and terrestrial prey base. EFED also concludes that these potential effects on prey base constitute habitat modification (HM) to critical habitat. Rationale for each component assessed is provided in Table 25.

Table 25 Effects Determination for Methyl Parathion

Assessment Endpoint	Effects determination	Basis for Determination
Aquatic-Phase CRLF (Eggs, larvae, tadpoles, juveniles, and adults)[a]		
Direct Effects		
1. Survival, growth, and reproduction of CRLF	No effect (use on rice is an LAA)	No exceedances of acute or chronic risk LOCs for surrogate organisms representing the CRLF except for use on rice where both acute and chronic risk LOCs are exceeded.
Indirect Effects and Critical Habitat Effects		
2. Reduction or modification of aquatic prey base	May affect Likely to adversely affect Modification of critical habitat	Acute and chronic risk LOC exceedances for aquatic invertebrates for all land uses assessed. Anticipated effects on aquatic prey base.
3. Reduction or modification of aquatic plant community	No effect	No LOC exceedances for aquatic plants.
4. Degradation of riparian vegetation	May affect Not likely to adversely affect (Discountable)	Based available data detrimental effects of a sufficient magnitude to cause take of CRLF due to by these plants appear unlikely.
Terrestrial-Phase CRLF (Juveniles and Adults)		
Direct Effects		
5. Survival, growth, and reproduction of CRLF	May affect Likely to adversely affect	Acute and chronic risk LOC exceedances for both adults and juveniles based on both T-REX and T-HERPS estimates for all land use categories.

Indirect Effects and Critical Habitat Effects		
6. Reduction or modification of terrestrial prey base	May affect Likely to adversely affect Modification of critical habitat	Acute and chronic risk LOC exceedances for all prey categories for all land use categories.
7. Degradation of riparian and/or upland vegetation	May affect Not likely to adversely affect (Discountable)	Based available data detrimental effects of a sufficient magnitude to cause take of CRLF due to by these plants appear unlikely.

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. Attachment 2, which includes information on the baseline status and cumulative effects for the CRLF, can be used during this consultation to provide background information on past US Fish and Wildlife Services biological opinions associated with the CRLF.

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.

6.0 Uncertainties

Risk assessment, by its very nature, is not exact, and requires the risk assessor to make assumptions regarding a number of parameters, to use data which may or may not accurately reflects the species of concern, and to use models which are a simplified representation of complex ecological processes. In this risk assessment, EFED has used the best available data regarding such important parameters as the life history of the California red-legged frog, typical environmental conditions in the proximity of frog habitat, toxicity of methyl parathion, and usage of methyl parathion in the action area. Frequently, such information is better expressed as ranges rather then points, and when this is the case, EFED has opted to use the end of range resulting in a conservative estimate of risk, in order to provide the benefit of doubt to the frog. These uncertainties, and the directions in which they may bias the risk estimate, are described below.

6.1 Exposure Assessment Uncertainties

Overall, the uncertainties inherent in the exposure assessment tend to result in over-estimation of exposures. This is apparent when comparing modeling results with monitoring data. In general, the monitoring data should be considered a lower bound on exposure, while modeling represents an upper bound.

Differences between modeled EECs and monitoring results are generally attributable to three sources: 1) simulation modeling estimates are made using maximum label rates, monitoring data reflects typical use, 2) modeled values represent a small static water body, the vast majority of monitoring data is for streams and rivers which tend to be less vulnerable as high concentration tend to be of short duration as they pesticide is carried downstream more rapidly; 3) simulation modeling represents a small watershed near the area of application; 4) monitoring data usually represents higher order streams with large basins and multiple land uses; 5: modeled values are 1-in-10 year exceedance values. Since most monitoring data are from one or two year studies at any one site, it represents 1 in 2 year values.

6.1.1 Modeling Assumptions

The uncertainties incorporate in the exposure assessment cannot be quantitatively characterized. However, given the available data and the EFED's reliance on conservative modeling assumptions, it is expected that the modeling results in an over-prediction of exposure. Qualitatively, conservative assumptions which may affect exposure include the following:

- Modeling for each use site assumes that the entire 10-hectare watershed is taken up by the respective use pattern.
- The assessment assumes all applications have occurred concurrently on the same day at the exact same application rate.
- The assessment assumes all applications are at maximum labeled rate.

6.1.2 Maximum Use Scenarios

The screening-level risk assessment focuses on characterizing potential ecological risks resulting from a maximum use scenario, which is determined from label 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 pesticide resistance, timing of applications, cultural practices, and market forces.

6.1.3 Modeling Inputs

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

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

6.1.4 Aquatic Exposure Estimates

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

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

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

6.1.5 Usage Uncertainties

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

6.1.6 Action Area

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

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

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

6.2 *Effects Assessment Uncertainties*

6.2.1 Age Class and Sensitivity of Effects Thresholds

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

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

6.2.2 Use of Surrogate Species Data

Currently, there are no FIFRA guideline toxicity tests for amphibians. Therefore, in accordance with the Overview Document (U.S. EPA 2004), data for the most sensitive freshwater fish are used as a surrogate for aquatic-phase amphibians such as the California red-legged frog. Available open literature information on methyl parathion toxicity to aquatic-phase amphibians suggests sensitivity of this taxa to methyl parathion is in the same range as that of freshwater fish. Species sensitivity distribution data for amphibians indicates the range of sensitivity for organic compounds is similar to that of freshwater fish (Birge *et al.*, 2000). Therefore, the endpoint based on freshwater fish ecotoxicity data is assumed to be protective. Extrapolation of the risk conclusions from the most sensitive tested species to the California red-legged frog is more likely to overestimate the potential risks than to underestimate the potential risk. Information to indicate were the California red-legged frog may fall in an amphibian species sensitivity distribution was not located.

6.2.3 Extrapolation of Effects

Length of exposure and concurrent environmental stressors (*e.g.*, urban expansion, habitat modification, predators) will likely affect the response of the California red-legged frog to methyl parathion. Because of the complexity of an organism's response to multiple stressors, the overall "direction" of the response is unknown. Additional environmental stressors may decrease or increase the sensitivity to the herbicide. Timing, peak concentration, and duration of exposure are critical in terms of evaluating effects. These factors will vary both temporally and spatially within the action area. Overall, the effect of this variability may result in either an overestimation or underestimation of risk

6.2.4 *Acute LOC Assumptions*

The risk characterization section of this assessment includes an evaluation of the potential for individual effects. The individual effects probability associated with the acute RQ is based on the assumption that the dose-response curve fits a probit model. It uses the mean estimate of the slope and the LC_{50} to estimate the probability of individual effects.

6.2.5 *Residue Levels Selection*

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.

6.2.6 *Dietary Intake*

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

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

6.2.7 *Mixtures*

The California red-legged frog and various components of its ecosystem may be exposed to multiple pesticides, introduced into its environment either via a multiple active ingredient formulated product, a tank mixture, or transport from independently applied active ingredients. Multiple pesticides may act in an additive, synergistic, or antagonistic fashion. Quantifying reasonable environmental exposures and establishing reasonable corresponding toxicological endpoints for the myriad of possible situations is beyond the scope of this document, and in some cases, beyond the current state of ecotoxicological practice. Mixtures could affect the CLRF in ways not addressed in this assessment. Exposure to multiple contaminants could make organisms more or less sensitive to the effects of methyl parathion, thus the directional bias associated with environmental mixtures is unknown, and may vary on a case-by-case basis.

6.2.8 Sublethal Effects

For an acute risk assessment, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the assessment is exercised on a case-by-case basis and only after careful consideration of the nature of the sublethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sublethal endpoint) and the assessment endpoints.

6.2.9 Location of Wildlife Species

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

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