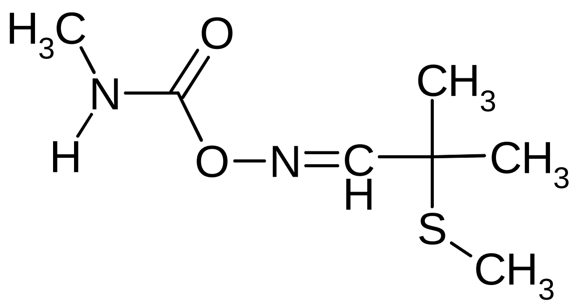
Risks of Aldicarb Use to Federally Listed Endangered California Red Legged Frog
(Rana aurora draytonii)



Authors:
Jonathan Angier
Fred Jenkins
Jeannette Martinez
Red Legged Frog Steering Committee

Reviewed by:
Donna Randall, Senior Effects Scientist
Dana Spatz, Senior Chemist/Branch Team Leader
Nelson Thurman, Senior Fate Scientist

Approved by:
Tom Bailey, Branch Chief
Environmental Risk Branch, 2
Environmental Fate and Effects Division

Environmental Fate and Effects Division
Office of Pesticide Programs
Washington, D.C. 20460
July 17 , 2007

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Executive Summary

Aldicarb is an insecticide, acaricide, and nematicide in the carbamate group of cholinesterase inhibitors. It is registered for use in California for both agricultural and non-agricultural purposes. These uses include: alfalfa, cotton, dried beans, sugar beet, sorghum, soybean, sweet potato, pecan, peanut, citrus, and ornamentals.

Granular aldicarb use in California entails a variety of application techniques and varies greatly in amounts applied, number of applications, application intervals, and timing of applications according to usage. Typically, the granules are spread on the surface and incorporated into the soil by 'shanking in', 'working into the soil', 'covering with soil', and/or 'wetting in'. Applications directly 'in-furrow' are also performed for some crops (e.g. sweet potato), but may be followed by later applications that are less effectively soil-incorporated. For the aquatic portion of this assessment, most applications were conservatively assumed to result in only 85% soil incorporation. Certain application techniques – specifically, in-furrow applications and banded applications that utilize state-of-the-art methods (such as positive displacement and immediate soil incorporation) – may theoretically result in incorporation efficiencies of 99%. However, crops that require additional applications after maturity cannot reasonably be expected to achieve 99% incorporation efficiency and are difficult to model jointly, so in cases where there are multiple applications in a single year (that also include post-emergent applications) an assumption of 85% incorporation (even if the first application could potentially be 99% effective) is more conservative than applying a 99% efficiency for all applications. To address this uncertainty, most model runs were conducted using both 85% and 99% incorporation efficiencies; all results are reported herein.

There are two aldicarb degradates of concern, aldicarb sulfoxide and aldicarb sulfone, that are also considered in this assessment. These degradates appear to form primarily in the shallow subsurface (although some may also form within plant tissue) and are potentially more mobile and persistent than the parent. As a conservative assumption, all three forms (parent aldicarb, sulfoxide, and sulfone) are considered as a single constituent for aquatic exposure estimates because of the longer degradate half-lives. Parent only is considered for terrestrial exposure because of its higher toxicity to animals, the likelihood that most exposure would be to whole granules, and because less of the degradate is expected to occur directly on the surface.

Alidcarb and its major toxic degradates of concern may move through the environment and be transported away from the site of application. Aldicarb and its degradates may potentially be transported as a component of runoff (dissolved in water or sorbed onto solids) or groundwater and end up in proximate surface water bodies. Historically, aldicarb and its major toxic degradates appears to be more likely to be found in groundwater than surface water. Although groundwater *per se* is not evaluated herein, it is nonetheless significant because discharging groundwater is likely to support low-order streams, wetlands, and intermittent ponds – environments that are favorable to California Red-Legged Frogs (CRLFs). Long-term chronic concentrations derived from the PRZM-

EXAMS model should reflect background concentrations that might be found in discharged groundwater/stream baseflow. Based on the product formulation and physical and chemical properties of aldicarb, atmospheric long range transport is not considered an exposure pathway of concern. While bioaccumulation of aldicarb or its major toxic degradates in animals through the food chain is also not expected to be a significant exposure pathway (*i.e.*, aldicarb and its degradates are expected to be rapidly metabolized at sublethal levels), secondary acute exposure is still a concern. Aldicarb is very highly toxic, and ingestion of a single granule is sufficient to result in death, with a delayed reaction time that potentially provides a window of opportunity for an exposed animal to move offsite before it is incapacitated or dies. Any granules not fully sorbed in the gut and metabolized in such animals potentially pose a secondary acute risk to a predator. In addition, dissolved aldicarb may be present in pools of water that typically form on the ground following an intense rainfall. Based on information on the extent of daily movements within a home range of small to medium size mammals (potential CRLR prey items), the potential extent of offsite movement was conservatively set to the upper range of one mile.

There were insufficient monitoring data to support an aquatic evaluation based on concentrations found in water samples; specifically there were no targeted monitoring data on aldicarb for this region. Thus, there are no values available that would be considered consistent with high-end ('peak') exposure concentrations expected in surface water – although positive aldicarb detections from non-targeted data sets may be indicative of lower-end exposure concentrations. Therefore, it was necessary to estimate exposure (and risk) based on modeled results. The initial aquatic estimation was based on standard PRZM-EXAMS operating methods described in the Overview Document (US EPA, 2004), using pre-existing scenarios as well as scenarios devised specifically for the CRLF (depending on crop type). The EXAMS outputs were then processed further to delineate an aquatic Action Area within which potential (direct and indirect) effects to relevant (plant and/or animal) species might result in their being adversely affected – regardless of the presence or absence of CRLFs in that area. Post-processing of EXAMS outputs included estimating dilution that would be expected to occur within a stream channel, extended downstream to a point where concentrations are predicted to drop below a level at which there is an expected impact on any aquatic plant or animal species.

In terms of direct effects, aquatic acute and chronic RQs are exceeded for the following modeled uses: dried bean, cotton, soybean (banded applications), pecan, peanut, alfalfa, and sugar beet. Sugar beet is the higher risk scenario and drives the overall risk in the aquatic environment and RQ/LOC exceedance based on sugar beet are used to determine the aquatic (downstream dilution) action area. Terrestrial acute and chronic RQs for on-site exposure are exceeded for all modeled scenarios: citrus, cotton, soybean, pecan, and sugar beet. Terrestrial acute and chronic risks off-site are not above levels of concern. Citrus drives the risk in the on-site terrestrial environment, followed by cotton. The initial area of concern for aldicarb is determined by including all potential crop land (agricultural and non-agricultural) from the 2002 National Land Cover Data (NLCD) and where aldicarb use has not been off-labeled (i.e. Del Norte and Humboldt Counties). The

Agency extended this area by 1 mile (home range of a CRLF prey item) to include the distance a CRLF prey item could fly (Haskell *et al.*, 2002) before succumbing to aldicarb effects. This one mile zone around crop land will account for part of the action area where aldicarb secondary poisoning effects, for predators ingesting birds, can be expected (extent of zone for small mammals likely to feed on fields is smaller).

Based on all available lines of evidence and the highest risk scenario, the Agency concludes a “likely to adversely affect” (LAA) determination for direct effects to the terrestrial and aquatic phase of the CRLF via mortality, growth, or reproduction in recovery units where exposure to aldicarb occurs; a “not likely to adversely affect” for direct effects to the terrestrial and aquatic phase of the CRLF via mortality, growth, or reproduction in recovery units where aldicarb could potentially be used, and the Agency determined LOC exceedances but CAL DPR PUR data informs that aldicarb has not been used from 2001 through 2005. The Agency concludes a LAA determination for indirect effects to the California Red Legged Frog based on expected adverse effects to the prey base of the CRLF.. The Agency also concludes a LAA determination for all designated critical habitats in recovery units 1, 3, 4, 5, 6, and 7 based on adverse effects expected to the terrestrial and aquatic animal components of the critical habitat. There is no designated critical habitat in recovery units 2 and 8.

Based on the highest risk scenario, the Agency also concludes that aldicarb is likely to indirectly adversely affect the terrestrial and aquatic phases of the CRLF by potentially negatively impacting the available prey items, for terrestrial prey this affect is limited to on-site exposures. This conclusion is based on the premise that there were LOC exceedances for all the potential prey items for the terrestrial (on-site) and aquatic phases of the CRLR for sugar beets.

No LOC exceedances are predicted for aldicarb sulfoxide based on modeled EECs and available freshwater fish and freshwater invertebrate endpoint values. The Agency concludes a “no effects” determination for direct effects of aldicarb sulfoxide to the aquatic phase of the CRLF.

The Agency also concludes a “no effects” determination for indirect effects to the aquatic phase of the CRLF via direct effects to aquatic plants in all recovery units. Lastly, the Agency concludes there is a “no effects” determination for indirect effects to the CRLF via direct effects to terrestrial plants and terrestrial plants growing in semi-aquatic areas (e.g., wetlands, saturated riparian zones, etc.) in all recovery units and critical habitat.

Key uncertainties and data gaps that affect conclusions about direct and indirect effects on California Red-Legged Frogs (and therefore the effects determination conclusions) include: 1) Lack of targeted monitoring data, which does not allow for direct comparison with model results – thus there is no means by which to definitively check the aquatic exposure estimates. However, monitoring data that are available indicate that, when present, sample concentrations are consistent with low-end model results, and may reflect ‘background’ levels in use areas; 2) Dilution factors used to establish the aquatic Action

Area were based upon drainage area rather than stream flow – thus requiring a number of simplifying assumptions that should be conservative and protective, but that nonetheless increases the likelihood of error (whereas stream flow would be a direct measure of actual dilution potential); 3) Information provided regarding aldicarb usage in California may be inaccurate, inconsistent, or contradictory, but is the best available at this time; 4) use of most sensitive freshwater and terrestrial animal endpoint values to calculate RQs, which are one of several lines of evidence used to make direct and indirect effects determinations; 5) use of surrogate species (bird) to assess risk to aquatic and terrestrial phase amphibians T-REX overestimates risk to small frogs by using the LD_{50} for small birds and underestimates risk to large frogs by using the LD_{50} for medium birds. Considering the uncertainties and unknowns, it is believed that this assessment provides the most accurate and reasonably protective risk evaluation currently possible.

Effects determinations for aldicarb direct effect, indirect effects, and effects to the critical habitat based on the highest risk scenario, sugar beet, and on-site effects to terrestrial prey items are displayed in Tables 1-3, below. Following the tables, effects determinations for individual registered crop uses and for on-site and off-site exposure of terrestrial prey items are delineated.

Table 1 Summarizes the effects determinations for direct effect of aldicarb to any of the life-stages of the CRLF in Eight Recovery Units.

Life stages include aquatic (eggs, larvae, tadpoles) and terrestrial phase of CRLF (young and adult frogs). The assessment endpoints are growth, survival, and reproduction of CRLF individuals.

Recovery Unit	Effects Determination	Basis for Effects Determination Conclusion
1	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF
2	NLAA	Based on lack of spatial overlap with Action Area (AA), frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
3	NLAA	Based on lack of spatial overlap with Action Area (AA), frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
4	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
5	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF;
6	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF
7	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
8	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF

* Summarize the effects determination by Recovery Unit, based upon the most conservative of the effects determinations. Summation by specific crops, more specific to on-site usage, is provided in the following text.

Table 2 Summarizes the effects determinations for indirect effect of aldicarb to any of the life-stages of the CRLF in Eight Recovery Units. The life stages include aquatic (eggs, larvae, tadpoles) and terrestrial phase of CRLF (young and adult frogs). The indirect effects include effects to habitat including effect to primary productivity, prey, and riparian habitat.		
Recovery Unit	**Effects Determination**	**Basis for Effects Determination Conclusion**
1	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.
2	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF food sources
3	NLAA	Based on lack of spatial overlap with AA
4	NLAA	Based on lack of spatial overlap with AA
5	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.
6	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.
7	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF food sources
8	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.

* Summarize the effects determination by Recovery Unit, based upon the most conservative of the effects determinations. Summation by specific crops, more specific to on-site usage, is provided in the following text.

Table 3 Summarizes the effects determinations for effects to the critical habitat the CRLF in recovery units one thru eight. The effects entail effects to growth and survival of terrestrial and aquatic plant and animal components.		
Recovery Unit	**Effects Determination**	**Basis for Effects Determination Conclusion**
1	LAA	Based on direct effects to terrestrial and aquatic animals which are components of the critical habitat.
2	NE	**No designated critical habitat in Recovery Unit (RU)**
3	NE	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to animals components of the critical habitat
4	NE	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to animals components of the critical habitat
5	LAA	Based on direct effects to terrestrial and aquatic animals which are components of the critical habitat.
6	LAA	Based on direct effects to terrestrial and aquatic animals which are components of the critical habitat.
7	NE	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to animals components of the critical habitat..
8	NE	**No designated critical habitat in RU**

*Summarize the effects determination by Recovery Unit, based upon the most conservative of the effects determinations. Summation by specific crops, more specific to on-site usage, is provided in the following text.

Aquatic Phase CRLF and Critical Habitat:

No Effect

Soybean (in-furrow and/or positive displacement applications only), Citrus, and Sorghum

Citrus, sorghum and soybean (but only when applied in-furrow with immediate soil incorporation or in-furrow with positive displacement) uses were determined to have "no effect" directly or indirectly on the aquatic-phase of the CRLF or the aquatic-phase of the critical habitat. This determination was based on the results of the risk assessment where all direct and indirect assessment endpoints of the aquatic-phase CRLF and its aquatic-phase critical habitat were either below endangered LOCs (i.e., no exceedences of LOCs for aquatic animals) or judged based on the best available information to not be affected (i.e., off-field terrestrial plant components of critical habitat and aquatic plants judged to not be affected, based on estimated exposure concentrations that were lower than a 'no observable effect' level for limited toxicity data). Although application rates for citrus are fairly high (4.95 lb a.i./A) and incorporation efficiency only 85%, low rainfall rates and other factors in citrus production areas of California contribute to relatively low aquatic exposure and risk estimates. For Sorghum use, low application rates (1 lb a.i./A) and high incorporation efficiency (in-furrow application, 99%) contribute to minimal aldicarb residues being exported into surface waters or off-field terrestrial habitat. When compared to less efficient application methods with approximately 85% soil incorporation (e.g., banded applications), the use of more efficient application techniques (e.g., in-furrow, positive displacement) results in higher incorporation efficiencies (99%), and concomitant exposure estimations well below LOCs for soybean.

Ornamentals (container grown) indoors

There is no exposure pathway by which aldicarb applied to ornamentals in containers grown indoors may reach and expose the aquatic-phase of the CRLF or its critical habitat (i.e., no run-off, no atmospheric transport, no CRLF or its critical habitat indoors). Therefore this use is determined to have "no effect" on the aquatic-phase of the CRLF or its critical habitat.

May Affect but Not Likely to Adversely Affect

Ornamentals (field grown—no containers) and Sweet Potato

Aldicarb registered uses on containerless field-grown ornamentals and sweet potato were identified as "may affect" because the acute RQ values for aquatic invertebrates exceeded the acute endangered LOC, the chronic RQ values exceeded the chronic LOC, and the chronic RQ for aquatic invertebrates exceeded the chronic LOC for sweet potato use. However, based on consideration of a number of factors, the level of effect both directly and indirectly to the aquatic-phase of the CRLF and its aquatic critical habitat for these assessment endpoints was determined to be discountable. Off-site terrestrial plant components of critical habitat and aquatic plants were judged to not be affected based on the best available information that estimated exposure concentrations were lower than ‘no observable effect levels’ (based on limited toxicity data). Therefore, aldicarb uses on containerless field-grown ornamentals and sweet potato were determined to “not likely adversely affect” the aquatic-phase of the CRLF and its critical habitat.

Direct effects to the aquatic-phase of the CRLF were considered discountable because the acute endangered RQ values did not exceed the endangered species LOC; while the chronic RQ value of 1 was exceeded, this exceedence was considered not significant and essentially indistinguishable from the no observable effect level. For example, the chronic RQ of 1.1 for containerless field grown ornamentals based on significant figures is not distinguishable from 1 (*i.e*., EEC/NOAEC = 0.49/0.46 ≅ 0.5/0.5 = 1), the level equivalent to no observable effects. In addition, ornamental usage is not extensive, and any potential impact on a water body adjacent to an application area would likely be minor, fleeting, and spatially very limited.

Loss of fish or aquatic invertebrates as dietary resources was considered discountable based on several factors affecting the frequency and duration of exposure and the magnitude of effect. For example, both of these uses are limited to a single application per year, with sweet potato application occurring at plant and ornamentals occurring at any time prior to or during an infestation but again limited by the label to a single application per year. Therefore, any potential impact on a water body adjacent to an application area would likely be minor and fleeting. The acute endangered LOC for fish is not exceeded for either use. Although the chronic LOC is exceeded, as discussed in the preceding paragraph these exceedences are essentially equivalent to the no observable adverse effect level. Additionally, other fish species are not as sensitive (*e.g*., fathead minnow), so any potential impact would be limited in both magnitude and number of species involved. For aquatic invertebrates, while the acute endangered LOC was exceeded, the likelihood that an individual would be affected for the most sensitive species was one-in-over a million (based on default slope of 4.5). Additionally, based on the invertebrate species sensitivity distribution, over 80 percent of the aquatic invertebrates would be even less sensitive. The chronic LOC was not exceeded for the ornamentals and was at the LOC of 1 for sweet potato use, which is equivalent to no observable effect on invertebrates.

Ornamentals (container grown) outdoors

Outdoor container grown ornamental use was considered to “not likely adversely affect” the aquatic-phase CRLF or its aquatic-phase critical habitat. This determination was based on the determination for containerless field grown ornamentals used as a surrogate. Surface water exposure concentrations are expected to be lower than that for containerless field grown ornamentals. This reduction is attributable to containers which are expected to physically reduce run-off of aldicarb and its major toxic degradates and lower application rates as compared to containerless field grown ornamentals. In addition, ornamental usage is not extensive, and any potential impact on a water body adjacent to an application area would likely be minor, fleeting, and spatially very limited.

May Affect and Likely to Adversely Affect

Dried Beans, Soybean (banded applications), Peanut, Pecans, Cotton, Alfalfa, Sugar beet

Aldicarb registered uses on dried beans, soybean, peanut, pecan, cotton, alfalfa, and sugar beet were identified as "may affect" and "likely to adversely affect" the CRLF directly because both the acute endangered LOC and chronic LOC were exceeded for amphibian assessment endpoints (fish used as surrogate) and indirectly because fish and aquatic invertebrate acute and chronic LOC values were exceeded.

It should be noted that for many of these crops, use of more efficient application techniques (i.e., ones that yield 99% vs. 85% incorporation) would result in exposure estimations well below the LOC for most categories (see Table 12). Although this might be impractical or impossible for some current uses (e.g., peanut application post-pegging, cotton application at bloom, pecan), in other cases (e.g., soybean, dried bean) achieving an incorporation efficiency of 99% results in acceptable levels of risk, and should be possible with appropriate application techniques (possibly requiring label changes).

Terrestrial Phase CRLF and Critical Habitat:

No Effect

Ornamentals (container grown) indoors

There is no exposure pathway by which aldicarb applied to ornamentals in containers grown indoors may reach and expose the terrestrial-phase of the CRLF or its terrestrial critical habitat (*i.e*., no run-off, no atmospheric transport, no CRLF or its critical habitat indoors). Therefore this use is determined to have "no effect" on the aquatic-phase of the CRLF or its critical habitat.

May Affect but Not Likely to Adversely Affect

Off-site All Outdoor Uses

Off-site exposure for all outdoor registered uses was identified as "may affect" because an individual terrestrial-phase CRLF that ingested a granule transported off-site in the gut (incidental ingestion) or on the fur of a small mammal would potentially be effected. All other off-site exposure of the terrestrial-phase CRLF (*i.e*., bioaccumulation in terrestrial invertebrates or mammalian dietary items) and its critical habitat (*i.e*., loss of dietary resources, riparian or upland plants) to aldicarb and its major toxic residues are below LOCs. Because exposure of a terrestrial-phase CRLF to a granule carried in a small-mammal off-field was considered unlikely and no other off-site exposure of the terrestrial-phase CRLF or its critical habitat were above LOCs, exposure off-site for all outdoor uses was considered discountable and therefore "not likely to adversely affect" either directly or indirectly the terrestrial-phase of the CRLF or its critical habitat.

Risks to terrestrial environments outside the zone of application for granular aldicarb are mainly limited to re-deposition of aldicarb residues in lower-lying areas affected by aldicarb runoff from nearby fields. However, calculations of the approximate amount of aldicarb potentially deposited as a result of registered aldicarb use (based on the highest risk scenario, cotton at 5 lbs a.i./A) indicate that concentrations (~ 10^{-6} mg a.i./kg soil) would be several orders of magnitude below those that would exceed the LOC.

Exposure off-site of a CRLF to a granule in the gut or on the fur of small mammal was considered unlikely because it is doubtful that the series of events needed to coincide for an actual exposure event to occur would be frequent, if they occurred at all. First, aldicarb is applied to most crops once per year, and infrequently for the others (*i.e.*, cotton at most three times and sugar beets and peanuts at most two times per year). Second, the duration of the integrity of a granule in the field is limited as it is fragile, and readily dissolves in water— irrigation or rainfall dissolves the granule and moves it down into the soil profile. Therefore the window of opportunity for a small mammal (as potential CRLF prey) to be exposed on field to a granule is limited to a few days a year. While it is considered likely that some small mammals may be exposed to aldicarb during this window, it is unlikely that a significant number of small mammals would then subsequently move off-site, and not die before encountering a CRLF (biological description does not indicate it feeds on carrion).

May Affect and Likely to Adversely Affect

On-site All Crops

On-site exposure for all outdoor registered uses was identified as "may affect" and "likely to adversely affect" the terrestrial-phase of the CRLF because the acute LOC was exceeded for the direct amphibian measurement endpoint (birds) and for indirect effects (*i.e.*, loss of small mammals, and on-site terrestrial invertebrates) for all uses. Bioaccumulation was demonstrated to not be a pathway of concern. This effects determination is based on the assumption that terrestrial-phase CRLF will come onto the treated site and that on-site resources are considered a critical component that supports CRLF (*i.e.*, invertebrates and insects on the field that the farmer is trying to eliminate are considered critical to the support of the CRLF) and that the field is considered part of the critical habitat. A number of the uses are applied on fields that have been prepared for planting and should be relatively barren of cover for the CRLF at the time of aldicarb application (i.e., sorghum, sweet potato, dried bean, and soybean).

Pooling the crop and aquatic- and terrestrial-phase specific analyses the following summarizes the effects determination by crop.

- A "No Effect" ("NE") determination was concluded for indoor container grown ornamentals because there is no exposure pathway for aldicarb to reach either the aquatic- or terrestrial-phase of the CRLF or its critical habitat.

- A “Not Likely to Adversely Affect” (“NLAA”) determination was concluded for soybean (in-furrow and/or positive displacement applications only), citrus, and sorghum uses based on the lack of direct and indirect, acute and chronic effects to the aquatic-phase of the CRLF and its critical habitat and the lack of or discountable direct and indirect, acute and chronic effects to off-site CRLF, or to its critical habitat.

- A “Not Likely to Adversely Affect” (“NLAA”) determination was concluded for containerless field-grown ornamentals, outdoor container grown ornamentals, and sweet potato based on the lack of direct or discountable direct and indirect, acute and chronic effects to the aquatic-phase of the CRLF and its critical habitat and the lack of or discountable direct and indirect, acute and chronic effects to off-site terrestrial-phase CRLF, or to its critical habitat.

- A “Likely to Adversely Affect” (“LAA”) determination was concluded for dried beans, soybean (banded applications), peanut, pecans, cotton, alfalfa, and sugar beet based on direct acute and chronic effects to the aquatic-phase of the CRLF, and indirect effects to fish and aquatic invertebrates (food resources to aquatic- and terrestrial-phase of the CRLF) and its critical habitat. However, there is no direct and indirect, acute and chronic effects to off-site terrestrial-phase CRLF, or its critical terrestrial habitat.

- A “LAA” determination was concluded for all uses if terrestrial-phase CRLF will come onto the treated site and that on-site resources are considered a critical component that supports CRLF (i.e., invertebrates and insects on the field that the farmer are trying to eliminate are considered critical to the support of the CRLF) and that the field is considered part of the critical habitat.

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 adverse modification to critical habitat.

2. 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. This assessment was completed in accordance with the August 5, 2004 Joint Counterpart Endangered Species Act (ESA) Section 7 Consultation Regulations specified in 50 CFR Part 402 (USFWS/NMFS 2004; FR 69 47762). 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 procedures outlined in the Overview Document (U.S. EPA 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 aldicarb on alfalfa (Section 24c), dried beans (Section 3), citrus, cotton (Section 3), peanuts (Section 3), pecan (Section 3 and 24c), sorghum (Section 3), soybean (Section 3), sugar beet (Section 3), sweet potato(Section 3), and ornamentals. In addition, this assessment evaluates whether these actions can be expected to result in the destruction or adverse modification of the species' critical habitat. Key biological information for the CRLF is included in Section 2.5, and designated critical habitat information for the species is provided in Section 2.6 of this assessment. This ecological risk assessment has been prepared as part of the *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)) settlement entered in the Federal District Court for the Northern District of California on October 20, 2006. It is one in a series of endangered species effects determinations for pesticide active ingredients involved in this litigation.

In this endangered species assessment, direct and indirect effects to the CRLF and potential adverse modification to its critical habitat are evaluated in accordance with the methods (both screening level and species-specific refinements, when appropriate) described in the Agency's Overview Document (U.S. EPA 2004). Use of such information is consistent with the guidance provided in the Overview Document (U.S. EPA 2004), which specifies that "the assessment process may, on a case-by-case basis, incorporate additional methods, models, and lines of evidence that EPA finds technically appropriate for risk management objectives" (Section V, page 31 of U.S. EPA 2004).

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook,* the assessment of effects associated with registrations of aldicarb are based on an action area. The action area is considered to be the area directly or indirectly affected by the federal action, as indicated by the exceedance of Agency Levels of Concern (LOCs) used to evaluate direct or indirect effects. It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of aldicarb may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the CRLF and its designated critical habitat within the state of California.

As part of the "effects determination," one of the following three conclusions will be reached regarding the potential for registration of aldicarb at the use sites described in this document to affect CRLF individuals and/or result in the destruction or adverse modification of designated CRLF critical habitat:

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

Critical habitat identifies specific areas that have the physical and biological features, (known as primary constituent elements or PCEs) essential to the conservation of 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 (Section 2.6).

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 the FIFRA regulatory action regarding aldicarb 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 regarding aldicarb.

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

The Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat.

Because aldicarb is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for aldicarb is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes (i.e., the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of aldicarb 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 and jeopardize the continued existence of the species have been identified by the Services and are discussed further in Section 2.6.

2.2 Scope

Aldicarb (2-methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl)oxime), also known by the trade name TEMIK®, is a granular pesticide that was first registered for use on cotton in 1970. Aldicarb is an insecticide, acaricide, and nematicide, and is used in California on a variety of crops. Currently registered crop uses in California include: alfalfa, cotton, dried beans, citrus, sugar beet, sorghum, soybean, sweet potato, pecan, and peanut. County level usage data for aldicarb were obtained from California's Department of Pesticide Regulation Use Reporting (CDPR PUR) database. Reported usage information considered in this assessment spans from 2001-2005 and is for the following commodities: *alfalfa, cotton, dried beans, citrus, sugar beet, sorghum, sweet potato, pecan, and ornamentals.*

There are a number of uses reported in the CDPR PUR database (37 records out of 14,960 records or 0.2% of the database) that either are misuses or entry errors in the database for they are not supported by past or current state (Section 24c) or national (Section 3) labels for aldicarb. These uses are not part of the FIFRA regulatory action and have not been included in this assessment but are identified here for completeness: *landscape maintenance (1 record), soil fumigation/preplant (2 records), tomato processing (1 record), rights of way (1 record), almonds (1 record), corn (forage-fodder) (9 records), corn (human consumption) (2 records),* and *structural pest control (1 record).* Aldicarb was also used in research (i.e., research commodity record) in 2004 (1 record, 23.1 lbs to 11 acres), in 2002 (2 records, 11.55 lbs to 5.5 acres, and 10.95 lbs to an unknown number of acres), and in 2001 (1 record, 4.5 lbs to unknown number of acres); the research occurred in Fresno and Tulare Counties. This use will be excluded as well from this assessment. Experimental use permits are federal actions that are taken for specific research projects which are typically of limited use and acreage. Each experimental use is considered on a case-by-case basis, limited to the year that the permit was granted; ESA effects would be considered at the time when experimental use permits are granted.

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

This ecological risk assessment is for currently registered uses of aldicarb in portions of the action area that are reasonably assumed to be biologically relevant to the CRLF and its designated critical habitat. Further discussion of the action area for the CRLF and its critical habitat is provided in Section 2.7.

Consideration of degradates is an integral part of this risk assessment. There are two degradates of concern, aldicarb sulfoxide and aldicarb sulfone, that appear to form primarily in the shallow subsurface (although they may also be produced within plants that have systemically appropriated the parent chemical). Based on acute toxicity studies for freshwater fish, the relative toxicity relationship is: aldicarb > aldicarb sulfoxide > aldicarb sulfone. Based on the acute toxicity for freshwater invertebrates, the relative toxicity relationship is: aldicarb $\approx$ aldicarb sulfoxide > aldicarb sulfone. Total toxic residues (parent aldicarb + aldicarb sulfoxide + aldicarb sulfone) were modeled and evaluated in this screening-level assessment for aquatic exposure. Assuming 100 % of aldicarb parent in the terrestrial environment is a more conservative exposure assumption than modeling residues that are less toxic; therefore, this assessment does not consider degradates in the terrestrial environment.

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). Aldicarb does not have any registered products that contain multiple active ingredients.

There are many variables within the landscape covered by this risk assessment that can affect predicted exposure to (and ultimately effects of) aldicarb in any given area; even within contiguous Red-Legged Frog critical habitats in California there is great variability in land use and cover, topography, and precipitation.

2.3 Previous Assessments

Two previously published, relevant risk assessments for aldicarb are the aldicarb Registration Eligibility Document (US EPA, May 2005) and revised RED (US EPA, September 2006). Key conclusions on exposure and risks to terrestrial and aquatic wildlife as well as relevant data gaps as they relate to these two assessments are listed here. For specific details not mentioned in this assessment, these documents can be consulted. Risk conclusions were consistent and remained unchanged between assessments.

Exposure and Risk to Terrestrial Organisms:

- The cotton scenario (4.05 lbs ai/A; *banded sidedress, 1 application*) poses the highest use risk in the terrestrial environment to mammals and birds due to aldicarb levels in soil (highest acute RQ for small birds = 6400), followed by potato, sugar beet, peanuts and dry beans (RQ for small birds = 3000, 2800, 2800, 2600, respectively).

- The acute risk, acute restricted use, and acute endangered species LOCs for birds and mammals are exceeded for all target crops (cotton, dry beans, sorghum, peanuts, potatoes, soybeans, sugar beets, sweet potatoes, citrus, pecans, ornamentals) due to aldicarb levels in soil at both maximum allowed label rates (1.05 to 10.05 lbs ai/A) and average use rates (0.6 to 3.1 lbs ai/A).

- Acute levels of concern are consistently exceeded by a factor of greater than 100 and are frequently exceeded by more than 1000.

- Granules left exposed on the surface appear to be the main source of exposure, but other sources such as residues of aldicarb taken up by plants and soil invertebrates (e.g., earthworms) may also serve as a means of exposure.

- A single granule of TEMIK® 15G can kill a small bird

- Reproductive effects to birds at sub-lethal levels could not be assessed because of the lack of reproductive studies with aldicarb or its degradates, due in part to high acute toxicity. It has been difficult to design an experiment that utilizes a dose low enough not to acutely intoxicate adult birds.

- Reduction in seedling emergence and vegetative vigor to non-target terrestrial plants from runoff could not be assessed because of the lack of seedling emergence and vegetative vigor toxicity tests. Label identified the potential for impact to certain crop plants.

Exposure and Risk to Aquatic Organisms

- The cotton scenario (4.05 lbs ai/A; 1 application) poses the highest use risk in the aquatic environment to aquatic invertebrates and fish due to estimated levels of aldicarb and its degradates in surface water from runoff (highest acute and chronic RQs for freshwater invertebrates = 1.4 and 26.6, respectively), followed by pecans, soybeans, citrus, and potato (acute and chronic RQs of 0.60, 0.36, 0.15, 0.07 and 11.40, 6.76, 2.80, 1.40, respectively).

- There is acute risk for freshwater fish and invertebrates and estuarine/marine fish and invertebrates for all of the registered uses (list) with the exception of potatoes for freshwater fish and invertebrates and estuarine/marine fish.

- Based on the use of an estimated NOAEC for reproductive effects in freshwater fish, the chronic level of concern is also exceeded for freshwater fish (larval and juvenile survival) for cotton, pecan, and soybean use patterns.

- Based on the use of an estimated NOAEC for reproductive effects in estuarine/marine fish, the chronic level of concern is exceeded for estuarine/marine fish for all crop scenarios.

- Aldicarb residues are most likely to exceed levels of concern for fish and aquatic invertebrates in low-order streams because these streams are dominated by baseflow conditions (where 100% of stream flow consists of discharged groundwater), and most of the toxic residues are believed to form within the subsurface (especially within the saturated zone) and are conveyed by groundwater. Higher-order streams are sustained by much larger contributing land areas, so there should be a greater dilution effect.

- In addition to risk based exposure estimates from modeling, there were also exceedances of the Agency levels of concern based on surface water residue monitoring data.

2.4 Stressor Source and Distribution

Chemical and Physical Properties

Common Name:	Aldicarb
Chemical Name:	2-methyl-2(methylthio)propionaldehyde O-(methylcarbamoyl)oxime
CAS No.	116-06-3
PC Code:	098301
Molecular Formula:	$C_7H_{14}N_2O_2S$
Molecular Weight:	190.2 g/mol
Density:	1.2 g/cm^3
Melting Point:	100^{N}C
Boiling Point:	decomposes above 100^{N}C
Vapor Pressure:	2.55×10^{-5} mm Hg at 25^{o}C
Water Solubility:	6,000 mg/L(pH 7, 25 ^{o}C)
Henry's Law Const.:	1.7×10^{-10} atm m^3/mole
Octanol/Water Partition Coefficient (K_{OW}):	14
Formulations:	Granules (*e.g.* Active ingredient 15.0%, Inert ingredients 85.0%)

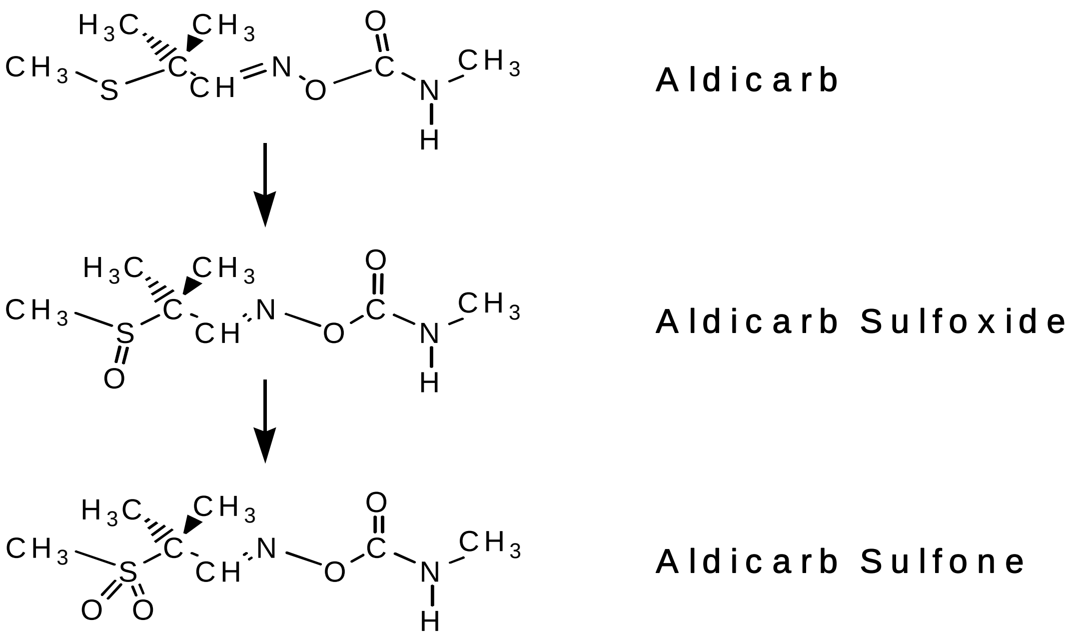


Figure 1 Chemical structure of aldicarb and its oxidative transformation products

2.4.1 Environmental Fate Assessment

Aldicarb rapidly degrades to aldicarb sulfoxide and aldicarb sulfone – both of which are as toxic or nearly as toxic as, and are more persistent than, the parent. Other aldicarb degradates may form as well, but are substantially less toxic and/or produced only in small amounts (<5%) and so are not included in this evaluation. Aerobic soil metabolism is the primary dissipation route for parent aldicarb in unsaturated soil. Half-lives for parent aldicarb range from 1 to 28 days (MRIDs 00102051, 00093642, 00080820, 00093640, 00053366, 00101934, 00035365, and 00102071). There is currently insufficient data to accurately estimate the formation and dissipation rates of the sulfoxide and sulfone degradates. However, the rapid oxidation of parent aldicarb to these forms, and their substantially greater persistence than the parent, have been well documented in the published literature (*e.g*. Bull et al., 1970; Smelt *et al.*, 1979).

Laboratory studies suggest that degradation of all three aldicarb forms (parent, sulfoxide, and sulfone) to relatively non-toxic, non-carbamate residues (oximes and nitriles) occurs slowly ($t_{1/2}$ up to 3 months) in aerobic soils, as a result of soil-catalyzed hydrolysis rather than aerobic metabolism (Lightfoot *et al.*, 1987; Bank and Tyrrell, 1984). Parent aldicarb is generally stable to hydrolysis, slowly hydrolyzing only at a pH of 9 (MRID 00102065). Aldicarb sulfoxide hydrolyzed more quickly ($t_{1/2}$ = 2.3 days) at pH 9 than at pH 7 (about 6% at 28 days) (MRID 00102066). Aqueous photolysis rapidly degraded aldicarb to oxime and nitrile forms (*i.e*. with a $t_{1/2}$ of four days: MRID 42498201). However, this process will only be dominant in clear, shallow waters, and will not affect residues in the subsurface.

While there is limited information on aerobic metabolism in aquatic environments, a published laboratory study (Vink *et al.*, 1997) reported half-lives ranging from 70 to 173 days in surface waters in the Netherlands. The fate of parent aldicarb under anaerobic aquatic conditions (particularly groundwater) is of less concern than that of the degradates (aldicarb sulfoxide and aldicarb sulfone), which have been detected in groundwater long after application of the parent chemical had ceased. Published studies have reported increased degradation rates under low redox conditions, perhaps due to catalysis by reduced metal species in these environments (Bromilow *et al.*, 1986). For example, Smelt *et al.* (1983) reported laboratory half-lives of aldicarb sulfone and sulfoxide ranging from 2 to 131 days in Dutch subsoils under "anaerobic conditions" (310 mV), and from 84 to 1100 days under aerobic conditions. Given this information, it is likely that aldicarb sulfoxide and aldicarb sulfone, which degrade relatively slowly in aerobic soil (MRID 44005001), can gradually leach into groundwater and continue to provide detectable levels of these materials over long time periods.

In published field studies, dissipation half-lives for total carbamate residues in soil have ranged from approximately 0.3 to 5 months in the unsaturated zone, and 1 to 36 months in the saturated zone (Jones and Estes, 1995), in apparent contradiction to the observation of faster degradation under anaerobic (saturated) conditions. The reasons for the extreme variability in reported transformation rates (3 hours to 36 months) for aldicarb residues under anaerobic/saturated conditions are not known, but may be related to temperature, pH, and the presence of soils for surface catalysis (Lightfoot, *et al.*, 1987). Also, not all saturated zones are necessarily anoxic; if they are shallow, there can be sufficient interaction with the unsaturated zone such that the groundwater may be sub-oxic or even atmosphere-equilibrated (oxic). Monitoring data in areas with historical aldicarb contamination confirm the high persistence of total aldicarb residues in some groundwater. For example, twenty years after cessation of aldicarb use on Long Island, NY, aldicarb sulfone and sulfoxide are still the most frequently detected pesticide compounds in groundwater there (Suffolk County Dept. of Health Services, 2000).

In this assessment, 'total aldicarb residues' – consisting of parent aldicarb, the degradate aldicarb sulfoxide, and the degradate aldicarb sulfone – are considered for the aquatic assessment. This is done partly because the sulfoxide and sulfone degradates are nearly as toxic as the parent and are more mobile and persistent. For aquatic exposures the parent aldicarb may undergo some transformation to the sulfoxide and sulfone residues between the time of application to the soil and a runoff event. Therefore, by including both transformation products in addition to the parent and by modeling the combined residues using the most mobile and persistent fate parameters and comparing estimated exposures to the most toxic endpoint, we are accounting for the maximum potential exposure of aldicarb residues in the aquatic environment. In the case of terrestrial exposure, though, the higher toxicity of the parent and expectation that on-site surface residues of greatest concern will consist mostly of parent (especially whole granules) lead to an assumption of parent-only exposure in the terrestrial arena. That is, in the terrestrial environment the highest potential exposure will occur at the time of application before transformation, when parent aldicarb only is present. By assuming parent-only exposures and the higher toxicity of the parent, we are being similarly protective for the terrestrial environment.

2.4.2 Environmental Transport Assessment

Parent aldicarb is most likely to be transported off-site as a component of field runoff. Following a rain event, aldicarb may reach aquatic environments as sheet and channel flow from areas of application, since aldicarb is moderately persistent in terrestrial environments and soluble in water. It is unlikely, though, that undissolved granules will reach surface water bodies. The toxic degradates (aldicarb sulfoxide and aldicarb sulfone) are more prone to move vertically down through the soil profile, and potentially into groundwater, as they form primarily in the shallow subsurface. Groundwater that contains aldicarb residues may then be discharged into surface waters as baseflow. If the receiving groundwater is cool, acidic, and oxic, the sulfoxide and sulfone degradates will be very persistent and capable of long-distance subsurface transport.

Aldicarb and its oxidation products are all highly mobile in soil. Aldicarb itself has Freundlich K_{ads} values ranging between 0.20 ml/g (for sand) and 0.60 ml/g (for clay) (MRID 42498202). Aldicarb sulfoxide has Freundlich K_{ads} values between 0.17 ml/g (sandy loam soil) and 0.36 ml/g (sandy clay loam) (MRID 43560301). Aldicarb sulfone had slightly lower values, ranging between 0.12 ml/g and 0.22 ml/g for the same set of soils as the sulfoxide (MRID 43560302). Degradation rates for combined aldicarb residues (parent plus sulfoxide plus sulfone) were calculated based upon the available information; details may be found in Appendix N & P.

Potential transport mechanisms include pesticide surface water runoff, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. The magnitude of pesticide transport via secondary drift depends on the pesticide'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. A number of studies have documented atmospheric transport and redeposition of pesticides from the Central Valley to the Sierra Nevada mountains (Fellers et al., 2004, Sparling et al., 2001, LeNoir et al., 1999, and McConnell et al., 1998). Prevailing winds blow across the Central Valley eastward to the Sierra Nevada mountains, transporting airborne industrial and agricultural pollutants into Sierra Nevada ecosystems (Fellers et al., 2004, LeNoir et al., 1999, and McConnell et al., 1998). Therefore, physicochemical properties of the pesticide that describe its potential to enter the air from water or soil (e.g., Henry's Law constant and vapor pressure), pesticide use, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevadas are considered in evaluating the potential for atmospheric transport of aldicarb to habitat for the CRLF. Because aldicarb is applied as a granule and its potential to enter the air from water or soil is considered insignificant based on Henry's Law constant and vapor pressure).

2.4.3 Mechanism of Action

Aldicarb is a systemic insecticide, acaricide, and nematicide. It is a potent cholinesterase (ChE) inhibitor causing inhibition of erythrocyte acetylcholinesterase (RBC ChE) as well as plasma butyryl ChE by binding to the active site of the enzyme. Acetylcholinesterase is an enzyme necessary for the degradation of the neurotransmitter acetylcholine (ACh) and subsequent cessation of synaptic transmission. Inhibition of these enzymes in animals (i.e. terrestrial and aquatic invertebrates, fish, birds, amphibians, reptiles, mammals) results in the accumulation of ACh at cholinergic nerve endings and continual nerve stimulation leading to death.

2.4.4 Use Characterization

National (Section 3) uses for aldicarb are presented in Table 4, with label maximum application rates. Use on potato[1] and sugarcane[2] is prohibited in California on the Section 3 label (EPA Reg. No. 264-330). In California, dry beans and sorghum have the lowest allowed maximum application rates (7 lbs of product/A), while pecans, citrus, and sugar beet have the highest allowed maximum application rates among all crop uses permitted in the state (33 lbs, 33 lbs, and 28 lbs of product/A, respectively). For aldicarb use on dry beans in California, the target pests, which differ slightly from the rest of the states, are leafhoppers, Mexican bean beetle, mites, and nematodes. For the use on sugar beet in California, the target pests do not differ from the rest of the country; but California has restrictions on application window for sugar beet and dry beans from May 1 through September 1. For aldicarb use on sorghum, there are no restrictions on the Section 3 label for California. For aldicarb use on citrus, the Section 3 restriction for California refers to the application window only (May 1 through September 1). The use on pecans is restricted by the Section 24c label and restricts the maximum application per acre to 33 lbs of product (4.95 lbs a.i.) per acre.

[1] Label permits use on potato only in Florida, Pacific Northwest, and the following counties in Utah (Beaver, Boxelder, Cache, Carbon, Davis, Duchesne, Iron, Millard, lute, Salt Lake, Sanpete, Sevier, Uintah, Utah, Wasatch, Washington, and Weber) and Nevada (Humboldt, Pershing)

[2] Label permits use on sugarcane in Louisiana only

Table 4 National Labels Supporting Aldicarb Uses and Maximum Application Rates

National - Section 3 Registration			
Site	**Max 1 Time appl rate (lbs/A)**	**Max appl rate/year (lbs/A)**	**Max # appl/year**
Citrus	33	33	1
Cotton	20	33	3
Dry Beans	14	14	1
Peanuts	20	20	1
Pecans	67	67	1
Potato*	20	20	1
Sorghum	7	7	1
Soybean	20	20	1
Sugarbeet	27	33	3
Sugarcane*	20	20	1
Sweet Potato	20	20	1

label for nectarine not found; thus not included in table
*off labeled in California

Figure 2 shows an overlay of where aldicarb was used in 2001 through 2005 (source: California Department of Pesticide Regulation Use Reporting (CAL DPR); map shows land in California which is under crop cultivation (based on National Land Cover Data (NLCD) 2002), describing, based on best available information, the aerial extent of potential aldicarb use in California. Del Norte and Humboldt Counties (northwest corner of state) have been off labeled since 1983.

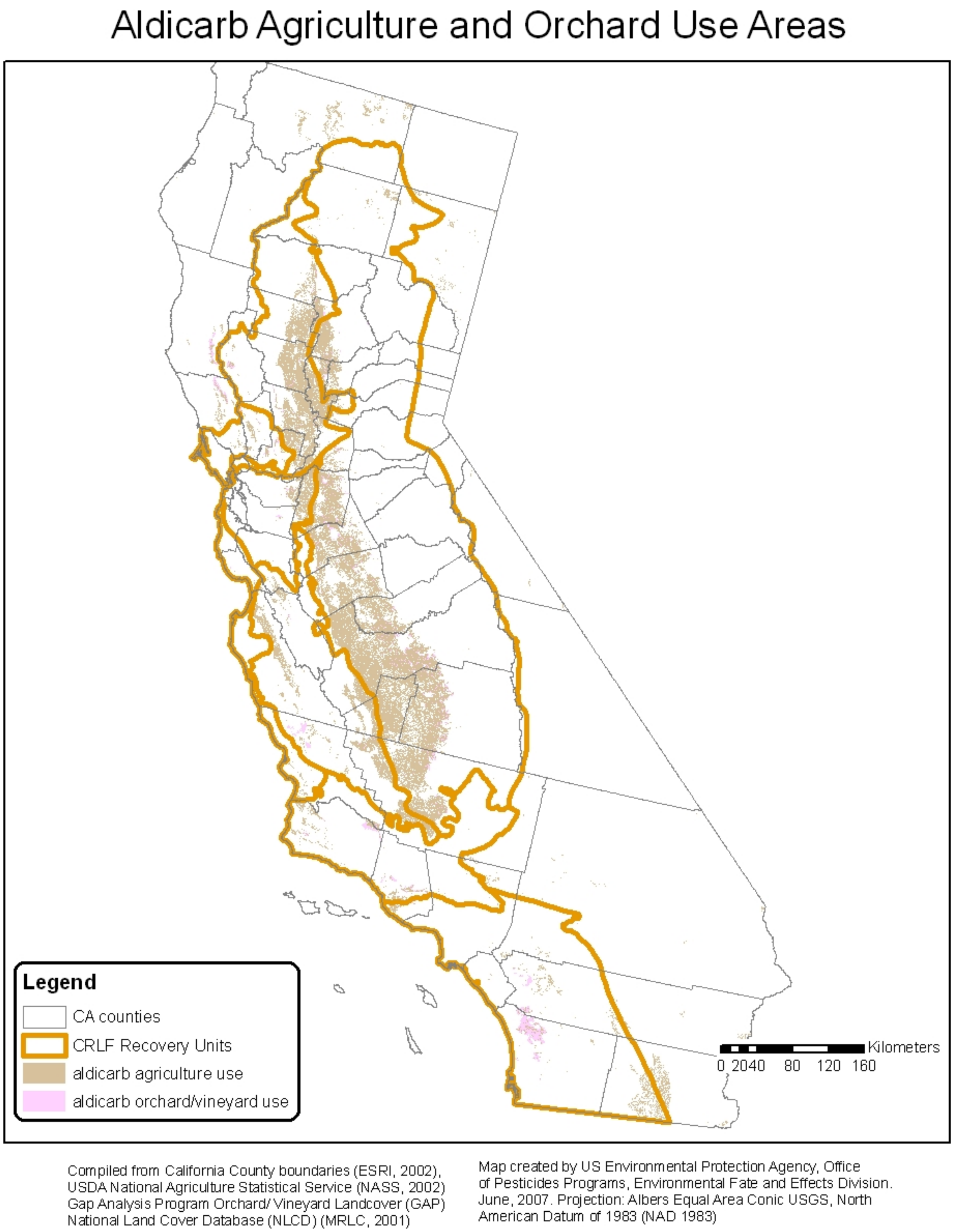


Figure 2 Aldicarb Use Areas (includes row crops and orchards) in California, with Recovery Units

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

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (BEAD, December 2006) using state-level usage data obtained from USDA-NASS[3], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature), and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[4] . CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for aldicarb by county in this California-specific assessment were generated using CDPR PUR data. Usage data are averaged together over the years 2000 to 2005 to calculate average annual usage statistics by county and crop for aldicarb, including pounds of active ingredient applied and base acres treated. California State law requires that every pesticide application be reported to the state and made available to the public. The summary of aldicarb usage for all use sites, including both agricultural and non-agricultural, is provided below in Table 5.

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

Table 5 California DPR Aldicarb Use, summarized by crop/use for 2001-2005

Use	AVG Annual Pounds Applied	AVG Annual Area Treated	Max. Avg. Application Rate (lb ai/A)	Max. 95 Percentile Application Rate (lb ai/A)	Max. 99 Percentile Application Rate (lb ai/A)	Max. Maximum Application Rate (lb ai/A)
Alfalfa	350.1	271.8 ac	2.18	2.69	2.69	2.69
Almond	63.0	30.0 ac	2.10	2.10	2.10	2.10
Bean, Dried	630.0	694.6 ac	1.06	2.10	2.10	2.10
Corn (Forage -Fodder) (a)	76.2	73.0 ac	0.86	2.10	2.10	2.10
Corn, Human Consumption (a)	45.4	60.5 ac	0.75	0.75	0.75	0.75
Cotton	234450.4	219023.3 ac	1.24	2.25	2.25	28.52
Landscape Maintenance (a)	0.2	Na	0.00	0.00	0.00	0.00
Nectarine	0.5	1.0 ac	0.45	0.45	0.45	0.45
N-Grnhs Flower	0.4	7400.0 sq ft	0.00	0.00	0.00	0.00
N-Grnhs Plants In Containers	0.4	22705.0 sq ft	0.00	0.00	0.00	0.00

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

Use	AVG Annual Pounds Applied	AVG Annual Area Treated	Max. Avg. Application Rate (lb ai/A)	Max. 95 Percentile Application Rate (lb ai/A)	Max. 99 Percentile Application Rate (lb ai/A)	Max. Maximum Application Rate (lb ai/A)
N-Outdr Flower	0.0	1425.0 sq ft	0.00	0.00	0.00	0.00
N-Outdr Plants In Containers	801.1	19219.1 ac	4.45	5.00	5.00	5.00
N-Outdr Transplants	19.3	6.5 ac	2.94	3.37	3.37	3.37
Pecan	5099.5	1067.4 ac	4.95	4.95	5.82	5.82
Research Commodity	11.4	4.1	2.10	2.10	2.10	2.10
Soil Fumigation/Preplant (a)	233.3	385.8 ac	0.90	0.90	0.90	0.90
Sorghum/Milo	16.5	8.0 ac	2.06	2.06	2.06	2.06
Structural Pest Control (a)	0.1	na	0.00	0.00	0.00	0.00
Sugarbeet	85.5	67.7 ac	1.31	2.40	2.40	2.40
Tomato, Processing (a)	10.5	17.5 ac	0.60	0.60	0.60	0.60
All Uses	241893.7	272460.2 ac	4.95	5.00	5.82	28.52

(a) Use reports in Cal DPR PUR that represent misuse or misreporting are excluded from this assessment
(b) Uses excluded in this assessment because they will not affect CRLF

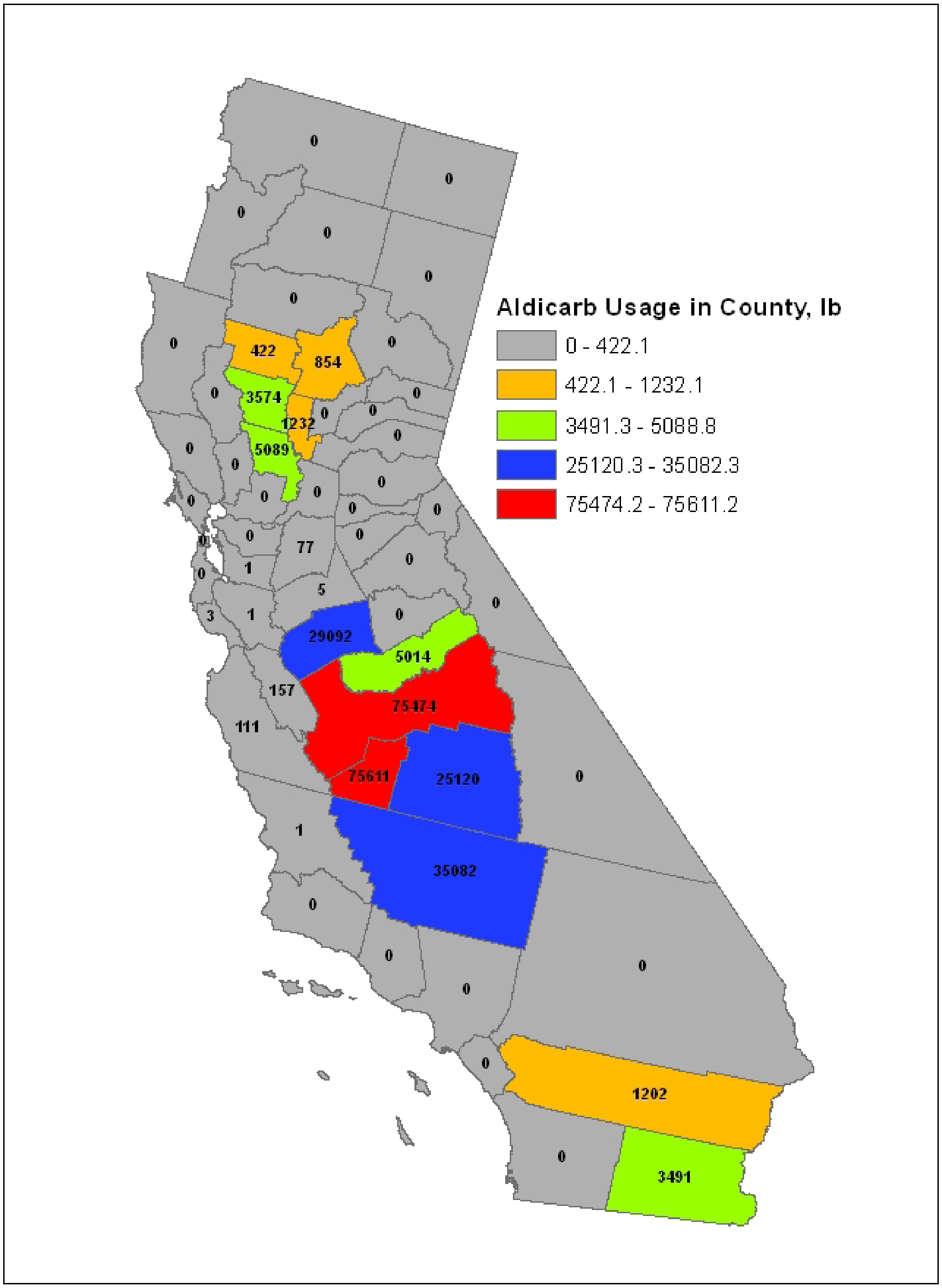


Figure 3 Aerial Extent of Known and Potential (Cultivated Land) Section 3 and 24c Aldicarb Use in California

2.5 Assessed Species

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

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

2.5.1 Distribution

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

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

The distribution of CRLFs within California is addressed in this assessment using four categories of location including recovery units, core areas, designated critical habitat, and known occurrences of the CRLF reported in the California Natural Diversity Database (CNDDB) that are not included within core areas and/or designated critical habitat (see Figure 4). Recovery units, core areas, and other known occurrences of the CRLF from the CNDDB are described in further detail in this section, and designated critical habitat is addressed in Section 2.6. Recovery units 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.

Recovery Units

Eight recovery units have been established by USFWS for the CRLF. These areas are considered essential to the recovery of the species, and the status of the CRLF "may be considered within the smaller scale of the recovery units, as opposed to the statewide range" (USFWS 2002). Recovery units reflect areas with similar conservation needs and population statuses, and therefore, similar recovery goals. The eight units described for the CRLF are delineated by watershed boundaries defined by US Geological Survey hydrologic units and are limited to the elevational maximum for the species of 1,500 m above sea level. The eight recovery units for the CRLF are listed in Table 6 and shown in Figure 4.

Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see Figure 4). Table 6 summarizes the geographical relationship among recovery units, core areas, and designated critical habitat. The core areas, which are distributed throughout portions of the historic and current range of the species, represent areas that allow for long-term viability of existing populations and reestablishment of populations within historic range. These areas were selected because they: 1) contain existing viable populations; or 2) they contribute to the connectivity of other habitat areas (USFWS 2002). Core area protection and enhancement are vital for maintenance and expansion of the CRLF's distribution and population throughout its range.

For purposes of this assessment, designated critical habitat, currently occupied (post-1985) core areas, and additional known occurrences of the CRLF from the CNDDB are considered. Each type of locational information is evaluated within the broader context of recovery units. For example, if no labeled uses of *aldicarb* occur (or if labeled uses occur at predicted exposures less than the Agency's LOCs) within an entire recovery unit, that particular recovery unit would not be included in the action area and a "no effect" determination would be made for all designated critical habitat, currently occupied core areas, and other known CNDDB occurrences within that recovery unit. Historically occupied sections of the core areas are not evaluated as part of this assessment because the USFWS Recovery Plan (USFWS 2002) indicates that CRLFs are extirpated from these areas. A summary of currently and historically occupied core areas is provided in Table 6 (currently occupied core areas are bolded). While core areas are considered essential for recovery of the CRLF, core areas are not federally-designated critical habitat, although designated critical habitat is generally contained within these core recovery areas. It should be noted, however, that several critical habitat units are located outside of the core areas, but within the recovery units. The focus of this assessment is currently occupied core areas, designated critical habitat, and other known CNDDB

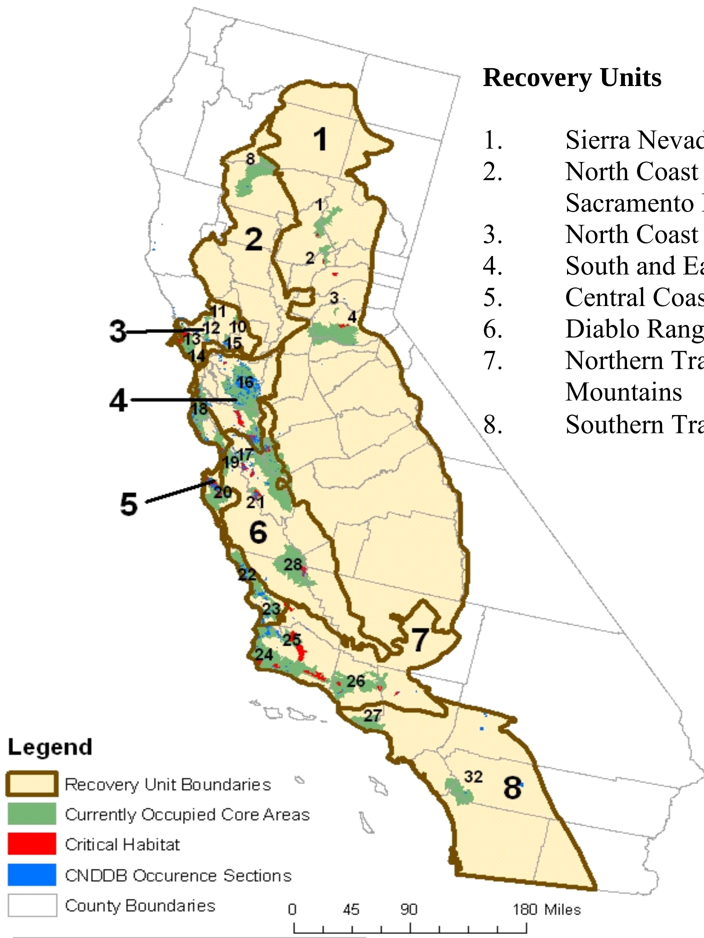
CRLF occurrences within the recovery units. Federally-designated critical habitat for the CRLF is further explained in Section 2.6.

Table 6 California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat.

Recovery Unit [1] (Figure 2.a)	**Core Areas [2,7] (Figure 2.a)**	**Critical Habitat Units [3]**	**Currently Occupied (post-1985) [4]**	**Historically Occupied [4]**
Sierra Nevada Foothills and Central Valley (1) (eastern boundary is the 1,500m elevation line)	**Cottonwood Creek (partial) (8)**	--	✓	
	Feather River (1)	BUT-1A-B	✓	
	Yuba River-S. Fork Feather River (2)	YUB-1	✓	
	--	NEV-1[6]		
	Traverse Creek/Middle Fork American River/Rubicon (3)	--	✓	
	Consumnes River (4)	ELD-1	✓	
	S. Fork Calaveras River (5)	--		✓
	Tuolumne River (6)	--		✓
	Piney Creek (7)	--		✓
	East San Francisco Bay (partial)(16)	--	✓	
North Coast Range Foothills and Western Sacramento River Valley (2)	**Cottonwood Creek (8)**	--	✓	
	Putah Creek-Cache Creek (9)	--		✓
	Jameson Canyon – Lower Napa Valley (partial) (15)	--	✓	
	Belvedere Lagoon (partial) (14)	--	✓	
	Pt. Reyes Peninsula (partial) (13)	--	✓	
North Coast and North San Francisco Bay (3)	Putah Creek-Cache Creek (partial) (9)	--		✓
	Lake Berryessa Tributaries (10)	NAP-1	✓	
	Upper Sonoma Creek (11)	--	✓	
	Petaluma Creek-Sonoma Creek (12)	--	✓	
	Pt. Reyes Peninsula (13)	MRN-1, MRN-2	✓	
	Belvedere Lagoon (14)	--	✓	
	Jameson Canyon-Lower Napa River (15)	SOL-1	✓	
South and East San Francisco Bay (4)	--	CCS-1A[6]		
	East San Francisco Bay (partial) (16)	ALA-1A, ALA-1B, STC-1B	✓	
	--	STC-1A[6]		
	South San Francisco Bay (partial) (18)	SNM-1A	✓	
Central Coast (5)	**South San Francisco Bay (partial) (18)**	SNM-1A, SNM-2C, SCZ-1	✓	
	Watsonville Slough- Elkhorn	SCZ-2 [5]	✓	

	Slough (partial) (19)			
	Carmel River-Santa Lucia (20)	MNT-2	✓	
	Estero Bay (22)	--	✓	
	--	SLO-8[6]		
	Arroyo Grande Creek (23)	--	✓	
	Santa Maria River-Santa Ynez River (24)	--	✓	
Diablo Range and Salinas Valley (6)	**East San Francisco Bay (partial) (16)**	MER-1A-B, STC-1B	✓	
	--	SNB-1[6], SNB-2[6]		
	Santa Clara Valley (17)	--	✓	
	Watsonville Slough- Elkhorn Slough (partial)(19)	MNT-1	✓	
	Carmel River-Santa Lucia (partial)(20)	--	✓	
	Gablan Range (21)	SNB-3	✓	
	Estrella River (28)	SLO-1A-B	✓	
Northern Transverse Ranges and Tehachapi Mountains (7)	--	SLO-8[6]		
	Santa Maria River-Santa Ynez River (24)	STB-4, STB-5, STB-7	✓	
	Sisquoc River (25)	STB-1, STB-3	✓	
	Ventura River-Santa Clara River (26)	VEN-1, VEN-2, VEN-3	✓	
	--	LOS-1[6]		
Southern Transverse and Peninsular Ranges (8)	**Santa Monica Bay-Ventura Coastal Streams (27)**	--	✓	
	San Gabriel Mountain (29)	--		✓
	Forks of the Mojave (30)	--		✓
	Santa Ana Mountain (31)	--		✓
	Santa Rosa Plateau (32)	--	✓	
	San Luis Rey (33)	--		✓
	Sweetwater (34)	--		✓
	Laguna Mountain (35)	--		✓

[1] Recovery units designated by the USFWS (USFWS 2000, pg 49).
[2] Core areas designated by the USFWS (USFWS 2000, pg 51).
[3] Critical habitat units designated by the USFWS on April 13, 2006 (USFWS 2006, 71 FR 19244-19346).
[4] Currently occupied (post-1985) and historically occupied core areas as designated by the USFWS (USFWS 2002, pg 54).
[5] Critical habitat unit where identified threats specifically included pesticides or agricultural runoff (USFWS 2002).
[6] Critical habitat units that are outside of core areas, but within recovery units.
[7] Currently occupied core areas that are included in this effects determination are bolded.



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 Recovery Units, Core Area, Critical Habitat, and Occurrence Designation for CRLF

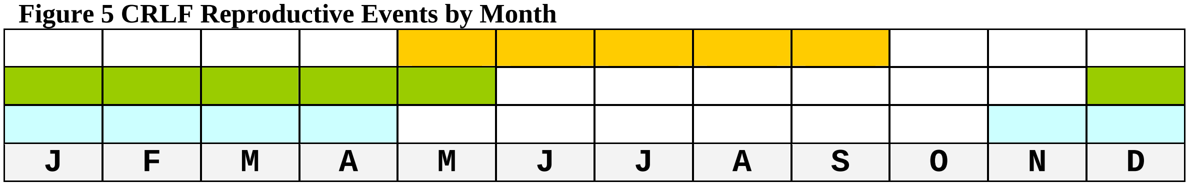
Other Known Occurrences from the CNDBB

The CNDDB provides location and natural history information on species found in California. The CNDDB serves as a repository for historical and current species location sightings. Information regarding known occurrences of CRLFs outside of the currently occupied core areas and designated critical habitat is considered in defining the current range of the CRLF. See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.

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



Light Blue = **Breeding/Egg Masses**
Green = **Tadpoles (except those that over-winter)**
Orange = **Young Juveniles**
Adults and juveniles can be present all year

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), and dense vegetation close to water and shading water of moderate depth are habitat features that appear especially important for CRLF (Hayes and Jennings 1988). Breeding sites include streams, deep pools, backwaters within streams and creeks, ponds, marshes, sag ponds (land depressions between fault zones that have filled with water), dune ponds, and lagoons. Breeding adults have been found near deep (0.7 m) still or slow moving water surrounded by dense vegetation (USFWS 2002); however, the largest number of tadpoles have been found in shallower pools (0.26 – 0.5 m) (Reis, 1999). Data indicate that CRLFs do not frequently inhabit vernal pools, as conditions in these habitats generally are not suitable (Hayes and Jennings 1988).

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

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

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

2.6 Designated Critical Habitat

In a final rule published on April 13, 2006, 34 separate units of critical habitat were designated for the CRLF by USFWS (USFWS 2006; FR 51 19244-19346). A summary of the 34 critical habitat units relative to USFWS-designated recovery units and core areas (previously discussed in Section 2.5.1) is provided in Table 6.

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

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

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

Please note that a more complete description of these habitat types is provided in Attachement 1.

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, USFWS does not include areas where existing management is sufficient to conserve the species. Critical habitat is designated outside the geographic area presently occupied by the species only when a designation limited to its present range would be inadequate to ensure the conservation of the species. For the CRLF, all designated critical habitat units contain all four of the PCEs, and were occupied by the CRLF at the time of FR listing notice in April 2006. The FR notice designating critical habitat for the CRLF includes a special rule exempting routine ranching activities associated with livestock ranching from incidental take prohibitions. The purpose of this exemption is to promote the conservation of rangelands, which could be beneficial to the CRLF, and to reduce the rate of conversion to other land uses that are incompatible with CRLF conservation. Please see Attachment 1 for a full explanation on this special rule.

USFWS has established adverse modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of aldicarb that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to USFWS (2006), activities that may affect critical habitat and therefore result in adverse effects to the CRLF include, but are not limited to the following:

(1) Significant alteration of water chemistry or temperature to levels beyond the tolerances of the CRLF that result in direct or cumulative adverse effects to individuals and their life-cycles.
(2) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat that could result in elimination or reduction of habitat necessary for the growth and reproduction of the CRLF by increasing the sediment deposition to levels that would adversely affect their ability to complete their life cycles.
(3) Significant alteration of channel/pond morphology or geometry that may lead to changes to the hydrologic functioning of the stream or pond and alter the timing, duration, water flows, and levels that would degrade or eliminate the CRLF and/or its habitat. Such an effect could also lead to increased sedimentation and degradation in water quality to levels that are beyond the CRLF's tolerances.
(4) Elimination of upland foraging and/or aestivating habitat or dispersal habitat.
(5) Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
(6) Alteration or elimination of the CRLF's food sources or prey base (also evaluated as indirect effects to the CRLF).

As previously noted in Section 2.1, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because *aldicarb* is expected to directly impact living organisms within the action area, critical habitat analysis for *aldicarb* is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7 Action Area

For listed species assessment purposes, the action area is considered to be the area affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). It is recognized that the overall action area for the national registration of aldicarb is likely to encompass considerable portions of the United States based on the large array of agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the state of California. Deriving the geographical extent of this portion of the action area is the product of consideration of the types of effects that aldicarb may be expected to have on the environment, the exposure levels to aldicarb that are associated with those effects, and the best available information concerning the use of aldicarb and its fate and transport within the state of California.

The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for aldicarb. An analysis of labeled uses and review of available product labels was completed. This analysis indicates that for aldicarb the following uses are considered as part of the federal action evaluated in this assessment:

- Alfalfa (for seed)
- Citrus
- Cotton
- Dried bean
- Sugar beet
- Sorghum
- Sweet potato
- Peanut
- Pecan
- Soybean
- Ornamentals (field-grown, no containers)

In all these cases granular aldicarb is applied directly onto/into the soil and is usually soil-incorporated.

After determination of which uses will be assessed, an evaluation of the potential "footprint" of the use pattern should be determined. This "footprint" represents the initial area of concern and is typically based on available land cover data. Local land cover data available for the state of California were analyzed to refine the understanding of potential aldicarb use. However, no areas are excluded from the final action area based on usage and land cover data. The initial area of concern is defined as all land cover types that represent the labeled uses described above. The borders of all cultivated land have been extended outward by 1 mile to account for secondary poisoning effects by listed terrestrial wildlife. This zone represents at most the home range for a small bird (Haskell *et al.*, 2002), and is used here synonymously with "the distance a small mammal could travel away from a site containing aldicarb" before falling prey to an adult CRLF. This constitutes the terrestrial portion of the aldicarb action area.

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

The physical/chemical properties of aldicarb are such that the dominant route of exposure is likely to be granules on the land surface. While there may be transient peaks in surface water bodies following large rain events that occur soon after application, both modeling and monitoring data indicate that this is probably not as common an occurrence. There is possible concern about infiltration into groundwater and subsequent discharge of tainted groundwater into water bodies inhabited by CRLFs. While this potential effect is not specifically incorporated into the delineation of the Action Area, some implications are discussed in section 3.2.

LOC exceedances are used to describe how far effects may be seen from the initial area of concern. Factors considered include: spray drift (N/A for aldicarb), downstream run-off, atmospheric transport (N/A for aldicarb), etc. This information is incorporated into GIS and a map of the action area is created. Figure 6 shows the spatial overlap of the aldicarb action area with all designated area for critical habitat in the eight recovery zones.

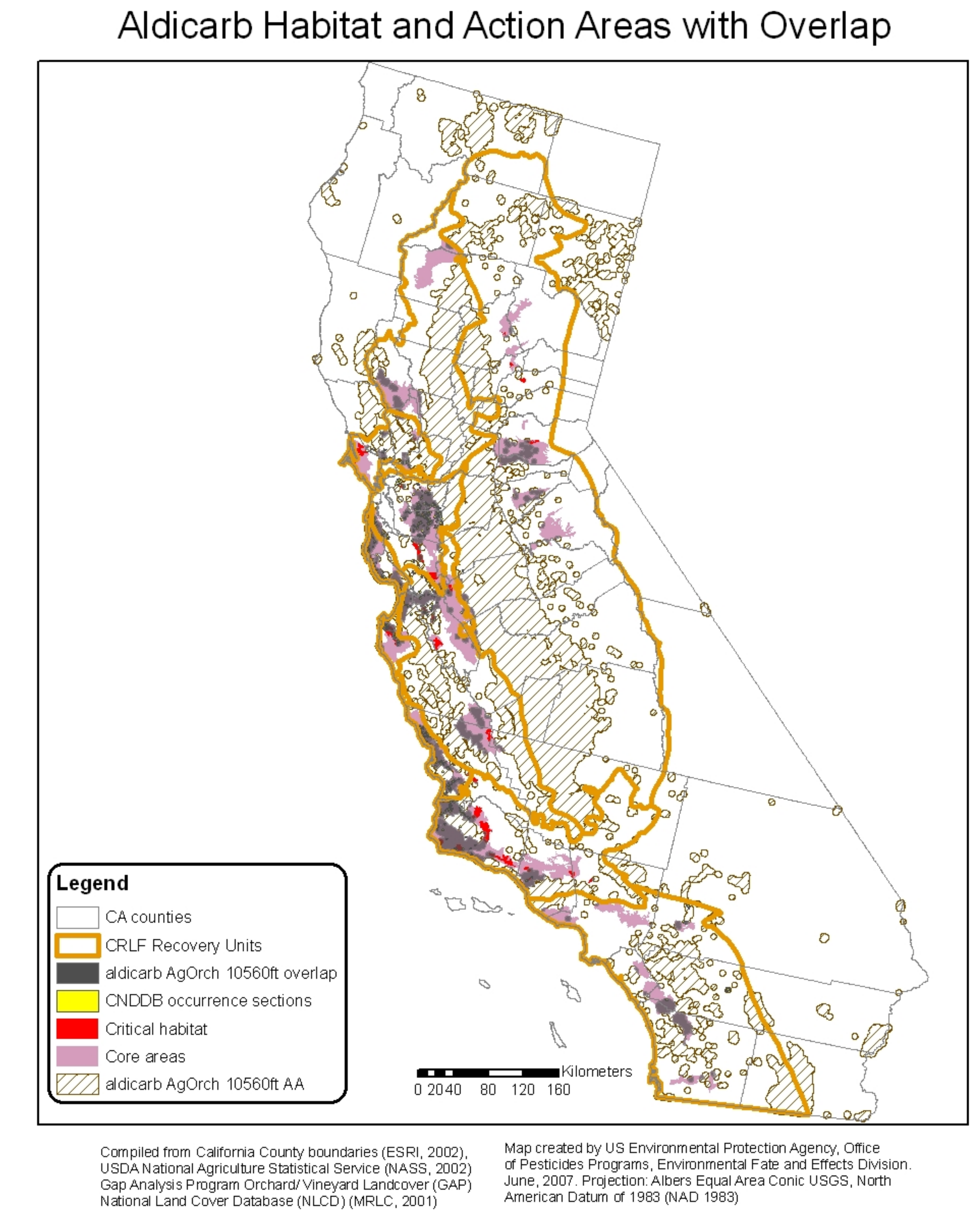


Figure 6 Spatial Overlap of Aldicarb Action Area with CRLF Critical Habitat.

Subsequent to defining the action area, an evaluation of usage information was conducted to determine the area where use of aldicarb may impact the CRLF. This analysis is used to characterize where predicted exposures are most likely to occur but does not preclude use in other portions of the action area

2.8 Assessment Endpoints and Measures of Ecological Effect

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected."[5] Selection of the assessment endpoints is based on valued entities (e.g., CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (e.g.,. water bodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of aldicarb and its major degradates (e.g., runoff, infiltration, etc.), and the routes by which ecological receptors are exposed to aldicarb-related contamination (e.g., direct contact, etc).

2.8.1. Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. In addition, potential destruction and/or adverse 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 aldicarb and its major degradates is provided in Table 7.

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

Table 7 Summary of Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of Aldicarb and its Degradates on the California Red Legged Frog

Assessment Endpoint	Measures of Ecological Effects[6] (Data Sources Reviewed)	Specific Selected Toxicity Value (basis)
	Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)[a]	
1. Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	1a. Most sensitive fish or amphibian acute LC_{50} (guideline or ECOTOX)	1a. Bluegill sunfish 96-hr LC_{50} = 52 ppb ai (most sensitive fish value)
	1b. Most sensitive fish or amphibian chronic NOAEC (guideline or ECOTOX)	1b. Bluegill sunfish early-life stage NOAEC = 0.46 ppb ai (estimated using ACR)
	1c. Most sensitive fish or amphibian early-life stage data	1c. same as 1b.
2. Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	2a. Most sensitive (1) fish, (2) aquatic invertebrate, and (3) aquatic plant EC_{50} or LC_{50} (guideline or ECOTOX)	2a1. Bluegill sunfish 96-hr LC_{50} = 52 ppb ai (most sensitive fish value)
		2a2. *Chironomus tentans* 48-hr EC_{50} = 20 ppb ai (most sensitive invertebrate value)
		2a3. Marine diatom 96-hr EC_{50} > 5000 ppb ai (only algal value available)
	2b. Most sensitive (1) aquatic invertebrate and (2) fish chronic NOAEC (guideline or ECOTOX)	2b1. *C. tentans* reproduction NOAEC = 1 ppb ai (estimated using ACR)
		2b2. Bluegill sunfish NOAEC = 0.46 ppb ai (estimated using ACR)
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Most sensitive vascular plant acute EC_{50} (duckweed guideline test or ECOTOX vascular plant)	3a. No data available
	3b. Most sensitive non-vascular plant acute EC_{50} (freshwater algae or diatom guideline or similar ECOTOX)	3b. Marine diatom 96-hr EC_{50} > 5000 ppb ai (only available algal test, used marine as surrogate for freshwater)
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	4a. Distribution of (1) seedling emergence and (2) vegetative vigor monocot EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX)	4a1. Pearl millet seedling emergence 21-d NOAEC = 2.05 lbs ai/A (No seedling emergence EC_{25} values available, used the only available plant study endpoint)
		4a2. Granular formulation so effect of residues on foliar vegetation is not applicable
	4b. Distribution of (1) seedling emergence and (2) vegetative vigor EC_{25} values for dicots (seedling emergence, vegetative vigor guidelines, or similar ECOTOX)[7]	4b1. No seedling emergence study data available
		4b2. Granular formulation so effect of residues on foliar vegetation is not applicable

[6] All registrant-submitted and open literature toxicity data reviewed for this assessment are included in Appendices D through F.
[7] The available information indicates that the California red-legged frog does not have any obligate relationships.

Assessment Endpoint	Measures of Ecological Effects[6] (Data Sources Reviewed)	Specific Selected Toxicity Value (basis)
Terrestrial Phase (Juveniles and adults)		
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Most sensitive bird[b] or terrestrial-phase amphibian acute LC_{50} or LD_{50} (guideline or ECOTOX)	5a. Mallard duck LD_{50} = 1 mg ai/kg-bw (most sensitive bird test as surrogate for terrestrial-phase amphibian)
	5b. Most sensitive bird[b] or terrestrial-phase amphibian chronic NOAEC (guideline or ECOTOX)	5b. Mallard duck reproduction NOAEC = 0.49 mg ai/kg-bw (Extrapolated using ACR)
6. Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*,terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	6a. Most sensitive terrestrial (1) invertebrate and (2) vertebrate acute EC_{50} or LC_{50} (guideline or ECOTOX)[c]	6a1. Honey bee acute contact LD50 = 0.285 µg ai/bee (most sensitive terrestrial invertebrate)
		6a2. rat LD_{50} = 0.9 mg ai/kg-bw (most sensitive terrestrial mammalian)
	6b. Most sensitive terrestrial (1) invertebrate and (2) vertebrate chronic NOAEC (guideline or ECOTOX)	6b1. No chronic NOAEC data for terrestrial invertebrates
		6b2. rat 2-generation reproduction study NOAEC = 0.4 mg/kg-bw
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	7a. Distribution of (1) seedling emergence and (2) vegetative vigor EC_{25} values for monocots (seedling emergence, vegetative vigor guideline or similar ECOTOX study)	7a1. Pearl millet seedling emergence 21-d NOAEC = 2.05 lbs ai/A (No seedling emergence EC_{25} values available, used the only available plant study endpoint)
		7a2. Granular formulation so effect of residues on foliar vegetation is not applicable
	7b. Distribution of (1) seedling emergence and (2) vegetative vigor EC_{25} values for dicots (seedling emergence, vegetative vigor, or ECOTOX)[5]	7b1. No seedling emergence study data available
		7b2. Granular formulation so effect of residues on foliar vegetation is not applicable

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

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of aldicarb that may alter the PCEs of the CRLF's critical habitat. PCEs for the CRLF were previously described in Section 2.6. Actions that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the CRLF. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (i.e., the biological resource requirements for the listed species associated with the critical habitat) and those for which aldicarb effects data are available.

Assessment endpoints and measures of ecological effect selected to characterize potential modification to designated critical habitat associated with exposure to aldicarb are provided in Table 8. Adverse modification to the critical habitat of the CRLF includes the following, as specified by USFWS (2006) and previously discussed in Section 2.6:

1. Alteration of water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult 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.

Measures of such possible effects by labeled use of aldicarb on critical habitat of the CRLF are described in Table 8. Some components of these PCEs are associated with physical abiotic features (e.g., presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 8 Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat

Assessment Endpoint	Measures of Ecological Effect[8] (Data Sources Reviewed)	Specific Selected Toxicity Value (basis)
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	a. Most sensitive aquatic plant EC_{50} (guideline or similar ECOTOX study)	a. Marine diatom 96-hr EC_{50} > 5000 ppb ai (only available algal test, used marine as surrogate for freshwater)
	b. Distribution of terrestrial monocot (1) seedling emergence and (2) vegetative vigor EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX studies)	b1. Pearl millet seedling emergence 21-d NOAEC = 2.05 lbs ai/A (No seedling emergence EC_{25} values available, used the only available plant study endpoint)
		b2. Granular formulation so effect of residues on foliar vegetation is not applicable
	c. Distribution of terrestrial dicot (1) seedling emergence and (2) vegetative vigor EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX studies)	c1. No seedling emergence study data available
		c2. Granular formulation so effect of residues on foliar vegetation is not applicable
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[9]	a. Most sensitive EC_{50} values for aquatic plants (guideline or similar ECOTOX studies)	a. Marine diatom 96-hr EC_{50} > 5000 ppb ai (only available algal test, used marine as surrogate for freshwater)
	b. Distribution of terrestrial monocot (1) seedling emergence and (2) vegetative vigor EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX studies)	b1. Pearl millet seedling emergence 21-d NOAEC = 2.05 lbs ai/A (No seedling emergence EC_{25} values available, used the only available plant study endpoint)
		b2. Granular formulation so effect of residues on foliar vegetation is not applicable
	c. Distribution of terrestrial dicot (1) seedling emergence and (2) vegetative vigor EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX studies)	c1. No seedling emergence study data available
		c2. Granular formulation so effect of residues on foliar vegetation is not applicable

[8] All toxicity data reviewed for this assessment are included in Appendices D through F.
[9] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

Assessment Endpoint	Measures of Ecological Effect[8] (Data Sources Reviewed)	Specific Selected Toxicity Value (basis)
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	a. Most sensitive EC_{50} or LC_{50} values for (1) fish or aquatic-phase amphibians and (2) aquatic invertebrates (guideline or similar ECOTOX study)	a1. Bluegill sunfish 96-hr LC_{50} = 52 ppb ai (most sensitive fish value) a2. *C. tentans* 48-hr EC_{50} = 20 ppb ai (most sensitive invertebrate value)
	b. Most sensitive reproductive NOAEC values for (1) fish or aquatic-phase amphibians and (2) aquatic invertebrates (guideline or similar ECOTOX studies)	b1. Bluegill sunfish early-life stage NOAEC = 0.46 ppb ai (estimated using ACR) b2. *C. tentans* reproduction NOAEC = 1 ppb ai (estimated using ACR)
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	a. Most sensitive aquatic plant EC_{50} (guideline or ECOTOX)	a. Marine diatom 96-hr EC_{50} > 5000 ppb ai (only available algal test, used marine as surrogate for freshwater)
***Terrestrial Phase PCEs* (*Upland Habitat and Dispersal Habitat*)**		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	a. Distribution of terrestrial monocot (1) seedling emergence and (2) vegetative vigor EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX studies) b. Distribution of terrestrial dicots (1) seedling emergence and (2) vegetative vigor EC_{25} values (seedling emergence and vegetative vigor guidelines or similar ECOTOX studies)	a1. Pearl millet seedling emergence 21-d NOAEC = 2.05 lbs ai/A (No seedling emergence EC_{25} values available, used the only available plant study endpoint) a2. Granular formulation so effect of residues on foliar vegetation is not applicable b1. No seedling emergence study data available b2. Granular formulation so effect of residues on foliar vegetation is not applicable
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	c. Most sensitive food source acute EC_{50} or LC_{50} and NOAEC values for terrestrial vertebrates (mammals) and invertebrates, birds or terrestrial-phase amphibians, and freshwater fish.	c1a. rat LD_{50} = 0.9 mg ai/kg-bw (most sensitive terrestrial mammalian) c1b. rat 2-generation reproduction study NOAEC = 0.4 mg/kg-bw c2a. Honey bee acute contact LD50 = 0.285 µg ai/bee (most sensitive terrestrial invertebrate) c2b. No chronic NOAEC data for terrestrial invertebrates
Reduction and/or modification of food sources for terrestrial phase juveniles and adults		c3a. Mallard duck LD_{50} = 1 mg ai/kg-bw (most sensitive bird test as surrogate for terrestrial-phase amphibian)
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.		c3b. Mallard duck reproduction NOAEC = 0.49 mg ai/kg-bw (Extrapolated using ACR)

2.9 Conceptual Model

2.9.1 Risk Hypotheses

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

- Labeled uses of aldicarb within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- Labeled uses of aldicarb within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;
- Labeled uses of aldicarb within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;
- Labeled uses of aldicarb within the action area may indirectly affect the CRLF and/or adversely 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 aldicarb within the action area may adversely 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 aldicarb within the action area may adversely 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 aldicarb within the action area may adversely 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 aldicarb within the action area may adversely 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 aldicarb within the action area may adversely modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor (aldicarb), 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 Figures 7 and 8, and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in Figures 9 and 10. Exposure routes shown in dashed lines are not quantitatively considered because the resulting exposures are expected to be so low as not to cause adverse effects to the CRLF.

Exposure Pathways and Routes in Aquatic Phase Conceptual Model

Eggs, larvae, tadpoles, juveniles, and adult frogs may potentially absorb across their membranes or gills and integuments dissolved aldicarb and its two major degradates (aldicarb sulfoxide, aldicarb sulfone) in surface water.

Aquatic animals that serve as prey to the juvenile and adult CRLF may be exposed via gills and their integument to aldicarb and its two major toxic degradates in surface water.

Aquatic vascular and non-vascular plants may sorb to their membranes or transfer across their membranes dissolved aldicarb and its major degradates in surface water.

Terrestrial plants in semi-aquatic areas (i.e. wetlands, riparian zones) may uptake dissolved aldicarb and its major degradates from soil pore water, surface water, or groundwater.

The exposure pathways discussed here in the aquatic phase conceptual model are modified to address attributes assessed in aquatic component of critical habitat and PCEs in conceptual model 13.

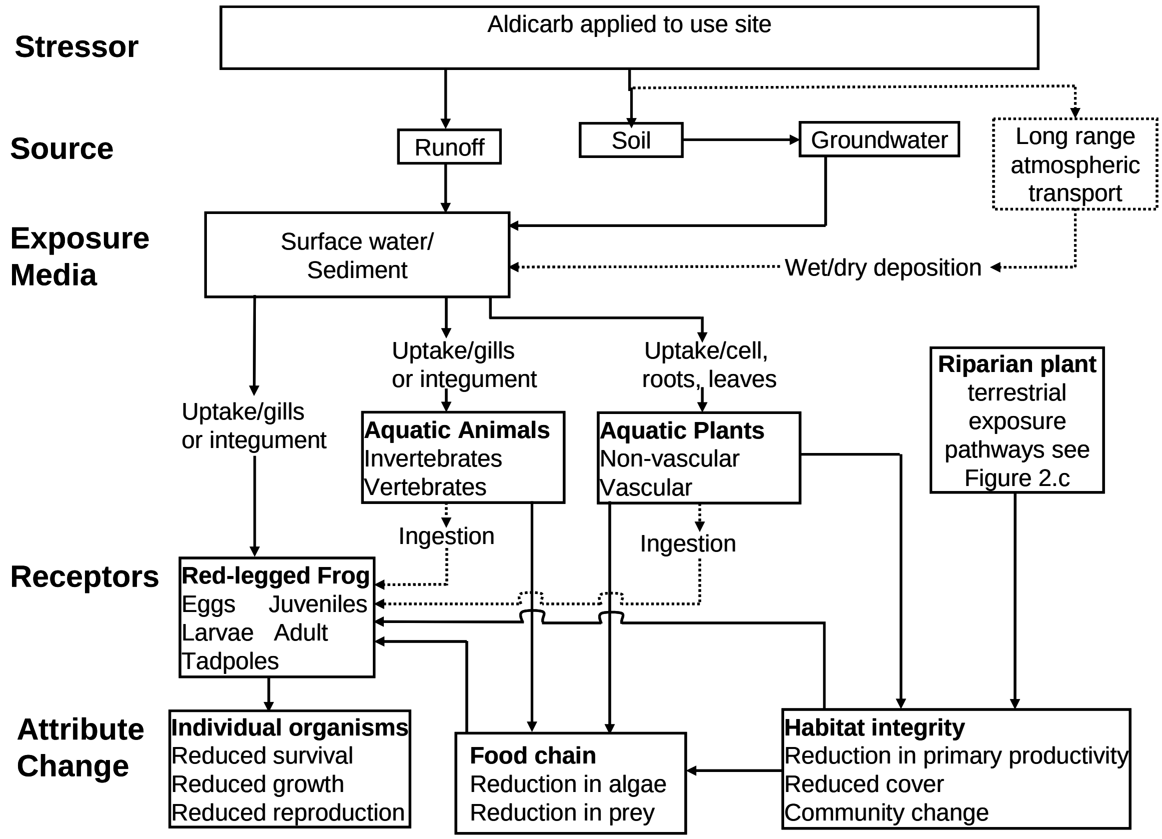


Figure 7 Conceptual Model for Aldicarb Effects on Aquatic Phase of the CRLF

Exposure Pathways and Routes in Terrestrial Phase Conceptual Model

Juvenile and adult frogs may experience dermal exposure to soil residues of aldicarb and its two major toxic degradates when seeking refuge in ground crevices from solar radiation or traversing across soils with aldicarb-related residues.

Juvenile and adult frogs may also incidentally ingest soil residues of aldicarb and its two major degradates along with prey items.

CRLF prey items, small mammals (mice) and terrestrial insects, may uptake across their dermal/cuticle soil residues of aldicarb and its two major degradates.

The exposure pathways discussed here in the terrestrial phase conceptual model are modified to address attributes assessed in terrestrial component of critical habitat and PCEs in conceptual model 14.

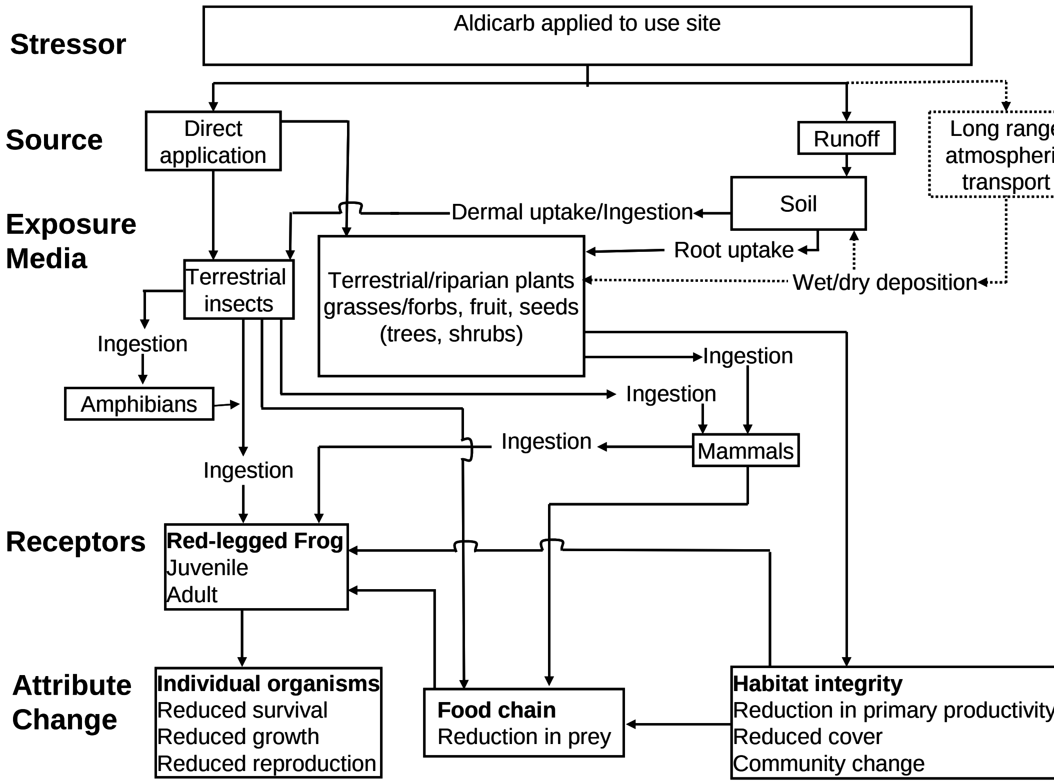


Figure 8 Conceptual Model for Aldicarb Effects on Terrestrial Phase of CRLF

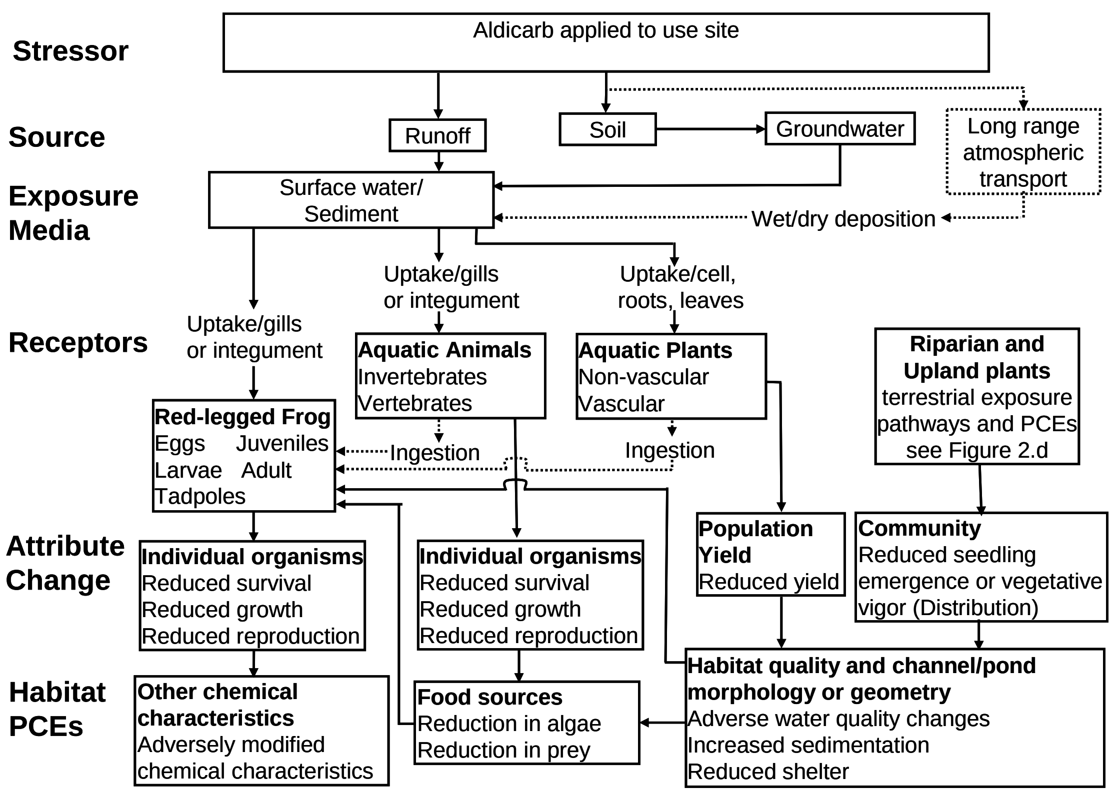


Figure 9 Conceptual Model for Aldicarb Effects on Aquatic Component of CRLF Critical Habitat

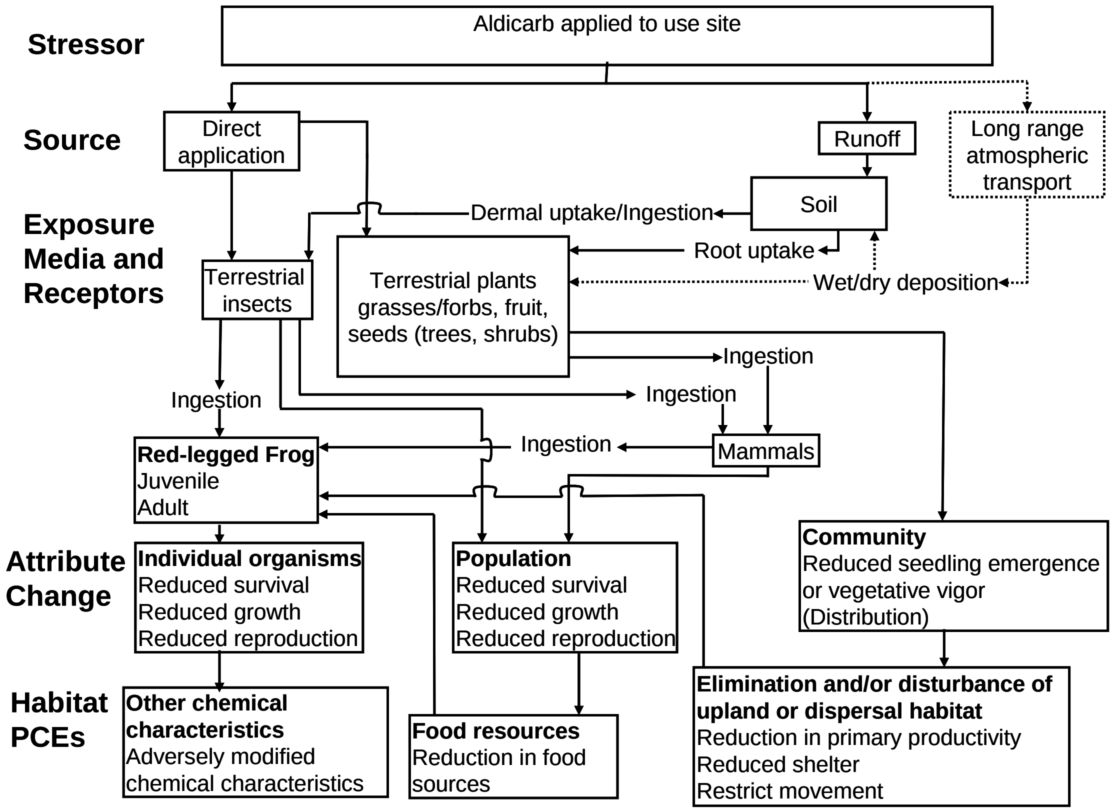


Figure 10 Conceptual Model for Aldicarb Effects on Terrestrial Component of the CRLF Critical Habitat

2.10 Analysis Plan

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

2.10.1 Exposure Analysis

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

Long-range transport of aldicarb is highly unlikely, given the chemical characteristics, formulation, and application methods. A vapor pressure of 2.5×10^{-5} mm Hg and Henry's Law Constant of 1.7×10^{-10} atm m^3/mole mean that aldicarb is not likely to volatilize and be transported offsite in the atmosphere. As a soil-incorporated granule, there is no spray drift, and a very limited amount of aldicarb is available at the surface. Whole granules dissolve readily, and will not move offsite intact (unless adhered to the integument of an organism, which should nevertheless limit the total amount transported). Some aldicarb residues may be transported as a component of field runoff, but dilution by receiving water bodies should limit the extent of long-range transport via surface water. While aldicarb residues may be subject to long-range transport through groundwater (which may be discharged to the surface some distance away from the application area), the greater the distance traveled, the more dilution is likely to occur and the greater opportunity for degradation. Thus, Agency believes that risk of long-range transport of aldicarb is minimal.

Surface water concentrations of aldicarb residues will be quantified using a model, PRZM-EXAMS. For the screening assessment, the standard EXAMS water body of 2 meters maximum depth, and 20,000 cubic meters volume, will be used. Since spray drift is expected to be minimal because aldicarb is applied as a granule to the ground, the model accounts for loading of aldicarb into the surface water via run-off and erosion. Agricultural scenarios appropriate for labeled aldicarb uses will be used to account for local soils, weather and growing practices which impact the magnitude and frequency of aldicarb loading to the surface water. Maximum labeled application rates, with maximum number of applications and shortest intervals, will be used to help define (1) the Action Area within California for the Federal Action and (2) for evaluating effects to the CRLF.

Concentrations of aldicarb estimated by PRZM-EXAMS represent aldicarb loading in water bodies adjacent to any treated field and assume that the concentration applies to any water body within the treated area. Aldicarb residues are also estimated for waters downstream from the treated areas by assuming dilution with stream water (derived from land area) from unaffected sources, propagating downstream, until a point is reached beyond which there are no relevant LOC exceedances. Once the distribution of predicted stream water concentrations is obtained, it is further processed using a model that calculates expected dilution in the stream according to contributing land area. As the land area surrounding the field on which aldicarb is applied is enlarged, it encompasses a progressively greater drainage area; in effect, a progressively larger 'sub-watershed' is created, with a concomitant increase in dilution at the drainage point. This drainage point moves down-gradient along the stream channel as the sub-watershed is expanded. At a certain point the predicted stream concentrations will become sufficiently diluted; the region beyond this then falls outside the Action Area.

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

2.10.2 Effects Analysis

Aldicarb Toxicity (Including Major Toxic Degradates):

As previously discussed in Section 2.8.1 and 2.8.2, assessment endpoints for the CRLF include direct toxic effects on survival, reproduction, and growth of the species itself, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. Direct effects to the CRLF are based on toxicity information for freshwater fish and birds, which are generally used as a surrogate for aquatic and terrestrial phase amphibians, respectively. The open literature will be screened also for available amphibian toxicity data. If no such data are available for aldicarb, then toxicity data for other N-Methyl carbamates will be screened to see if amphibian toxicity data are forthcoming that would allow making inferences with respect to aldicarb toxicity. Indirect effects to the CRLF are assessed by looking at available toxicity information of the frog's prey items and habitat requirements (freshwater invertebrates, freshwater vertebrates, aquatic plants, terrestrial invertebrates, terrestrial vertebrates, and terrestrial plants).

Aldicarb's toxicity dataset is incomplete; chronic avian studies are lacking. Other N-Methyl carbamates were therefore screened for available chronic bird data that could used to derive a carbamate avian acute to chronic ratio (ACR). Plant Tier I and Tier II guideline studies are not available for aldicarb, therefore the open literature was screened for similar toxicological data.

Acute (short-term) and chronic (long-term) toxicity information for aldicarb and its degradates is characterized based on registrant-submitted studies and an updated review of the open literature. An extensive review of the open literature was done for the recent aldicarb screening level ecological risk assessment (May 2005). Based on an updated review of the open literature for October 2004 through December 2006, if new and more sensitive or otherwise relevant toxicological data were available, this information was included and used in this assessment to modify the Action Area and evaluate direct and indirect effects to the CRLF and its critical habitat.

Where there are data gabs, estimates for these values may be extrapolated for the same taxa for other N-methyl carbamates, or extrapolated within taxa based on relationships within taxa for aldicarb or for N-methyl carbmates. To help refine the risk characterization, species sensitivity distributions may be established for prey (e.g., aquatic invertebrates) and for the CRLF (using surrogate species) if enough data are available. N-Methyl carbamate data was used to derive an ACR for use on birds (surrogate for terrestrial phase amphibians). Other sources of information, including use of the acute probit dose response relationship to establish the probability of an individual effect and reviews of the Ecological Incident Information System (EIIS), were conducted to further refine the characterization of potential ecological effects associated with exposure to granular aldicarb. A summary of the available freshwater and terrestrial ecotoxicity information, the community-level endpoints, species' sensitivity distributions, use of the probit dose response relationship, and the incident information for aldicarb are provided in Sections 4.1 through 4.4.

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

Product Formulations Containing Multiple Active Ingredients:

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

Aldicarb does not have any registered products that contain multiple active ingredients.

2.10.3 Action Area Analysis

The Action Area for the federal action is the geographic extent of exceedance of Listed species Levels of Concern (LOC) for any taxon or effect (plant or animal, acute or chronic, direct or indirect) resulting from the maximum label-allowed use of aldicarb. To define the extent of the Action Area, the following exposure assessment tools will be used where appropriate: PRZM-EXAMS, TREX, AgDrift, and ArcGIS (a geographic information system (GIS) program). Other tools may be used as required if these are inadequate to define the maximum extent of the Action Area.

The initial area of concern (or terrestrial action area) is assumed to be all agricultural land, orchards, and vineyards where granular aldicarb could potentially be applied and the area surrounding these areas where secondary poisoning effects are expected to be visible. Secondary poisoning to listed species could result if listed species consumes all or part of the poisoned prey. A model for secondary poisoning effects is in development by the Agency. However, from that model, which relies on allometric relationships that relate body weight to food consumption and body weight to home range, it was preliminarily determined that a CRLF prey item bird could travel approximately one mile from the field before dying from aldicarb poisoning. Thus, a one-mile buffer is applied around cultivated land to account for secondary poisoning effects to wildlife from aldicarb granular exposure.

In order to determine the extent of the action area downstream from the initial area of concern, the Agency will need to complete the screening level risk assessment. Once all aquatic risk quotients (RQs) are calculated, the Agency determines which RQ to level of concern (LOC) ratio is greatest for all aquatic organisms (plant and animal). For example, if both fish and aquatic plants have the same RQ of 1, the fish RQ to LOC ratio (1/0.05) would be greater than for plants (1/1). Therefore, the Agency would identify all stream reaches downstream from the initial area of concern where the PCA for the land uses identified for aldicarb are greater than 1/20, or 5%. All streams identified as draining upstream catchments greater than 5% of the land class of concern, will be considered part of the action area.

3 Exposure Assessment

3.1 Label Application Rates and Intervals

In California, aldicarb is registered for use on cotton, dry beans, peanuts, pecans, sorghum, soybean, sugar beet, sweet potato, alfalfa (for seed), citrus, and field-grown ornamentals (no containers). Application rates are listed in Table 10. Only cotton and sugar beet allow more than one application per season; up to 3 applications may be used for these crops. Application intervals are not specified on the labels. Instead, cotton applicators are instructed to apply "once at planting, at first squaring, and between first squaring and bloom." Use directions for sugar beet simply list an application window from 3/1-9/1. The best estimate that could be construed from these explanations, plus additional research, indicates a likely average application interval of 30 days.

3.2 Aquatic Exposure Assessment

Aldicarb rapidly degrades in the aquatic environment to aldicarb sulfoxide and aldicarb sulfone, both of which are toxic to aquatic organisms. Therefore, exposure to all 3 of these forms of aldicarb (parent + sulfoxide + sulfone) must be considered. Direct application of aldicarb to streams, lakes, and ponds is forbidden by product labels. However, following a rain event, aldicarb may reach aquatic environments in runoff from areas of application, since aldicarb is moderately persistent in terrestrial environments and soluble in water. It is unlikely that whole, intact granules will reach the aquatic environment because of the highly soluble nature of the compound (granules will dissolve rather than be transported intact) and the application methods (direct application onto field, typically with soil incorporation). Groundwater discharged to the surface (mostly in low-lying areas) could result in additional exposure to aldicarb residues, independent of rainfall and runoff conditions.

3.2.1 Conceptual Model of Exposure

The basic conceptual model for aldicarb exposure includes terrestrial on-site exposure to granules at (and just below) the surface, indirect exposure to fauna that have been exposed and may transport aldicarb (internally or externally) off-site, and aquatic exposure to aldicarb in surface water (as a component of runoff/erosion from a treated field). Exposure to dissolved granules in pooled surface water or damp soil within or adjacent to a treated field is also considered. However, potential exposure to aldicarb in discharged groundwater (e.g., as baseflow) is not explicitly considered.

3.2.2 Existing Monitoring Data

Aldicarb is one of the pesticides for which monitoring is routinely performed; however, no targeted monitoring regimes in California have been implemented. Only non-targeted monitoring data are available. These data are not specifically tied to periods of aldicarb use or even to areas where such use is allowed. Thus, it is not suitable for evaluating the impact of aldicarb use on affiliated waterways. At best, the non-targeted data can establish a lower bound for potential aldicarb surface water exposure.

Nationally, the USGS NAWQA database (1992-2001) indicates that aldicarb has been detected in surface water approximately 0.2% of the time. The highest concentration detected was 0.5 ug/L (Martin et al., 2001). However, results of targeted monitoring in smaller streams suggest that aldicarb may occasionally pose a contamination hazard. For example, Williams and Harris (1996) found substantially higher aldicarb concentrations in small southeastern streams after a rainfall event (concentrations up to 430, 68, and 14 µg/l for aldicarb, aldicarb sulfoxide, and aldicarb sulfone, respectively). Absent a sampling regime specifically targeted to aldicarb use in California, surface water modeling will be employed to estimate environmental concentrations.

The detection rate for aldicarb residues in CA groundwater (~0.1%) appeared to be similar to surface water (~0.2%), but, where detected, concentrations in groundwater were often much higher. Based on well monitoring in California reported by CA-DPR, conducted from 1986-1999, groundwater concentrations of aldicarb sulfoxide ranged from 0.05-1281 ug/L and aldicarb sulfone from 0.06-13.2 ug/L (http://www.cdpr.ca.gov/docs/empm/pubs/ehapreps/eh0308.pdf). Evidence for persistence of aldicarb residues in California groundwater has been documented by the presence of aldicarb sulfoxide and aldicarb sulfone in well water samples from counties (Humboldt and Del Norte) where aldicarb use had been suspended (http://www.cdpr.ca.gov/docs/empm/pubs/ehapreps/eh9001.pdf).

3.2.3 Modeling Approach

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

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

3.2.3.1 Model Inputs

Generic PRZM-EXAMS inputs are listed in Table 9. Specific inputs (application rates, application intervals, etc.) used for individual crop/noncrop model runs that were used in this assessment are listed in Table 10.

Degradation of parent compound aldicarb to aldicarb sulfoxide, and, subsequently, aldicarb sulfoxide to aldicarb sulfone, each occur at different rates and to varying extents under different conditions. Since each compound is toxic, and each is formed from the previous, it is necessary to treat the half-lives for all additively. Thus, half-lives used for modeling the environmental fate of aldicarb account for degradation of parent through each degradate of concern, for a half-life reflecting total toxic residues. The range for field dissipation of total aldicarb residues considered in this document, derived from Jones and Estes, 1995, is 15-105 days. The aerobic soil half-life used for model inputs, however, is 55 days, derived from the upper 90th pct bound on mean for total aldicarb residue half-lives from 19 soils (see Appendix N).

Table 9 Generic Aldicarb Inputs Used in PRZM-EXAMS Runs

Input Parameter	Value	Reference/Comment
Molecular Weight	190.2 g/mol	MRID 00152095
Henry's Law Constant	1.7 E-10 atm-m^3/mol	Acc 255979
Vapor Pressure	2.6 E-5 @ 25°C	MRID 00152095
Solubility	6,000 mg/L	Acc 255979
K_d	0.12	Minimum non-sand value for aldicarb sulfone (MRID 43560302)
Hydrolysis	pH 5, stable (0) pH 7, stable (0) pH 9, 60 days	Parent hydrolyzed only at pH 9 (MRID 00102065) – degradates may hydrolyze more rapidly at neutral-to-high pH
Aqueous Photolysis Half-life	4 days	MRID 42498201
Water Half-life	12 days	MRID 44592107. Single acceptable guideline study for parent / sulfoxide / sulfone (4days) x 3; corresponds w/ DT90
Benthic Half-life	24 days	No data; use 2X aerobic aquatic half-life
Soil Half-life	55 days	Upper 90th pct bound on mean for combined parent+sulfoxide+sulfone half-life from 19 soils
FILTRA, UPTKF, PLVKRT, PLDKRT	0	Default values
FEXTRC	0.0	Soil incorporated
Additional Notes	Modeled total aldicarb residues	Half-life input values based on combined aldicarb residues; lowest K_d of the 3 chemicals used for mobility. Assumes equal toxicity of parent, degradates

Table 10 Specific Inputs for Individual PRZM-EXAMS Runs

Crop/Noncrop Modeled	Application Rate (lbs product/A)	Number of Applications (per season)	Comments
Sugar beet	14	2	Used 2 applications at maximum one-time rate
Pecan	33	1	Used “CAalmond” scenario
Soybean	20	1	Used “CARowCrop” scenario
Cotton	14	1	Used maximum one-time rate
Cotton	7	3	Used 3 applications; however, first 2 applications were set only 1 day apart to approximate a single application at the max one-time rate (14 lbs/A), followed by a third application after 30 days (at 7 lbs/A) for a max seasonal total of 21 lbs/A
Citrus	33	1	
Sweet potato	30*	1	Used “CAPotato” scenario
Dried bean	21*	1	Used “CARowCrop” scenario
Alfalfa (seed)	20	1	
Sorghum	7	1	Used “CAWheat” scenario; 99% soil incorporation only
Peanut	30*	1	Used “CARowCrop” scenario
Ornamentals (field grown, no containers)	50*	1	Used “CANursery” scenario; 99% soil incorporation only – positive displacement required

* Only ‘10g’ (10%) formulation use allowed – all others utilize the ‘15g’ (15%) formulation.

3.2.3.2 Results

Model runs for the model input parameters listed in Tables 9 & 10 are shown in Table 11, below.

Table 11 Results of Individual PRZM-EXAMS Runs With 85% Soil Incorporation

COTTON-1 application:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
6.8352	6.5129	5.5533	3.5314	2.5216	0.62953

Average of yearly averages: 0.139943

COTTON-3 applications:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
7.6324	7.1959	5.9147	3.45	2.3772	0.59044

Average of yearly averages: 0.152104

SOYBEAN:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
6.1421	5.8186	4.4673	2.5769	1.8282	0.45514

Average of yearly averages: 0.181126

PECAN:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
7.373	6.9331	5.3896	3.1468	2.2254	0.55532

Average of yearly averages: 0.226344

SUGARBEET:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
11.377	10.8066	8.6342	5.425	3.9293	1.00713
	Average of yearly	averages:	0.279823		

Citrus:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.371	0.317	0.181	0.0823	0.0564	0.0141
	Average of yearly	averages:	0.004684		

Sweet Potato:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
1.385	1.3017	0.9959	0.5642	0.39333	0.097279
	Average of yearly	averages:	0.0202545596666667		

Peanut:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
6.4341	6.119	5.044	3.3383	2.5214	0.66757
	Average of yearly	averages:	0.281116203333333		

Dried Bean:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
4.5047	4.2833	3.5313	2.3365	1.7652	0.46739
	Average of yearly	averages:	0.196776023333333		

Alfalfa (for seed):

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
10.048	9.5516	8.4132	5.2773	3.7682	0.94253
	Average of yearly	averages:	0.296203966666667		

3.2.4 Additional Modeling Exercises Used to Characterize Potential Exposures

For purposes of comparison, and where specialized application techniques (e.g., positive displacement, in-furrow) are required, the following scenarios were modeled with 99% incorporation efficiency. Results are listed in Table 12.

Table 12 Results of Individual PRZM-EXAMS Runs With 99% Soil Incorporation

Sorghum:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.664	0.62995	0.52367	0.31246	0.22142	0.055175
	Average of yearly	averages:	0.0337101333333333		

Field-Grown Ornamentals (no containers):

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.90759	0.8685	0.72054	0.49119	0.37888	0.102639
	Average of yearly	averages:	0.0277671827		

COTTON-1 application:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.455	0.4335	0.3697	0.2352	0.1679	0.04194
	Average of yearly	averages:	0.0093270679		

COTTON-3 applications:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.5108	0.4816	0.3959	0.2309	0.1593	0.03951

Average of yearly averages: 0.0101877812

SOYBEAN:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.4095	0.388	0.2978	0.1718	0.1219	0.03034

Average of yearly averages: 0.0120820702

PECAN:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.4912	0.4622	0.3593	0.2099	0.1484	0.03704

Average of yearly averages: 0.015090452

SUGARBEET:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.7577	0.7194	0.5749	0.3611	0.2616	0.06709

Average of yearly averages: 0.01864548122

Citrus:

Peak	96 hr	21 Day	60 Day	90 Day	Yearly
0.02469	0.02113	0.01204	0.00548	0.00376	0.000943

Average of yearly averages: 0.00031204619

3.2.5 Comparison of Modeled EECs with Available Monitoring Data

There are insufficient targeted monitoring data from California to allow a meaningful comparison with modeled EECs. However, it can be assumed that what little sampling data do exist under-represents real expected surface water aldicarb peaks (which are almost certainly much higher). Thus, the Agency is reliant on modeling data for this assessment. Based on the untargeted national data, it would appear that ,where detected, aldicarb residues in surface waters may be 1-2 orders of magnitude lower than indicated by the 'peak' or 'acute' modeled EECs, but possibly reflective of 'background' or 'chronic' EEC surface water concentrations in aldicarb use areas. This appears to be roughly consistent with observed differences between background concentrations for other chemicals also detected in surface waters (as would be expected from non-targeted sampling) and peak concentrations detected during (targeted) sampled post-application runoff events.

Detected concentrations of aldicarb residues in California well water were sometimes higher than would be predicted using the OPP-EFED *tier 1* groundwater screening model, SciGrow. This model should give an estimate of likely high-end exposure due to registered usage. However, the highest predicted Environmental Exposure Concentration (EEC) obtained from the SciGrow model, using the greatest quantity applied (5 lb a.i./A – for Ornamental use) and a conservative K_{OC} value of 4.9 (reflecting total residues), was 37.3 ug/L. Thus, risk to groundwater may be greater than indicated from model results. Considering the greater persistence and mobility of the sulfoxide and sulfone degradates, and the historical evidence of widespread long-term groundwater contamination (both nationally and in certain counties in California), the impact of discharged tainted groundwater on receiving surface water bodies cannot be ignored.

Surface Water Impacts: Available surface water monitoring data indicate that impacts to fish and aquatic invertebrates as a result of aldicarb (including the sulfone and sulfoxide products) are likely to be confined to smaller (lower-order) streams in high use areas. Widespread contamination of surface water is not expected in larger (higher-order) streams. In NAWQA monitoring sites, aldicarb and its sulfone and sulfoxide transformation products were detected infrequently at low concentrations.
Ground Water Impacts: Aldicarb residues may be persistent in groundwater. Therefore, there is the potential for exposure to aldicarb residues (particularly aldicarb sulfoxide and aldicarb sulfone) in discharged groundwater. This is especially true for small streams, low-order riparian zones, and wetlands, which may be largely dependant on consistent groundwater discharge in addition to intermittent storm runoff to sustain ponding and flow conditions. These shallow water bodies are also important habitat for CRLFs. Groundwater can thus present a constant, low-level source of aldicarb residues in sensitive environments.

3.3 Terrestrial Plant Exposure Assessment

Aldicarb is an insecticide/miticide, and thus, registrants have not been required to submit Tier I plant studies under the old Agency guidelines. This explains that the only available information on effects of aldicarb on plants comes either from crop growers (anecdotal) or from the open literature. There was one acceptable open literature plant study for the pearl millet which was used for RQ calculations in the terrestrial plant section of the risk estimation section. This one species (monocot) was used to represent terrestrial plants and terrestrial plants growing in semi-aquatic areas. How representative pearl millet is of all other terrestrial plant species remains unknown.

TerrPlant (v.1.2.2) was used to assess risk to terrestrial plant and terrestrial plants growing in semi-aquatic areas. The model assumes complete incorporation of granules into the ground, which is an unrealistic assumption, especially for crops where applications occur after plants have emerged and root systems have already begun to establish. 85% incorporation for some crops (i.e. citrus) is still a generous assumption. Therefore, risk calculated for terrestrial plants may be underestimated.

TerrPlant input parameters for the model included: (1) terrestrial plant toxicity values; (2) application rate; (3) runoff, based on chemical solubility; and (4) soil incorporation depth. The model provides estimates of exposure concentrations and risk quotients (RQs) for non-listed and listed terrestrial and semi-aquatic plants. A detailed explanation of the model as well as the modeling inputs and outputs for estimating terrestrial and semi-aquatic plant exposure risks to aldicarb are summarized in Appendix B. Only one application is considered in this assessment due to model limitations.

3.4 CRLF Terrestrial Phase Exposure Assessment

Terrestrial exposures from granular applications (mg ai/square foot)[10] for the California red-legged frog will be estimated using the Tier 1 model, T-REX Version 1.3.1 (T-REX, 2007). In addition, a banded granular application assumes that 100% of the granules are unincorporated on the ground. Risk to terrestrial animals from ingesting granules will be based on LD_{50}/ft^2 values. The LD_{50}/ft^2 values are calculated using avian toxicity value (adjusted LD_{50} of the assessed animal and its weight c-lasses; the bird toxicity data is used as surrogate data for the CRLF) and the EEC (mg ai/ft^2) and are directly compared with Agency's levels of concern (LOCs). Since aldicarb is used only for granular applications, exposures to animals from foraging on food items with aldicarb residues (short and tall grass, broadleaves, seeds) are not estimated because no spray drift is produced (granular application assumes 0% drift) that settles on the foliar surfaces of those food items. Details of the TREX model along with the input and output results are presented in Appendix A.

Additionally, using the TREX model to estimate risk to the terrestrial phase of the CRLF may potentially be an overly conservative method of risk estimation. This is primarily because the CRLF is not expected to readily ingest as many granules as a foraging bird (as simulated by the TREX model) which may either: 1) mistakenly select an aldicarb granule to consume instead of grit that will aid in digestion or 2) incidentally consume aldicarb granules while ingesting other food items on the ground. The CRLF does not intentionally ingest grit. Thus, it is not expected to mistakenly ingest aldicarb granular for grit. However, the CRLF may incidentally ingest aldicarb granules that may be fixed to a prey item such as a mammal, bird, or frog. Because the amphibians typically have slower metabolisms than avian species, amphibians have lower feeding rates than birds. Thus, the CRLF red-legged frog is not expected to consume as many granules as a bird. Consequently, the TREX model may overestimate the risk of aldicarb exposure to the CRLF. However, the CRLF may potentially be exposed to aldicarb via other routes such as thru the skin or drinking water contaminated with aldicarb. Currently, there is no approved method available to EFED for capturing these routes of exposure. Thus, the TREX calculations will be assumed to capture these other routes of exposure to the CRLF. Thus, this assumption may address the potential over estimation calculations of the TREX model.

Off-site Terrestrial Risk from Aldicarb Runoff:

Risks to terrestrial environments outside the zone of application for granular aldicarb are mainly limited to re-deposition of aldicarb residues in lower-lying areas affected by aldicarb runoff from nearby fields. It is not expected that significant amounts of whole granules will be exported offsite, except those small amounts that may adher to the skin, fur, or feathers (integument) of organisms passing through a treated field. While aldicarb residues could potentially be transported as a component of runoff, and be re-deposited

[10] mg ai/ft2 = $\frac{\text{application rate x \% active ingredient x 453,590 mg/lb}}{\text{no. of rows/acre x row length x bandwidth}}$ x % incorporation

into environments occupied by the CRLF the transported amount is limited. Calculations of the approximate amount of aldicarb potentially deposited as a result of registered aldicarb use (based on high application and low incorporation rate scenarios) indicate that concentrations in off-site soil would be several orders of magnitude below those that would trigger risk. Specifically, aldicarb concentrations in runoff water and loading to off-site soils (based upon the results of the TerrPlant model) were used to calculate the approximate amount of aldicarb residues that might be found in soil receiving runoff from a treated field under a high-use (4.95 lb ai/A) scenario. Assuming an affected soil depth of 1 inch (from surface), a soil bulk density of 1 g/cm^3 (average soil bulk density of 1.2 g/cm^3 rounded to 1.0 for simplicity), and an initial terrestrial off-site concentrations of 0.09 lb ai/A, it was determined that the quantity of aldicarb in soil in 'receiving' areas would be very low – on the order of 10^{-6} mg ai/kg soil.

4. Effects Assessment

Aldicarb ecological effects data and ecological effects data for its major toxic degradates, available from registrant and public literature as discussed in the Analysis Plan (Section 2.10.2), and their use for calculating RQ values are summarized in this Section. Specific values selected from registrant submitted data and the public literature for the measurement endpoints, and the basis for their selection, are also discussed (Tables 13-16). In addition extrapolation methods were used to fill the data gap for reproductive effects on aquatic vertebrates and birds, the extrapolation methods used are described.

4.1 Taxa specific toxicological endpoints and LOCs

Results of the Effects Assessment performed for the 2006 revised screening level ecological risk assessment, which are also appropriate for measurement endpoint values for the CRLF effects determination,, are listed in Table 13. The basis for the selection in the 2006 revised screening level ecological risk assessment are also identified in Table 13. No new registrant data has been submitted since the revised aldicarb chapter has been finished. The updated review of public literature, which is discussed in Section 4.2, did not result in any more sensitive measurement endpoint values than those values already identified in 2006, and no aldicarb amphibian toxicity data was found. However, a seedling emergence and growth test for a terrestrial monocot plant, pearl millet, was found in open literature and the selected measurement endpoint included in Table 13. A review of this study is briefly summarized in Section 4.2.1. Additionally, based on avian acute and chronic toxicity ratios for other N-methyl carbamates, an avian chronic NOAEL for aldicarb was extrapolated. The extrapolation approach used is described in Section 4.3 and the estimated value provided in Table 13. The avian chronic NOAEL is used as a surrogate for estimating risk for the terrestrial-phase CRLF. Additionally, a NOAEL was estimated for freshwater invertebrates using ACR value for aldicarb (Section 4.6).

Table 13 Aldicarb Acute and Chronic Ecotoxicological Values Listed in 2005 RED and Used for RQ Calculations in this Assessment

Assessment Endpoint and Species from Selected Study	Measurement Endpoint Value	Basis for selection	MRID/Reference
Bluegill sunfish (representing aquatic vertebrate prey and surrogate for aquatic phase CRLF)	96-hr LC_{50} = 52 ppb ai	Most sensitive 96-hr LC_{50} value	MRID40098001, Meyer & Ellersieck, 1986
Bluegill sunfish (representing aquatic vertebrate prey and surrogate for aquatic phase CRLF)	Estimated chronic NOAEC = 0.46 ppb ai	Extrapolated NOAEC: 96-h LC_{50} for bluegill sunfish (52 ppb ai) divided by ACR[(a)] (fathead minnow 48-h EC_{50} of 8860 ppb ai divided by NOAEC of 78 ppb ai)	
Chironumus tentans (representing aquatic invertebrate prey of CRLF)	48-hr EC_{50} = 20 ppb ai	Most sensitive ≤96-hr LC_{50}[(b)] acute value	Moore *et. al*., 1998
C. tentans (representing aquatic invertebrate prey of CRLF)	Chronic NOAEC = 1 ppb ai	Extrapolated using an ACR approach	

Assessment Endpoint and Species from Selected Study	Measurement Endpoint Value	Basis for selection	MRID/Reference
Marine diatom (surrogate for freshwater algae, both a dietary item for CRLF larva and a Habitat Component of CRLF)	96-hr EC_{50} > 5000 ppb ai	Most sensitive algal ≤96-hr EC_{50} (where effect is measure of biomass and growth rate)	MRID 40228401 (US EPA, 1986)
Mallard duck acute oral (surrogate for terrestrial phase of CRLF)	LD_{50} = 1 mg ai/kg-bw	Most sensitive avian acute oral value	MRID 00107398
Mallard duck reproduction (surrogate for terrestrial phase of CRLF)	NOAEC = 0.49 mg/kg-bw	Extrapolated NOAEC:	N/A
Rat acute oral/ rat (representing mammalian prey of CRLF)	LD_{50} = 0.9 mg ai/kg bw	Most sensitive mammalian acute oral value	MRID 00057333
Rat reproduction (representing mammalian prey of CRLF)	Chronic NOAEL = 0.4 mg/kg bw[(c)], decreased parental body weight gain (2-generation reproduction study)	Most sensitive mammalian reproduction NOAEC value	MRID 42148401
Mallard duck acute oral (Terrestrial-phase CRLF)	LD_{50} = 1 mg ai/kg-bw	Most sensitive avian acute oral value	MRID 00107398
Mallard reproduction (Terrestrial-phase CRLF)	Estimated chronic NOAEL = 0.49 mg ai/kg bw	Acute oral LD_{50} for mallard duck (1mg ai/kg-bw) divided by ACR (N-methyl carbamate acute geometric mean of 1223.2 ppm ai divided by N-methyl carbamate chronic geometric mean of 137.3 ppm ai)	
Honey bee (representing terrestrial invertebrate prey of CRLF)	Acute contact LD_{50} = 0.285 ug/bee	Most sensitive acute contact beneficial insect value	MRID00036935
Pearl millet (representing terrestrial plant habitat PCE component)	Seedling emergence and growth 21-d NOAEC 2.05 lbs ai/A	Only existing seedling emergence data for plants	Kennedy 2002; see Section 4.2.1

[(a)] ACR = acute to chronic ratio

(b) For cladocerans, standards for an immobilization effect (EC_{50}), that is considered a surrogate for mortality, are used in place of a lethality endpoint (LC_{50}).

[(c)] Toxicity value is similar to acute oral LD_{50} in rats and suggests that mammals that survive acute aldicarb exposure may suffer adverse reproductive effects from chronic exposure.

Table 14 shows the acute ecotoxicological values, based upon the toxic degradate of concern aldicarb sulfoxide, that were used for calculating RQs. Table 15 gives the acute and chronic LOCs that were used in this assessment.

Table 14 Aldicarb Sulfoxide Acute Ecotoxicological Values Used for RQ calculations in this Assessment

Species	Endpoint	MRID/Reference
Aldicarb Sulfoxide		
Rainbow trout	96-hr LC_{50} = 7,140 ppb ai	MRID 45592115
Daphnid (adults)	48-hr EC_{50} = 43 ppb ai	Foran *et al.,* 1985

Table 15 Specific LOCs Used in this Assessment

Taxa	Acute LOC	Chronic LOC
Avian[1] (terrestrial phase amphibians)	0.1	1
Mammalian[2]	0.1	1
Terrestrial plants[3]	1	
Aquatic Animals[4]	0.05	1
Terrestrial Insects[5]	0.05*	

*The Agency has not established LOCs for terrestrial insects. This assessment will use the ratio of 0.05 as a cut-off value for making effects determinations.
Toxicity values used in RQ calculations:
[1] LD_{50} and estimated NOAEL, respectively
[2] LD_{50} and NOAEL, respectively
[3] EC_{50} for non-listed and NOAEC for endangered
[4] LC/EC_{50} and estimated and reproductive NOAEC, respectively (the acute designation is not applicable for plants)
[5] LD_{50}

4.2 Evaluation of Ecotoxicity Studies

Open literature data considered in this assessment include those obtained prior to October 2004 for the 2006 revised screening level ecological risk assessment (U.S. EPA, 2006) as well as updated information obtained since the last ECOTOX run (Oct 2004 through Dec 2006). ECOTOX data of the 2006 revised SLERA and not considered for RQ calculations in the CRLF assessment are included in appendices G through I of this assessment.

In order to be included in ECOTOX, papers must meet the following initial, minimum criteria:

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

Data that pass the ECOTOX screen are further evaluated for scientific soundness along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered if they meet Agency guidelines for scientific soundness and use for quantitative purposes. The degree to which open literature data are quantitatively or qualitatively characterized is dependent on whether the information is relevant to the assessment endpoints (i.e., maintenance of CRLF survival, reproduction, and growth) identified in Section 2.8.1. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because quantitative relationships between modifications and reduction in species' survival, reproduction, and/or growth are not available.

Results of ECOTOX updated search for aldicarb

A brief summary and table of open literature data deemed acceptable for use in RQ calculations is presented below. All additional ECOTOX information (acceptable, not acceptable, and excluded studies) is provided in Appendices E through F and not included in this chapter. No additional studies found in the updated ECOTOX search had lower endpoint values than values presented in the 2006 revised screening level ecological risk assessment or were deemed otherwise relevant for the purpose of this assessment. Thus, studies listed in Appendix D (accepted papers) are a compilation of accepted and potentially rejected papers because no further analysis went into sorting out papers that had higher endpoint values than what was already available.

Table 16 Ecotox Study for Formulated Aldicarb Used for RQ Calculations in this Assessment (Oct 2004 - Dec 2006)

Species	Endpoint	MRID/Reference Number
Pearl millet	21-d NOAEC = 2.05 lbs ai/A, decreased seedling emergence	Kennedy, 2002

4.2.1 Toxicity to Terrestrial Plants

Kennedy (2002) exposed seeds of the pearl millet cereal [*Pennisetum glaucum* (L.)] to 15% Temik® at 2.05 lbs ai/A, 3.08 lbs ai/A, and 4.1 lbs ai/A in a randomized complete block experiment with three replications (repeated twice under greenhouse conditions) to determine effects of in-furrow insecticides on seedling emergence and growth of this feedgrain crop. The seeds were watered once 7 days after sowing; emergence was determined at day 10; growth of seedlings was determined at day 21. In the first treatment (2.05 lbs ai/A), as compared to the control, no effects on seedling emergence were observed. Reductions in seedling emergence were observed at 3.08 lbs ai/A (actual % reduction not reported), and 4.1 lbs ai/A (57% reduction in emergence). The study did not identify what the minimum significant difference detected was for seedling emergence. Furthermore, Kennedy reports that pearl millet seeds surviving past the seedling emergence stage did not have their dry weight significantly reduced by aldicarb. This information seems to be in line with reports from agricultural growers who state that use of aldicarb has increased their crop yield (biomass), likely from reduced pest pressure.

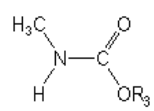
Labeled application rate data for at plant provides ancillary information regarding levels considered by the registrant as not reducing yield. Application rates at planting are 1.0 lb ai/A for sorghum; 2.1 lbs ai/A for dried bean, cotton, and sugar beet; and 3.0 lbs ai/A for soybeans, peanuts, and sweet potato. Additionally there are established crops that are exposed at levels of upto 5 lbs ai/A such as citrus and containerlesss field-grown ornamentals.

The NOAEL for seedling emergence (2.05 lbs ai/A) was selected for screening effects to terrestrial plants.

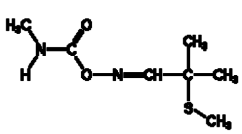
4.3 Acute-to-Chronic Ratio Derivation for the CRLF

The following section presents the methodology used in deriving an avian ACR for N-methyl carbamates, the group to which aldicarb belongs. The resulting avian reproduction NOAEL was used as a surrogate for the terrestrial-phase amphibian (U.S. EPA 2006). There was data for three N-methyl carbmates evaluated for this extrapolation. These N-methyl carbamates (methomyl, methiocarb, and thiodicarb) were chosen because they are the only chemicals for which acute dose-based as well as chronic toxicological data are readily available and have been reviewed previously for scientific soundness. Where there were multiple studies for a given species (e.g., mallard duck and/or bobwhite quail) and endpoint (e.g., acute and chronic toxicity) the average was calculated for each chemical.

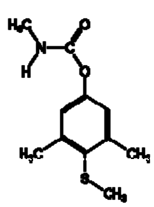
All three N-methyl carbamates share with aldicarb the active N-methyl carbamate moiety (carbamate cation is double bonded to an oxygen with a hydrogen (H) at the R_1 position on the nitrogen (N), a methyl group (CH_3) at the R_2 position on the N and an oxygen at the R_3 position on the carbon) (Figure 11); thiodicarb is a dimmer of methomyl and transforms to the carbamate. Thiodicarb is known to more readily metabolize to the carbamate in insects than mammals. The R_3 group attached to the oxygen differs and may be an akyl group, aryl group, oxime derivative or some other more complex group. The N-methyl carbamates share the ability to inhibit cholinesterase through a specific pathway and therefore share similar symptomology during acute and chronic exposure. Other 'carbamate' pesticides do not share the same common mechanism. Carbamates whose R_1 and R_2 groups are larger than hydrogen and a methyl group tend to posses a much reduced, if at all, anticholinesterase activity. Structural differences at the R_3 group between N-methyl carbamates result in differences of affinity for cholinesterases, differences in toxicokinetics and toxicodynamics and therefore differences in potency.



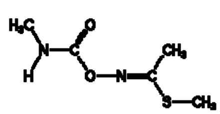
N-methyl carbamate
Structural backbone



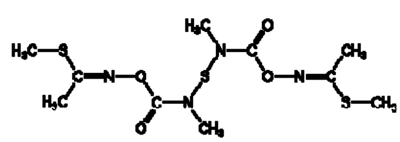
Aldicarb



Methiocarb



Methomyl



Thiodicarb

Figure 11 Comparison of structures of N-methyl carbamates

Dietary ACR Calculations (Acute LC_{50}/Chronic NOAEC):

Methomyl (Mallard duck): 19.6 mg/kg-bw : 50 mg/kg-bw = 0.39*
Methomyl (Bobwhite quail): 24.2 mg/kg-bw : 78.5 mg/kg-bw = 0.31*
Methiocarb: 16.4 mg/kg-bw : 50 mg/kg-bw = 0.33*
Thiodicarb: 2023 mg/kg-bw : 1000 mg/kg-bw = 2.02

Three of the preceeding ACRs are not valid, the chronic endpoint value is higher than the acute mortality endpoint value: 0.39 (Methomyl); 0.31 (Methomyl); (0.33). Methiocarb. The fact that chronic endpoint values were higher than acute mortality endpoint values is most likely due to the fact that the studies were conducted by different laboratories. Therefore, the thiodicarb ACR (2.02) was used to derive a mallard duck (the most acutely sensitive bird) chronic NOAEL for aldicarb as follows:

The (aldicarb) mallard duck LC_{50} used in this assessment is 1 mg/kg-bw, and the thiodicarb acute-to-chronic ratio of 2.02 is used to calculate the final estimated NOAEL for aldicarb.

$$Estimated \quad NOAEL = \frac{Test \;\; animal \;\; LC_{50}}{ACR} = \frac{1 \;\; mg \; / \; kg - bw}{2.02} = 0.49 \;\; mg \; / \; kg - bw$$

The estimated avian (terrestrial phase amphibian) NOAEL is practically identical to the measured chronic mammalian NOAEL for rats (0.4 mg/kg); acute terrestrial phase amphibian LD_{50} is practically identical to the acute LD_{50} (0.9 mg/kg) for rats. This lends additional support in using the estimated NOAEL to make qualitative risk characterizations for chronic effects of aldicarb to the CRLF. The fact that acute and estimated chronic endpoint value are very close together with estimated chronic endpoint slightly lower suggests that if a bird (or amphibian) survives acute exposure to aldicarb, chronic reproductive effects can be expected.

Table 17 Avian N-Methyl Carbamate Data

Chemical	Species & Acute Endpoint	14-d LD_{50} (mg/kg-bw)	Avg Value (ppm)	MRIDs/ Labs	NOAEL (ppm)	Avg Value (ppm)	MRIDs/ Labs	Species/ Chemical Specific ACR
Methiocarb	Bobwhite, 14-d LD_{50}	19.6	19.6	40560018 REF (1983)	50*	50	00128119 MCC (1982)	0.39 – not valid
Methomyl	Mallard, 14-d LD_{50}	15.9	16.4	00160000 FWS (1984)	50*	50	41898601 WLI (1991)	0.33 – not valid
	Mallard, 14-d LD_{50}	16.8		ACC233993 DUP (1970)				
	Bobwhite, 14-d LD_{50}	24.2	24.2	00161886 WLI (1983)	137	78.5	41898602 WLI (1991)	0.31 – not valid
					20*		N.R.	
Thiodicarb	Bobwhite, 14-d LD_{50}	2023	2023	92185002 WLI (1978)	1000	1000	43313003 BLA 1994	**2.02**

N.R. = not reported
* acute measurement endpoint is lower than chronic measurement endpoint

4.4 N-Methyl Carbamate Toxicological Data for Frogs

No toxicological data on frogs is available for aldicarb; and there is very limited amphibian toxicity data for other N-methyl carbamates in the public literature (Table 18). For other wildlife (e.g., avians, mammals, fish, invertebrates) aldicarb is typically among the most toxic of the N-methyl carbamates, along with carbofuran. Thus, the ecotoxicological frog data presented in Table 18 likely under represents aldicarb's acute oral toxicity and the 96-hr lethal concentration to this taxa. While the data is limited a comparison of these amphibian N-methyl carbmate toxicity values to those of the surrogate taxa support the assumption that the selected surrogates are at least as sensitive if not more sensitive than amphibians for N-methyl carbamates. For example, the Mallard Duck acute oral LD_{50} value of 7.4 mg ai/kg-bw for propoxur (ACC 94546) is 80 times more toxic than the propoxur acute oral LD_{50} of 595 mg ai/kg-bw for the Bullfrog (Table 18), and the Bluegill Sunfish 96-hr LC_{50} of 210 ppb (MRID 400980-01) for methiocarb is 41 times more toxic than the Leopard frog methiocarb 96-hr LC_{50} of 8700 ppb (Table 18).

Table 18 N-Methyl Carbamate Toxicological Data for Amphibians

Chemical	Species	Endpoint	Reference
Propoxur	Bullfrog (adult)	14-d LD_{50} = 595 mg ai/kg bw	Hudson *et al.*, 1984
Methiocarb	Leopard frog (larva)	96-hr LC_{50} = 8.7 ppm	Armitage, 1984

4.5 Aquatic Freshwater Plants

Aquatic freshwater plant data is not available for aldicarb and is a data gap; thus, the Agency will use the marine diatom study to characterize potential risk to all aquatic plants in this risk assessment (riparian plants were assessed using the results on pearl millet (Kennedy 2002).

4.6 Acute-to-Chronic Ration Derivation for Freshwater Invertebrates

The most acutely sensitive freshwater invertebrate species was *Chironomus tentans* (20 ppb ai) (Moore *et al.* 1998). However, there was no reproduction and emergence study found in the literature for this species. Since for aldicarb there was both an acute 48-hr EC_{50} for *Daphnia magna* immobilization and a 21-d reproduction NOAEC, this information was used to calculate an ACR of 20. The estimated NOAEC for C. tentans is 1 ppb ai (estimated NOAEC = 48-hr EC_{50}/ACR = 20/20 = 1 ppb).

4.7 Probit Analysis

The Agency uses the probit dose response relationship as a tool for providing additional information on the listed animal species acute levels of concern (LOC) and on calculated RQ values, when the acute LOC is not exceeded. The listed LOC evaluated is 0.05 for aquatic animals. Interpretation is presented in terms of the chance of an individual event (i.e., mortality or immobilization) should exposure at the EEC actually occur resulting in an RQ equivalent to the LOC or higher. The probit analysis is performed specifically by using either the slope of the dose response relationship available from the toxicity study used to establish the acute toxicity measurement endpoints for each taxonomic group, or if this information is not available the default slope. In addition to a single effects probability estimate based on the mean slope for a taxa, upper and lower estimates of the effects probability are also provided to account for variance in the slope. The upper and lower bounds of the effects probability are based on available information on the 95% confidence interval of the slope. A statement regarding the confidence in the applicability of the assumed probit dose response relationship for predicting individual event probabilities is also included. Studies with good probit fit characteristics (i.e., statistically appropriate for the data set) are associated with a high degree of confidence. Conversely, a low degree of confidence is associated with data from studies that do not statistically support a probit dose response relationship. In addition, confidence in the data set might be reduced by high variance in the slope (i.e., large 95% confidence intervals), despite good probit fit characteristics.

Individual effect probabilities are calculated using an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The tool performs calculations based on user inputs of the mean slope estimate (and the 95% confidence bounds of that estimate) as the slope parameters. The summary of probabilities of an individual to demonstrate an effect using probit slope relationships can be found in the Risk Estimation section of the Risk Characterization for the acute listed LOC and RQ.

4.8 Review of Ecological Incident Information System (EIIS)

Twenty-nine ecological incidents, dating from 1988 to 2005, related to aldicarb poisoning have been reported and summarized in the 2006 revised screening level ecological risk assessment. Only the two new incidents reported in the database since 2005 are listed here. These two new incidents, summarized below, came about due to illegal use of alidcarb.

On January 3, 2006 a man in Floyd County (GA) found his dog severely sick (I017085-001). The following day, his other dog was found dead near his home. The next day, a ranger of the Georgia Department of Natural Resources (GA DNR) found two opossum carcasses in the same area where his dog had died. Necropsies were performed on the two opossums; the gastrointestinal contents of one of them contained 96 ppm of aldicarb and the other contained 185 ppm aldicarb. Further study of the area led to the discovery of a dead white-tailed deer that had been dumped on the property. The ranger investigating the deaths feels that the deer, too badly decomposed to analyze for pesticide residues, was the source of the aldicarb in the animals that were killed. He said that Temik was not sold locally, and that the main crop grown in the area was corn, for which Temik is not registered. He suspects that the deer carcass was baited with aldicarb and placed to kill coyotes.

On March 27, 2006, one dog and two black vultures were found near a partially-consumed carcass of a cottontail rabbit (I017462-001). The incident occurred on municipal property that was used by the town of Hoinsville, Georgia, for disposal of wastewater from a sewage treatment plant. Analysis of the vulture and rabbit found that brain cholinesterase levels were significantly depressed in both animals, indicating that both had ingested an anticholinesterase chemical. Toxicological analysis found 43 ppm aldicarb in the stomach of the rabbit and "greater than 0.1 ppm" of aldicarb sulfoxide in the liver of the vulture. The testimony of a local GA DNR employee as well as a GIS analysis done by EFED indicated that very little or no land in the vicinity was planted in crops on which aldicarb is registered for use. Thus, while there is little doubt that the animals were poisoned by alidcarb, the most likely scenario is that the animals were poisoned by illegal baiting or some other illegal use of aldicarb.

4.9 Sensitivity Distribution

4.9.1 Freshwater Fish

Of all the freshwater fish data reviewed by the Agency (registrant submitted studies as well as open literature studies) in the 2006 revised screening level ecological risk assessment, only three studies were classified as ‘acceptable’ or ‘supplemental’ according to guidelines. Not enough data were available to develop a sensitivity distribution of freshwater fish 96-h LC_{50} values.

4.9.2 Freshwater Invertebrate

An acute freshwater species sensitivity distribution was constructed using acute toxicity values for freshwater invertebrates from registrant and open literature studies. The kinds of data desired for an acute species sensitivity distribution generally consist of 96-h LC_{50} values for invertebrates except for cladocerans. The desired measurement endpoint for daphnids and other cladocerans is the 48-h EC_{50} based on percentage of organisms immobilized plus percentage of organisms killed. These kinds of data are consistent with FIFRA guideline studies and acute toxicity data measurement endpoints for water quality criteria (Stephens et al., 1985). Freshwater acute toxicity data for aldicarb identified as scientifically sound and useable quantitatively from the RED and this effects determination are listed in Table 19. Aldicarb acute invertebrate data excluded from the analysis include those tests where controls were insufficient or not reported (Margin et al., 1988; Pantani et al., 1997), tests with single-celled organisms, these are not considered acute tests (Edmiston et al., 1984); and tests with saline environmental conditions (Song and Brown, 1998). A 24-hr EC_{50} value for *Daphnia magna* was included along with the 48-hr values because it was lower than some 48-hr values. The only scientifically sound *Chironomus riparius* and *Chironomus tetans* acute toxicity data was for 24 hour and 48 hour exposures, respectively, rather than 96 hours. The 96-h acute values for these *Chironomous* spp. are expected to be lower and may therefore result in an underestimation of the concentration where the lower tail lies (e.g., underestimation of the concentration at and below which 0.05 of a fraction of the taxa lie).

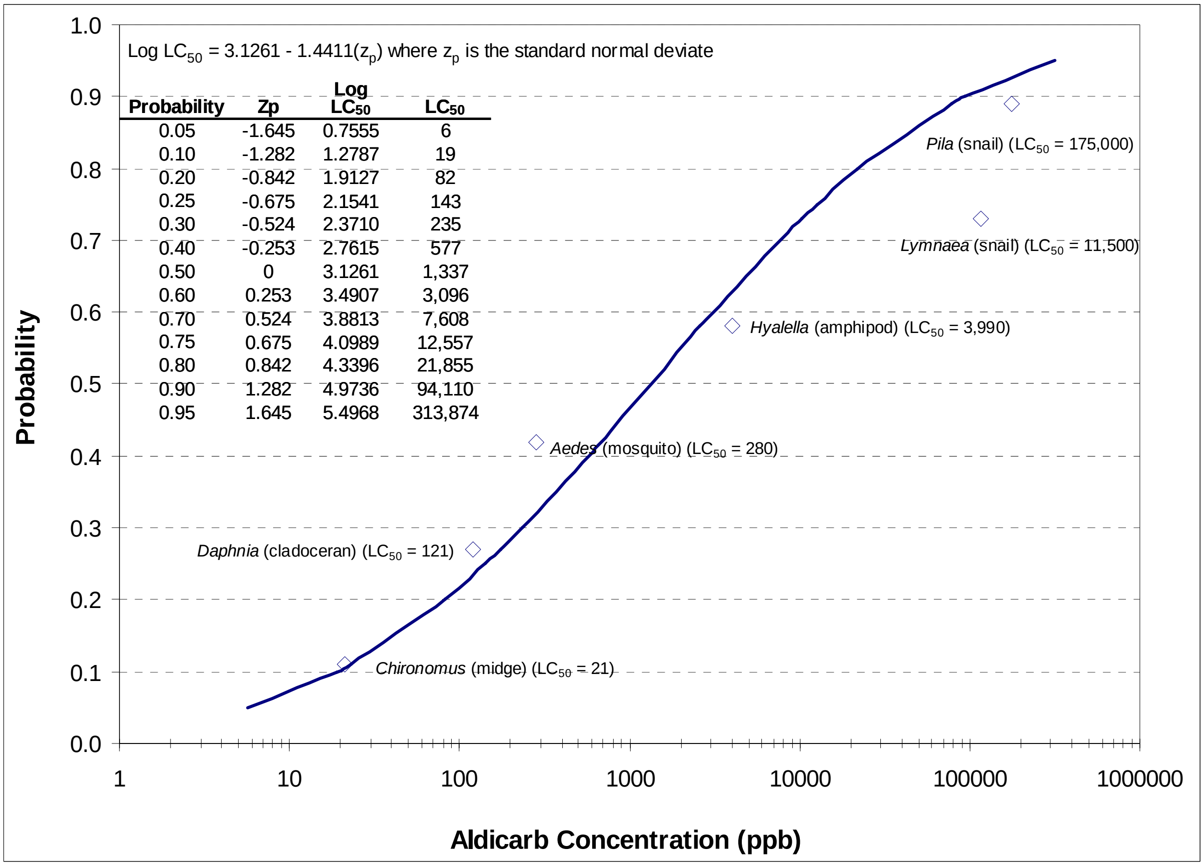
Where there were multiple results for a single species, a species mean acute value (SMAV) was calculated by taking the geometric mean of the data for that species. Where there were multiple results for a genus, a genus mean acute value (GMAV) was calculated by taking the geometric mean of the SMAV. The method of calculating SMAV and GMAV for constructing the sensitivity distribution is consistent with Office of Water quality criteria development (Stephan et al., 1985). The use of GMAVs is used to prevent data sets from being biased by overabundance of species in one or a few genera, given that on the average, species within a genus are generally much more toxicologically similar than species in different genera (Stephen et al., 1985). The GMAVs are assumed to be log normally distributed. The mean (3.1261) and standard deviation (1.4411) of the log transformed GMAVs were used to calculate the sensitivity distribution (Figure 12). The 5, 25, 50 and 75 percent of the freshwater invertebrate taxa fall at and below 6, 143, 1337, and 12557 ppb aldicarb, respectively. The 95% lower confidence limit for the 0.05 fraction is (mean-standard deviation * $t_{0.05,5}$; 3.1261 – 1.4411*2.015=2 ppb).

Table 19 Freshwater Acute Invertebrate Toxicity Data and Species and Genus Mean Acute Values

Species	Genus	96-hr LC_{50}[(a)] (ppb)	Log 96-hr LC_{50}	Species Mean[(b)] Acute (ppm)	Genus Mean[(b)] Acute (ppm)	Reference
Pila globosa	*Pila*	175000	5.243	175000	175000	Singh and Agarwal, 1981
Lymnaea acuminate	*Lymnaea*	11500	4.061	11500	11500	Singh and Agarwal, 1981
Hyalella azteca	*Hyalella*	3990	3.601	3990	3990	Moore et al., 1998
Aedes aegypti, 27°C	*Aedes*	290	2.462	280	280	Song et al., 1997
Aedes aegypti, 20°C		270	2.431			Song et al., 1997
Daphnia magna, 20°C	*Daphnia*	583	2.766	253	121	Moore et al., 1998
Daphnia magna		411	2.614			Acc. No. 098663
Daphnia magna[(c)]		228	2.358			Sturm and Hansen, 1999
Daphnia magna, 27°C		75	1.875			Song et al., 1997
Daphnia Laevis juvenile		65	1.813	58		Foran et al., 1985
Daphnia Laevis adult		51	1.708			Foran et al., 1985
Chironomus riparius[(d)], pH 4	*Chironomus*	17	1.230	22	21	Suorsa and Fisher, 1986
Chironomus riparius[(d)], pH 6		21	1.322			Suorsa and Fisher, 1986
Chironomus riparius[(d)], pH 8		28	1.447			Suorsa and Fisher, 1986
Chironomus tetans[(e)]		20	1.301	20		Moore et al., 1998

[(a)] Tests with daphnids and other cladocerans are 48-hr EC_{50} based on percentage of organisms immobilized plus percentage of organisms killed (Stephan et al., 1985)
[(b)] Geometric mean
[(c)] Result is a 24-hr value which may underestimate the desired 48-h EC_{50} measurement endpoint
[(d)] Test conducted using 4th instar rather than 2nd or 3rd instar which are considered a more sensitive midge life stage (Stephan et al., 1985) and result is a 24-hr value which may underestimate the desired 96-h LC_{50} measurement endpoint
[(e)] Result is a 48-hr value which may underestimate the desired 96-h LC_{50} measurement endpoint

Figure 12 Cumulative Acute Sensitivity Distribution of Freshwater Invertebrates to Aldicarb



5 Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations to determine the potential ecological risk from varying aldicarb use scenarios within the action area and likelihood of direct and indirect effects on the CRLF. The risk characterization provides an estimation and a description of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the effects determination (i.e., “no effect,” “likely to adversely affect,” or “may affect, but not likely to adversely affect”) for the CRLF.

5.1 Risk Estimation

Risk was estimated by calculating the ratio of estimated environmental concentrations (EECs; see Table 11) and the appropriate toxicity endpoint. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (Tables 15).

Aquatic screening level RQs are based on the most sensitive endpoints for each assessment endpoint (Tables 7, 8 and 13) and modeled surface water concentrations from the following scenarios of aldicarb:

- Citrus (1 application @ 33 lbs of product/A)
- Cotton (1 application @ 21 lbs of product/A)
- Cotton (3 applications @ 7 lbs of product/A each with a 30 day interval between applications)
- Soybean (1 application @ 20 lbs of product/A)
- Pecan (1 application @ 33 lbs of product/A)
- Sugar beet (2 applications @ 14 lbs of product/A with a 30 day interval between applications)
- Sweet potato (1 application @ 30 lbs of product/A – Temik 10g only)
- Dried bean (1 application @ 21 lbs of product/A– Temik 10g only)
- Alfalfa (1 application @ 20 lbs of product/A)
- Sorghum (1 application @ 7 lbs of product/A)
- Peanut (1 application @ 30 lbs of product/A– Temik 10g only)
- Ornamentals (1 application @ 50 lbs of product/A– Temik 10g only)

Terrestrial screening level RQs for the terrestrial phase of the CRLF and small mammalian prey are based on the most sensitive endpoints and EECs/sq ft for the following scenarios[11] as modeled by T-REX (ver.1.3.1):

- Citrus (1 application @ 33 lbs of product/A, 85% incorporation efficiency)

[11] Alfalfa was not modeled in the terrestrial risk assessment because its application rate, application method, and RQs are representative of RQs derived for the peanut and soybean scenarios.

- Cotton (3 applications @ 7 lbs of product/A, 30 day interval between applications, 85% incorporation efficiency)
- Dry beans (1 application @ 7 lbs of product/A, 99% incorporation efficiency)
- Peanuts (1 application @ 20 lbs of product/A, 99% incorporation efficiency)
- Sorghum (1 application @ 7 lbs of product/A, 99% incorporation efficiency)
- Soybean (1 application @ 20 lbs of product/A, 99% incorporation efficiency)
- Sugar beet (2 applications @ 14 lbs of product/A, 30 day interval between applications, 85% incorporation efficiency)
- Sweet potato (1 application @ 14 lbs of product/A, 99% incorporation efficiency)

Application of aldicarb to pecans could not be adequately modeled using T-REX because the model assumes that aldicarb is applied by shanking in below the dripline of the tree. Based on information provided by OPP BEAD, (pecan trees are grown up to 60 feet; 30 feet spacing within row; canopies touching; little space between canopies of adjacent rows), the Agency calculated LD_{50}/sq ft for pecans based on 'shanking-in' application, band with of 6.25", and 72" row spacing (space between adjacent canopies).

Terrestrial screening level RQs for terrestrial invertebrates and terrestrial phase of the CRLF (due to secondary poisoning) are based on the highest estimated aldicarb concentrations in soil from all use scenarios (see T-REX) as estimated by the most sensitive endpoints and the Earthworm Fugacity model. Terrestrial plant RQs are based on the most sensitive endpoint and EECs as modeled by TerrPlant (ver.1.2.2). EECs will be calculated for all labeled uses permitted in California.

In cases where the screening level RQ exceeds one or more LOC, additional factors, including CRLF life history characteristics, probit dose-response analysis (IEC V1.1), and species sensitivity distribution are considered and used to characterize the potential for aldicarb to affect the CRLF. Risk estimations of direct and indirect effects of aldicarb to the CRLF are provided in section 5.1.1 and 5.1.2, respectively.

5.1.1 Direct Effects

Risk to the aquatic stage of the CRLF is driven by the sugar beet scenario and generated acute and chronic RQs of 0.22 and 11.79, respectively (LOC ≥0.05 and ≥1). Due to lack of a dose response slope value, individual probabilities of mortality were bracketed by evaluating a slope of 2 (high probability of individual mortality) and a value of 9 (low probability of individual mortality). The aquatic acute listed LOC (0.05) at default slope 95% bounds of 2 and 9 correspond to a probability of individual mortality of 1 individual in 216 and 1 individual in 1.8E+31, respectively. One of the reasons it is difficult to get a slope is because of the almost all or none response observed in most studies. Therefore, the slope actually is expected to tend more towards 2 than 9. Probabilities for the calculated RQ values above the acute listed LOC (0.05) but below the acute LOC (0.5) for all assessments at the default average slope of 4.5 and the 95% lower bound slope of 2 are provided in Table

Risk to the terrestrial phase of the CRLF is driven by aldicarb use on citrus, followed by cotton, with an acute LD_{50}/sq ft (RQ) of 2978 and 468 for small and large red legged frogs, respectively (LOC ≥0.1). For the pecan scenario, it was assumed based on mature orchard information from BEAD, that adult tree canopies within the same row touch, and therefore shanking of aldicarb granules into the soil in one continuous row as modeled by T-Red's LD_{50}/sq ft method became a reasonable assumption. It was further assumed that trees between rows leave a 72" gap between canopies of adjacent rows of trees, and that this distance was the row spacing between rows. Chronic RQs could not be calculated by the LD_{50}/sq foot method of the T-REX model, but the estimated NOAEL of 0.11mg ai/kg bw will be qualitatively discussed in the risk description section. Direct toxicity to the red legged frog by way of secondary poisoning exposure from terrestrial invertebrates is not expected to lead to LOC exceedances (LOC ≥0.05).

.

Table 20 Summary of Aldicarb Direct Effects RQs for the CRLF

Effects to CRLF	**Surrogate Species**	**Toxicity Value**	**Scenarios**	**RQ**		**Probability of Individual Effect (Default slope = 4.5)**	**LOC Exceedance**
Aquatic Phase CRLF							
Acute Direct Toxicity	Bluegill sunfish	96-h LC_{50}= 52 ppb ai	Citrus Cotton (1) Cotton (3) Soybean Pecan **Sugar beet**	0.0071 **0.13** **0.15** **0.12** **0.14** **0.22**		>1-in-4.3E8 1-in-30,000 1-in-9,600 1-in-58,000 1-in-16,000 1-in-648	No Yes Yes Yes Yes Yes
Chronic Direct Toxicity	Bluegill sunfish/Fathead minnow ACR	Estimated NOAEC= 0.46 ppb ai	Citrus Cotton (1) Cotton (3) Soybean Pecan **Sugar beet**	0.81 **7.68** **7.50** **5.60** **6.84** **11.79**		Not applicable	Yes Yes Yes Yes Yes Yes
Terrestrial phase CRLF							
				Sm frog[6]	**Lg frog[6]**		
Acute Direct Toxicity	Mallard duck	LD_{50}= 1 mg/kg-bw	**Citrus** Cotton [1, 4] Dry Beans[3] Peanuts[3] Pecans[5] Sorghum[3] Soybean[3] Sugarbeet[2,3] Sweet potato[3]	**2978** **1599** **84** **180** **571** **185** **150** **1158** **84.23**	**467** **251** **13** **28** **89** **29** **23** **181** **13**		Yes Yes Yes Yes Yes Yes Yes Yes Yes
Acute Direct Toxicity via Secondary poisoning	Mallard duck	LD_{50}= 1 mg/kg-bw	Citrus	0.0017			No

Bolded scenarios are the highest risk in the aquatic or terrestrial environment and bolded RQ values exceed LOC values

[1] T-REX does not allow for different application rates; thus the modeling run generating the highest RQs was chosen for final RQs in Table 24, which was for 3 applications @ 7 lbs/A

[2] Three applications are allowed for sugar beet with a maximum 1 time application rate of 14 lbs/A and a total of 28 lbs/yr. The modeling run generating the highest RQs was chosen for final RQs in Table 24

[3] Incorporation efficiency 99%

[4] incorporation efficiency 85%

[5] LD_{50}/sq ft calculated assuming granules shanked in, row spacing between canopy of trees in adjacent rows 72".

[6]small refers to a 20 g bird; a small CRLF however would be around 50g. Therefore this RQ estimate may be higher than expected. Large refers to a 100g bird; a large CRLF may weigh up to 100 g. Therefore, this RQ estimate may be lower than expected.

Aldicarb Degradates and Direct toxicity to the Red Legged Frog

Aldicarb sulfoxide has been classified as moderately toxic on an acute basis to freshwater fish (MRID 45592115). Based on the one study available, it can be assumed that aldicarb sulfoxide is not likely to pose a risk to the aquatic phase of the red legged frog. None of the scenarios modeled (combined aquatic EECs for parent and degradates were used in these calculations) lead to LOC exceedances (LOC ≥0.05).

Table 21 Aldicarb Sulfoxide Direct Effects to the CRLF

Effects to CRLF	Surrogate Species	Toxicity Value	Scenarios	RQ	Probability of Individual Effect	LOC Exceedance
Acute direct toxicity	Rainbow trout	96-hr LC_{50} = 7,140 ppb ai	Citrus Cotton (1) Cotton (3) Soybean Pecan Sugar beet	0.00005 0.001 0.001 0.0009 0.001 0.002	At LOC of 0.05 and slopes of 2 and 9 1 in 216 1 in 1.8E+31	No

5.1.2 Indirect Effects

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

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

If LOCs are exceeded for freshwater and terrestrial vertebrates as well as invertebrates that are prey items of the CRLF, there is a potential for aldicarb to indirectly affect the frogs by reducing available food supply. In such cases, the dose response relationship from the toxicity study used for calculating the RQ of the surrogate prey item is analyzed to estimate the probability of acute effects associated with an exposure equivalent to the EEC. Generally, the greater the probability that exposures will produce effects on a taxa, the greater the concern for potential indirect effects for listed species dependant upon that taxa (U.S. EPA, 2004). However, life history characteristics of each taxa affected and serving as prey to the CRLF will have to be considered in conjunction with the probability of exposure. In addition, the species' sensitivity distribution for aquatic invertebrates can be used to further refine an effects determination.

As an insecticide, indirect effects to CRLFs from potential effects on primary and secondary consumers are a principle concern. Furthermore, aldicarb has shown to have deleterious effects on seedling emergence in terrestrial plants, and therefore, potential effects on terrestrial plants growing in semi-aquatic areas is of concern as well. Based on the emergence data, aldicarb's systemic nature, and its positive effects on biomass in terrestrial plants, it can be concluded that potential effects on primary productivity of aquatic vascular plants is of concern as well. This risk assessment will address risk to aquatic vascular plants in a qualitative way because of lack of data.

5.1.2.1 Evaluation of Potential Indirect Effects via Reduction in Food Items

Potential indirect effects from direct effects on animal food items were evaluated by considering the diet of the California Red Legged frog and the sensitivity distribution of aquatic prey organisms. Aquatic phase CRLF larvae consume algae, diatoms, and detritus, for which no data are available. The saltwater diatom data was used as a surrogate for freshwater diatoms to assess potential indirect effects on the larval stage of the CRLF; no other aquatic plant data are available for an indirect effects analysis of the aquatic phase of the CRLF. Terrestrial phase CRLFs feed on a wide range of freshwater and terrestrial invertebrates, and freshwater and terrestrial vertebrates, including water striders, sow bugs, fish, other frogs, salamanders, and small mice. While aquatic and terrestrial invertebrates comprise the most numerous food items, 50% of the prey mass in larger adult CRLFs consists of vertebrates such as mice, frogs, and fish. The RQs used to characterize potential indirect effects to the terrestrial and aquatic phase of the CRLF from direct acute and chronic effects on freshwater vertebrate and invertebrate as well as terrestrial vertebrate and invertebrate food sources are provided in Table 22. Acute RQs are based on the most sensitive toxicity endpoints of the bluegill sunfish (96-h LC_{50} = 52 ppb ai), *C. tentans* (20 ppb ai), the rat (LD_{50} = 0.9 mg ai/kg-bw), and the honey bee (LD_{50} = 0.285 µg/bee). Chronic RQs are based on the bluegill sunfish (estimated NOAEC = 0.46 ppb ai), and *C. tentans* (NOAEC = 1 ppb ai). Chronic RQs cannot be calculated by the LD_{50}/sq foot method of the T-REX model; but the rat NOAEL of 0.4 mg ai/kg-bw will be qualitatively discussed in the Risk Description section of this assessment.

There are acute LOC exceedances (≥ 0.05) for fish and invertebrates and aquatic animals from all use scenarios except citrus (low runoff PRZM-EXAMS scenario), sorghum and by default soybean with infurrow and positive displacement application methods only which have lower EECs than citrus (Table 22). Containerless field grown ornamentals (and by default container grown outdoor ornamentals represented by this scenario) and sweet potato do not exceed the acute listed LOC for fish. There are chronic LOC exceedences for fish and aquatic invertebrates for all scenarios except citrus (soybean applied infurrow and/or with positive displacement by default) and sorghum. Sugar beet drives both the acute and chronic risks LOC exceedances to these potential dietary sources of the CRLF and invertebrates and, therefore, drives the indirect effects to the CRLF on an overall basis.

There are LOC exceedances (≥0.1, Ratio of ≥0.05 for terrestrial invertebrates) for small mammals and terrestrial invertebrates from all use scenarios (Table 23). Aldicarb use on citrus leads to the highest LOC exceedance for small mammals (LD_{50}/sq ft =1042) followed by cotton, sugar beets, and pecans (LD_{50}/sq ft =560, 405, and 200, respectively). Aldicarb use on citrus also produced the highest soil concentration estimated with the Earthworm Fugacity model (14.3 mg/kg soil); this estimated soil concentration was used to estimate risk to concentrations on a honey bee of 0.1g (or 0.0001 kg). The resulting RQ for honey bee is 5.03 (LOC = 0.05) and is representative of all terrestrial invertebrates on-site. An estimate of the off-site soil concentrations were estimated using Terrplant as discussed in Section 3.4 and resulted in concentrations below the LOC. Since aldicarb use on cotton has the highest reported usage in California, soil concentrations from this use were considered as well to estimate risk to terrestrial invertebrates. Aldicarb use on citrus produced a soil concentration of 1.2 mg/kg soil. The resulting RQ for honey bee is 0.42 and exceeds the LOC of 0.05 for terrestrial invertebrates for on-site soils. The off-site soil as discussed in the previous sentence will be below the LOC.

5.1.2.2 Evaluation of Potential Indirect Effects via Reduction in Habitat and/or Primary Productivity

Potential indirect effects on habitat and/or primary productivity were assessed using the RQs from a saltwater diatom. This species is used as a surrogate for freshwater diatoms and will only provide insight into a small part of the sensitivity spectrum of freshwater plant. If aquatic plant RQs exceed the Agency's non-listed species LOC (because the aquatic and terrestrial phase of the CRLF relies on multiple plant species), potential community level effects are evaluated using the threshold concentrations (No Adverse Effects Levels, i.e. NOAEC). Risk quotients used to estimate potential indirect effects to the CRLF from effects on aquatic and terrestrial plants primary productivity are summarized in Table 24.

None of the use scenarios led to LOC exceedances for freshwater aquatic plants (using saltwater diatom as surrogate) and terrestrial plants, or for terrestrial plants growing in semi-aquatic areas. Both aquatic plant and terrestrial plant RQs were <0.5 and do not trigger the LOC. The TerrPlant model assumes that 100% of the granules are incorporated, which is not a realistic assumption for all aldicarb incorporation methods. In reality, citrus and cotton (3 applications) are more likely to have only 85% of aldicarb granules incorporated (because established trees for citrus and established plants for second and third applications for cotton do not allow for use of the type of equipment necessary to achieve 99% incorporation). If TerrPlant had the ability to model partial granular incorporation, the resulting RQs would be higher for terrestrial plants and plants growing in semi-aquatic areas.

Table 22 Summary of Aldicarb RQs Used to Estimate Indirect Effects to the CRLF via Acute and Chronic Effects on Aquatic Dietary Items(1)

Crop	Efficiency of Method	Amount Product	% a.i.	EEC			Fish [1, 2, 3]		Invertebrate [1, 2, 3]	
				Peak	21-d	60-d	Acute	Chronic	Acute	Chronic
Citrus	(85%)	33 lb/A	15g	0.4	0.2	0.1	0.01	0.2	0.02	0.2
Sorghum	IF (99%)	10 lb/A/yr	10g	0.7	0.5	0.3	0.01	0.7	0.04	0.5
	IF (99%)	7 lb/A/yr	15g	0.7	0.5	0.3	0.01	0.7	0.04	0.5
Ornamentals (field-no contaniners)	SD (99%)	50 lb/A/yr	10g	0.9	0.7	0.5	0.02	**1.1**	**0.05** 4.5S (1-in-4.2E8) 2S (1-in-216)	0.7
Sweet Potato	Band (99%)	30 lb/A/crop	10g	1.4	1	0.6	0.03	**1.3**	**0.07** 4.5S (1-in-9.9E6) 2S (1-in-96)	**1.0**
Dried Bean	Band (85%)	21 lb/A/ crop	10g	4.5	3.5	2.3	**0.09** 4.5S (1-in-7.9E5) 2S (1-in-55)	**5.0**	**0.23** 4.5S (1-in-491) 2S (1-in-9)	**3.5**
Soybean	(85-99%)	20 lb/A	15g	6.1	4.5	2.6	**0.12** 4.5S (1-in-5.8E4) 2S (1-in-30)	**5.7**	**0.31** 4.5S (1-in-91) 2S (1-in-6)	**4.5**
Peanut	Band (85%)	30 lb/A/crop	10g	6.4	5	3.3	**0.12** 4.5S (1-in-5.8E4) S (1-in-30)	**7.2**	**0.32** 4.5S (1-in-77) 2S (1-in-6)	**5.0**
Pecans	(85%)	33 lb/A	15g	7.4	5.4	3.1	**0.14** 4.5S (1-in-1.6E4) 2S (1-in-23)	**6.7**	**0.37** 4.5S (1-in-39) 2S (1-in-5)	**5.4**
Cotton	(85-99%)	21 lb/A/season	15g	7.6	5.9	3.4	**0.15** 4.5S (1-in-9,600) 2S (1-in-20)	**7.4**	**0.38** 4.5S (1-in-34) 2S (1-in-5)	**5.9**
				6.8	5.5	3.5	**0.13** 4.5S (1-in-3E4) 2S (1-in-20)	**7.6**	**0.34** 4.5S (1-in-57) 2S (1-in-6)	**5.5**
Alfalfa (seed)	Drill (85%)	20 lb/A/yr	15g	10	8.4	5.3	**0.19** 4.5S (1-in-1700) 2S (1-in-13)	**11.5**	**0.50**	**8.4**
Sugarbeet	(99%)		15g	11.4	8.6	5.4	**0.22** 4.5S (1-in-648) 2S (1-in-11)	**11.7**	**0.57**	**8.6**

(1) Bolded acute values exceed the acute listed LOC (0.05) and bolded chronic values exceed the chronic LOC (1).
(2) Peak EECs are used for calculating acute RQs; 21-day EECs are used for invertebrate chronic RQs and 60-day EECs for vertebrate chronic RQs.
(3) Fish bluegill 96-h LC_{50} 52 ppb; NOAEC 0.46 ppb; 48-hr EC_{50} *Chironomus tentans* 20 ppb; estimated NOAEC 1 ppb

Table 23 Summary of Aldicarb RQs Used to Estimate Indirect Effects to the CRLF via Acute Effects on Terrestrial Dietary Items[(1)]

Indirect Effect to CRLF	Surrogate Food Item Toxicity Value	Use	Dose or Concentration			RQ	LOC[(2)] Exceedance
			Dose LD_{50}/sq ft				
Reduced Terrestrial Food via **Acute** Direct Toxicity	Rat LD_{50} 0.9 mg a.i./kg-bw		**15 g mammal**	**35 g mammal**	**1000 g mammal**		
		Citrus				**1042**	Yes
		Cotton (3)	560	296	24	**559[1]**	
		Dry Beans	30	16	1.26	**29[1]**	
		Peanuts	63	35	2.7	**63[1]**	
		Pecans	200	106	9	**200[1]**	
		Sorghum	65	34	2.8	**65[1]**	
		Soybean	53	28	2	**52[1]**	
		Sugar beet	405	214	17	**405[1]**	
		Sweet potato	1.26	16	29	**29[1]**	
			On-site[(3)] Soil Concentration				
Reduced Terrestrial Food via **Acute** Direct Toxicity	Honey bee (0.0001 kg) LD_{50} 0.000285 mg a.i./bee	Citrus	14.3 mg ai/kg soil (=0.0014 mg a.i./bee)			**5.03[2]**	Yes
		Cotton (3)	1.2 mg ai/kg soil			**0.42**	Yes

(1) Bolded sections represent use scenarios that are driving risk in aquatic and terrestrial environment, bolded RQs exceed LOC

(2) Acute endangered LOC of 0.1 is used for terrestrial animals and the LOC of 0.05 is used for acute effects to terrestrial invertebrates.

(3) Off-site soil estimated soil concentrations are below LOC of 0.05 (see Section 3.4)

Table 24 Aldicarb RQs Used to Estimate Indirect Effects to the CRLF via Direct Acute Effects on Aquatic and Terrestrial Habitat Components

Indirect Effect to CRLF	Surrogate Species/ Toxicity Value	Use	EEC		RQ		Exceedance and Risk Interpretation
Reduced Cover to Aquatic Phase of CRLF via Direct Toxicity	Marine diatom 96-hr EC_{50} > 50,000 ppb ai	Citrus	0.371		0.000007		No
		Cotton (3)	7.632		0.0002		No
		Soybean	6.142		0.0001		No
		Pecan	7.373		0.0001		No
		Sugar beet	11.377		0.0002		No
			Total loading to adjacent areas	**Total loading to semi aquatic areas**	**Emerg. RQs adjacent area, monocots**	**Emerg. RQs semi aquatic area, monocots**	
Reduced Plant Stand of Terrestrial Habitat Component via Direct Toxicity to seedling emergence	Pearl millet 21-d NOAEC = 2.05 lbs ai/A	Citrus	0.0825	0.8250	0.04	0.40	No
		Cotton	0.0525	0.5250	0.03	0.26	No
		Dry bean	0.0175	0.1750	0.01	0.09	No
		Peanut	0.0500	0.5000	0.02	0.24	No
		Pecan	0.0825	0.8250	0.04	0.4	No
		Sorghum	0.0350	0.3500	0.02	0.17	No
		Soybean	0.0500	0.5000	0.02	0.24	No
		Sugar beet	0.0700	0.7000	0.03	0.34	No
		Sweet potato	0.0350	0.3500	0.02	0.17	No

5.2 Risk Description

The risk description synthesizes an overall conclusion regarding the likelihood of adverse impacts leading to an effects determination (i.e., “no effect,” “may affect, but not likely to adversely affect,” or “likely to adversely affect”) for the California Red Legged frog.

If the RQs presented in the Risk Estimation (Section 5.1.2) show no indirect effects, and LOCs for the CRLF are not exceeded for direct effects (Section 5.1.1), a “no effect” determination is made based on aldicarb’s use within the action area. If, however, indirect effects are anticipated and/or exposure exceeds the LOCs for direct effects, the Agency concludes a preliminary “may affect” determination for the CRLF.

Following a “may affect” determination, additional information is considered to refine the potential for exposure at the predicted levels based on the life history characteristics (i.e., habitat range, feeding preferences, etc) of the CRLF and potential community-level effects to aquatic plants and terrestrial plants growing in semi-aquatic areas. Based on the best available information, the Agency uses the refined evaluation to distinguish those actions that “may affect, but are not likely to adversely affect” from those actions that are “likely to adversely affect” the CRLF.

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

- Significance of Effect: Insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where “take” occurs for even a single individual. “Take” in this context means to harass or harm, defined as the following:

   - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.

   - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

- Likelihood of the Effect Occurring: Discountable effects are those that are extremely unlikely to occur. For example, use of dose-response information to estimate the likelihood of effects can inform the evaluation of some discountable effects.

- Adverse Nature of Effect: Effects that are wholly beneficial without any adverse effects are not considered adverse.

A description of the risk and effects determination for each of the established assessment endpoints for the CRLF is provided in Sections 5.2.1 through 5.2.3.

5.2.1 Direct Effects to the California Red Legged Frog

5.2.1.1 Direct Effects to the Aquatic Phase of the CRLF

Aquatic acute and chronic RQs exceeded acute listed and chronic LOCs for the following modeled uses within the action area: cotton, dried bean, soybean (banded applications), peanut, pecan, alfalfa and sugar beet. Sugar beet drives the risk in the aquatic environment with acute and chronic RQs of 0.22 and 12, respectively. These RQs were based on maximum label application rates. What constitutes typical application rates for the uses having LOC exceedances is unclear and can, therefore, not be discussed for characterization purposes. For the purpose of refinement, the CAL DPR PUR data will be used in conjunction with spatial CRLF data, RQ exceedances, species' life history information, and more to make direct effects determinations for the CRLF.

The probability of an individual event to the CRLF was calculated for all acute RQs based on the dose response curve slopes of 4.5 (default) and its lower and upper 95% bounds of the slope range (2 and 9) due to lack of actual probit slope values for individual taxa). The corresponding estimated chance of an individual acute mortality to the larva of the CRLF at RQs above the acute listed LOC ranging from 0.09 to 0.22 (based on the acute toxic endpoint for surrogate freshwater fish) is 1-in-790,000 to 1-in-648, respectively, for the mean slope of 4.5 (range if slope of 2 is used: 1-in-55 to 1-in-11). The acute listed LOC estimated chance of an individual acute mortality for the mean slope is 1-in-4.2E8 (for slope of 2 and 9: 1-in-216 and 1-in-1.8E31). There is considerable amount of uncertainty around the probability of an individual mortality occurrence based on the default slope bounds; however, expect the slope to be more towards 4.5 and 2 based on the all-or-none response observed in most acute tests. In absence of a species' sensitivity distribution for acute mortality endpoint values, this uncertainty cannot be further refined at this point. For dried beans, soybean (banded application), peanut, pecan, cotton, alfalfa, and sugar beet, given the high probability of an individual experiencing a mortality event based on the steeper slopes, and chronic RQs that are above the chronic LOC, aldicarb was considered likely to cause direct adverse effects to the aquatic phase of the CRLF where exposure to pesticide actually occurs.

Based on the usage information provided by California Department of Pesticide Programs (PUR database) for 2001 through 2005, minor use of aldicarb (total amount of aldicarb in California has been reported (1 and 1,232 lbs/A) for the following twelve counties during the five year period: Alameda (1 lbs/A), Butte (854 lbs/A), Glenn (422 lbs/A), Monterey (111 lbs/A), San Benito (157 lbs/A), San Joaquin (77 lbs/A), San Luis Obispo (1 lbs/A), Santa Cruz (3 lbs/A), Santa Clara (1 lbs/A), Stanislaus (5 lbs/A), Sutter (1,232 lbs/A), and Riverside Counties (1,202 lbs/A). Significant aldicarb use (total amount of aldicarb used in five years greater than 1,232 lbs/A) has been limited to the following nine counties: Colusa (3,574 lbs/A), Fresno (>75,000 lbs/A), Imperial (3,491 lbs/A), Kern (>25,120 lbs/A), Kings (>75,400 lbs/A), Madera (5,014 lbs/A), Merced (2,909 lbs/A), Tulare (2,512 lbs/A), and Yolo (5,089 lbs/A). No aldicarb use has been reported for the remaining counties in California. Of the nine and twelve counties with highest and lowest total aldicarb use (for all commodities) listed above, the following ten counties are expected to clearly overlap with occurrence polygons, occurrence sections, critical habitat, or core areas in recovery units (RU): Alameda (RU4), Butte (RU1), Fresno (RU1), Merced (RU1), Monterey (RU5, RU6), San Luis Obispo (RU5, RU6), San Benito (RU5, RU6), Santa Cruz (RU4, RU5), Santa Clara (RU4, RU6), and Riverside (RU8). The remaining counties from that list are not expected to overlap with occurrence polygons, occurrence sections, critical habitat, or core areas: Butte, Colusa, Glenn, Imperial, Kern, Kings, Madera, San Joaquin, Stanislaus, Sutter, Tulare, and Yolo. The highest total use of aldicarb has been on *cotton* in Colusa (2,800 lbs/A), Fresno (74,000 lbs/A), Imperial (3,500 lbs/A), Kern (31,500 lbs/A), Kings (74,000 lbs/A), Madera (4,700 lbs/A), Merced (27,800 lbs/A), Riverside (1,200 lbs/A), Sutter (1,200 lbs/A), Tulare (22,300 lbs/A), and Yolo (5,000 lbs/A). All other aldicarb uses listed in the CAL DPR PUR database make up insignificant amounts when compared to aldicarb use on cotton.

As discussed in the 2006 revised screening level ecological risk assessment, two incidents for freshwater fish (I003826-002 and I000799-005) related to aldicarb have been reported in the Environmental Incident Information System (EIIS) database (North Carolina (1995): one incident as a result of registered use and one of undetermined use). No aquatic incidents have been reported in California.

Based on all available lines of evidence, the Agency concludes a "likely to adversely affect" determination for direct effects to the aquatic phase of the CRLF via mortality, growth, or reproduction in areas where exposure to aldicarb is expected to occur, such as in recovery unit 1, 5, 6, and 8, for dried bean, soybean (banded application), peanut, pecan, cotton, alfalfa for seed, and sugar beet. The Agency concludes a "not likely to adversely affect" determination for direct effects to the aquatic phase of the CRLF via growth, survival, and reproduction in recovery units 2, 3, 4, and 7 due to lack of spatial overlap of CRLF habitat and occurrence data with the aldicarb action area. The Agency concludes a "likely to adversely affect" determination for direct effects of aldicarb to the aquatic phase of the CRLF in RU1, RU5, RU6, RU8.

No LOC exceedances are predicted for aldicarb degradates based on modeled EECs and available freshwater fish and freshwater invertebrates endpoint values. The Agency concludes a "no effects" determination for direct effects of aldicarb sulfoxide to the aquatic phase of the CRLF.

5.2.1.2 Direct Effects to the Terrestrial Phase of the CRLF

Terrestrial acute RQs, based on on-site exposure, are exceeded for all modeled scenarios (and by default the other uses they represent) within in the action area. Citrus drives the risk in the terrestrial environment followed by cotton with acute RQs for a small and large size frog of 2978 and 468, and 1599 and 251, respectively. These RQs were based on maximum label application rates. What constitutes typical application rates for these uses having LOC exceedances is unclear and can, therefore, not be discussed for characterization purposes. Terrestrial acute effects from aldicarb transport off-site was evaluated for citrus and was below the LOC; therefore by default all other scenarios, which result in lower exposure, also do not pose a risk of concern off-site.

For the purpose of refinement, the CAL DPR PUR data (see discussion in Section 5.2.1.1) will be used in conjunction with spatial CRLF data, RQ exceedances, species' life history information, and more to make direct effects determinations for the CRLF. As previously mentioned, direct effects to the CRLF are based on avian data, which are used as a surrogate for terrestrial-phase amphibians. Chronic risk to the terrestrial phase of the CRLF could not be assessed quantitatively via the LD_{50}/sq ft method. However, the following qualitative statement can be made regarding chronic risk from aldicarb exposure to the adult phase of the CRLF. The estimated NOAEL (0.49 mg/kg) suggests that if an adult frog experiences acute exposure to aldicarb (LD_{50} = 1mg/kg) and survives the incidence, chronic reproductive effects may potentially be expected.

Based on all available lines of evidence, the Agency concludes a "not likely to adversely affect" determination for direct effects of aldicarb to the terrestrial phase of the CRLF via growth, survival, and reproduction in recovery units 2, 3, 4, and 7 due to lack of spatial overlap of CRLF habitat and occurrence data with the aldicarb action area. The Agency concludes a "likely to adversely affect" determination for direct effects of aldicarb to the terrestrial phase of the CRLF in RU1, RU5, RU6, RU8 considering on-site exposure. Off-site exposure does not pose a risk of concern because off-site EECs are below LOCs. There is no designated critical habitat in recovery units 2 and 8.

5.2.2 Indirect Effects via Reduction in Food Items

5.2.2.1 Indirect Effects to the Terrestrial Phase of the CRLF

The results of the screening-level risk assessment for the CRLF suggest the potential for direct acute adverse effects to terrestrial invertebrates and vertebrates exposed on-site for all agricultural and non-agricultural uses. Citrus and cotton produce the greatest LOC exceedances for terrestrial invertebrates with acute RQs of 5.03 and 0.42, respectively. Aldicarb use on citrus and cotton produces RQs of 1042 and 560 for small mammals, 2978 and 1599 for small frogs, and 468 and 251 for large frogs (LD_{50}/sq ft RQs for birds). Off-site exposure levels in the terrestrial environment and riparian environment are below levels of concern for both terrestrial invertebrates and vertebrates for all uses. Soybean (in-furrow and/or positive displacement applications only), citrus, and sorghum do not exceed acute listed or chronic LOCs for freshwater invertebrates. Sugar beets produce the greatest acute and chronic LOC exceedances for freshwater invertebrates (0.57 and 8.63, respectively) followed by cotton (0.38 and 5.91, respectively), and pecans (0.37 and 5.39, respectively). Based on the highest risk scenarios, because the chronic LOC exceedances for some crops are above the Agency LOC, aldicarb is likely to pose a risk to the terrestrial prey base of the CRLF.

Indirect Effects to CRLF via Effects to Freshwater Fish and Freshwater Invertebrate Prey Base

For freshwater invertebrates, acute listed and chronic RQs exceed the LOC of 0.05 and 1, respectively for all uses of aldicarb except soybean (in-furrow and/or positive displacement application methods only), citrus, and sorghum. For freshwater fish, acute listed and chronic RQs exceed the LOC of 0.05 and 1, respectively for all uses of aldicarb except soybean (in-furrow and/or positive displacement application methods only), citrus, sorghum, and essentially containerless field grown ornamentals (chronic RQ $\cong$ 1, the no observable effect concentration for the ornamental scenario). Because the RQ values are above the Agency LOC, based on the highest risk scenarios, alidicarb is likely to pose a risk to the freshwater fish and freshwater invertebrate prey base of the CRLF.

Explanation of Indirect Effects Determination Based on Effects to the CRLF Terrestrial and Aquatic Prey Base

Based on all available lines of evidence, the Agency concludes a "not likely to adversely affect" determination for indirect effects to the CRLF via aldicarb adverse effects to the terrestrial and aquatic prey base of the CRLF in recovery units 2, 3, 4, and 7 due to lack of spatial overlap of CRLF habitat and occurrence data with the aldicarb action area. Based on the highest risk scenarios, the Agency concludes a "likely to adversely affect" determination for indirect effects to the CRLF via aldicarb adverse effects to the terrestrial and aquatic prey base of the CRLF in RU1, RU5, RU6, RU8. The Agency also concludes "a like to adversely affect" to the critical habitat for RU1, RU5, RU6, RU8 of the CRLF because of the adverse effect expected to the terrestrial and aquatic organisms base which is a component of the critical habitat of the CRLF.

Indirect Effects to CRLF via Effects to Aquatic Plants

Due to lack of other aquatic plant data, the Agency had to rely on the only aquatic data available, an estuarine/marine species used as a surrogate for freshwater, and on making inferences for riparian plants from the results for terrestrial plants listed in this assessment (Section 5.2.4). No direct effects are predicted to aquatic plants when the estuarine/marine diatom is used in the RQ calculations. RQs for all use scenarios are well below 1 and do not indicate reason for concern. Terrestrial plant emergence RQs are also well below 1; highest emergence RQs for terrestrial plants growing in semi-aquatic areas are for the citrus and pecan scenario and are 0.4. However, the TerrPlant model assumes complete incorporation of granules, which is not a feasible assumption for aldicarb applications to citrus. Therefore, these emergence RQs may represent an underestimate of risk of aldicarb use to aquatic vascular plants.

Agency concludes a “no effects” determination for indirect effects to the aquatic phase of the CRLF via direct effects to aquatic plants in all recovery units.

Indirect Effects to CRLF via Effects to Mammalian and Frog Prey

Acute RQs for small mammals exposed to on-site levels exceed the LOC of 0.1, and suggest that granular application of aldicarb to agricultural and non-agricultural commodities has the potential to indirectly affect the CRLF via reduction in the availability of sensitive terrestrial food items. The mammalian calculations were based on the rat LD_{50} of 0.9 mg ai/kg-bw. No comparison of the rat LD_{50} with other species' LD_{50} is possible due to lack of data. Whether the 0.9 mg ai/kg-bw represents a lower or upper value of the sensitivity spectrum for mammals is unclear. The chronic value (NOAEL = 0.4 mg ai/kg-bw) suggest that where acute exposure to small mammals occurs and individuals survive that chronic reproductive effects can be expected.

Acute RQs for small and large frogs exceed the LOC of 0.1, suggesting that granular application of aldicarb to agricultural and non-agricultural commodities has the potential to indirectly affect the CRLF via reduction in the availability of sensitive terrestrial food items. The frog calculations were base on the surrogate mallard duck LD_{50} of 1 mg ai/kg-bw. No other data is available to assess birds' sensitivity to acute aldicarb exposure. The estimated chronic NOAEL of 0.1 mg ai/kg-bw suggests that where acute exposure to frogs occurs and individuals survive that chronic reproductive effects may potentially expected. In absence of aldicarb amphibian endpoint values, other (less sensitive) N-methyl carbamate frog data was used in conjunction with aldicarb EECs to see whether LOC exceedances would occur. Table 15 shows that when the amphibian endpoint for propoxur (carbamate class) is used that LOC exceedances occur for almost all uses of aldicarb. The highest LOC exceedances are for citrus (4.48 small frog and 0.70 large frog) and cotton (2.4 small frog and 0.38 large frog). This analysis strengthens the argument that aldicarb use on these crops can be expected to lead to LOC exceedances with an aldicarb toxicological endpoint value as well.

EFED presumes that because the LOC exceedances for mammalian and frog prey items are well above the Agency LOC, aldicarb poses a likely risk to mammalian and amphibian food prey of the CRLF, if on-site mammalian and amphibian populations are critical to the CRLF. Off-site aldicarb concentrations are below levels of conern.

Based on all available lines of evidence, the Agency concludes a "not likely to adversely affect" determination for indirect effects to the CRLF via aldicarb adverse effects to the mammalian and amphibian prey base of the CRLF in recovery units 2, 3, 4, and 7 due to lack of spatial overlap of CRLF habitat and occurrence data with the aldicarb action area. The Agency concludes a "likely to adversely affect" determination for indirect effects to the CRLF via aldicarb adverse effects to mammalian and amphibian prey base of the CRLF in RU1, RU5, RU6, RU8, assuming on-site prey base is critical to CRLF. The Agency also concludes "a like to adversely affect" to the critical habitat for RU1, RU5, RU6, RU8 of the CRLF because of the adverse effect expected for the mammalian and amphibian organisms which are a component of the critical habitat of the CRLF, assuming on-site is considered critical habitat.

5.2.2.2 Indirect Effects via Reduction of Aquatic Primary Productivity

As already stated in Section 5.2.2 (indirect effects to CRLF via direct effects to aquatic plants), due to lack of other aquatic plant data, the Agency had to rely on the only aquatic data available, an estuarine/marine species as a surrogate, and on making inferences for riparian plants from the results for terrestrial plants listed in this assessment (Section 5.2.4). No direct effects are predicted to aquatic plants when the estuarine/marine diatom is used in the RQ calculations (see Table 26). RQs for all use scenarios are well below 1 and do not indicate reason for concern. Terrestrial plant emergence RQs are also well below 1; highest emergence RQs for terrestrial plants growing in semi-aquatic areas are for the citrus and pecan scenario and are 0.4. However, the TerrPlant model assumes complete incorporation of granules, which is not a feasible assumption for aldicarb applications to citrus. Therefore, these emergence RQs may represent an underestimate of risk to aquatic vascular plants. The Agency concludes a "no effects" determination for indirect effects to the CRLF via direct effects to aquatic plants in all recovery units and critical habitat.

5.2.2.3 Indirect Effects via Alteration in Terrestrial Plant Community

Emergence RQs for terrestrial monocots are below the LOC of 1 for all use scenarios, range from 0.01 to 0.04, and do not indicate reason for concern. Emergence RQs for terrestrial monocots growing in semi-aquatic areas are slightly higher but also below the LOC of 1, and range from 0.09 (dry beans) to 0.4 (citrus). However, the TerrPlant model assumes complete incorporation of granules, which is not a feasible assumption for aldicarb applications to citrus. Therefore, the emergence RQs of 0.4 may represent an underestimate of risk to riparian plants.

Agency concludes a “no effects” determination for indirect effects to the CRLF via direct effects to terrestrial plants and terrestrial plants growing in semi-aquatic areas in all recovery units and critical habitat.

5.2.3 Secondary Poisoning of CRLF by Consuming Terrestrial Invertebrates Contaminated with Aldicarb Residues

The Earthworm Fugacity model was used to calculate the aldicarb concentration (Appendix C) in soil (mg/kg). The conservative assumption was made that the concentration in a 1 kg of soil is equivalent to the aldicarb concentration in 1 kg of terrestrial invertebrate. The size of terrestrial invertebrate was set at 10 grams (approximate weight of a large slug); however, most invertebrates that a CRLF consumes will have a weight much below this value (water strider ~1g; spiders ~6mg). The citrus scenario resulted in the highest concentration of aldicarb in soil (14.3 mg/kg) and was used in estimating aldicarb concentrations in a terrestrial invertebrate of 10 grams (0.01 kg) as follows.

<u>Aldicarb concentrations in a large terrestrial invertebrate:</u>
14.3 mg ai/kg * 0.010 kg = 0.143 mg ai/lg invert

<u>The allometric food ingestion rate equation for amphibians/reptiles is:</u>
FI (g/day) = $0.013 * Wt^{0.773}$ =0.077 g/day = 0.000077 kg/day

The estimated aldicarb concentration in a terrestrial invertebrate (0.0143 mg/kg), the LD_{50} for mallard duck (1mg/kg; surrogate for terrestrial phase amphibians), the daily mass of invertebrates eaten by an amphibian/reptilian surrogate based on range of weight for CRLF, the highest value cited for food water content in terrestrial animals and aquatic animals (**87%;** or dry weight of food (13%)* 7.7=100%), and the weight (upper and lower end; 100 g, 50 g) of a CRLF were used to calculate an RQ for the terrestrial phase CRLF (LOC = 0.1). The Wildlife Exposure Factor Handbook (US EPA, 1993, vol I) provided amphibian/reptilian insectivorous food ingestion rate equations and water content of food to convert dry weight to wet weight of food; USGS (2004) provided upper and lower bound weight of CRLF frog. These RQs measure risk to the CRLF from secondary poisoning exposure via terrestrial invertebrates. The calculations show that RQs are not significantly different for small and large adult CRLFs. The RQ for smaller frogs will be used for the purpose of determining direct effects to the CRLF from secondary poisoning exposure.

$$RQ = \frac{\left(\frac{mg\_ai}{kg\_invert} * \frac{kg\_invert\_consumed}{day}\right) \div bodyweightCRLF}{\frac{mg\_ai}{kg\_bw\_CRLF}}$$

$$\mathbf{RQ}_{\text{(for 50g frog)}} = \frac{0.143 mg/kg * (0.000077 kg * 7.7/day) \div 0.05 kg\_bw}{1 mg/kg} = \mathbf{0.0017}$$

$$RQ_{\text{(for 100g frog)}} = \frac{0.143mg/kg * (0.000077kg * 7.7/day) \div 0.1kg\_bw}{1mg/kg} = 0.00085$$

Based upon the RQ values calculated above, aldicarb CRLF secondary poisoning via earthworms contaminated with aldicarb is below the Agency LOC (LOC $\geq$ 0.1).

5.3 Final Effects Determination

The following tables (25-27) summarize the effects determination by Recovery Unit, based upon the most conservative of the effects determinations, sugar beets, with the assumption of on-site exposure of CRLF and that on-site terrestrial invertebrates are a critical component of the diet of the CRLF and its critical habitat. Summation by specific crops, more specific to on-site usage, is provided in text following these tables.

Table 25 Summarizes the effects determinations for direct effect of aldicarb to any of the life-stages of the CRLF in Eight Recovery Units.

The life stages include aquatic (eggs, larvae, tadpoles) and terrestrial phase of CRLF (young and adult frogs). The assessment endpoints are growth, survival, and reproduction of CRLF individuals.

Recovery Unit	Effects Determination	Basis for Effects Determination Conclusion
1	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF
2	NLAA	Based on lack of spatial overlap with Action Area (AA), frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
3	NLAA	Based on lack of spatial overlap with Action Area (AA), frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
4	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
5	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF;
6	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF
7	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF
8	LAA	Based on spatial overlap with frog habitat and occurrence information, CAL DPR PUR data, and direct effects for both phases of CRLF

* Summarize the effects determination by Recovery Unit, based upon the most conservative of the effects determinations. Summation by specific crops, more specific to on-site usage, is provided in the following text.

Table 26 Summarizes the effects determinations for indirect effect of aldicarb to any of the life-stages of the CRLF in Eight Recovery Units.

The life stages include aquatic (eggs, larvae, tadpoles) and terrestrial phase of CRLF (young and adult frogs). The indirect effects include effects to habitat including effect to primary productivity, prey, and riparian habitat.

Recovery Unit	Effects Determination	Basis for Effects Determination Conclusion
1	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.
2	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF food sources
3	NLAA	Based on lack of spatial overlap with AA
4	NLAA	Based on lack of spatial overlap with AA
5	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.
6	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.
7	NLAA	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to CRLF food sources
8	LAA	Expected indirect effects to CRLF via adverse effects to CRLF prey sources.

* Summarize the effects determination by Recovery Unit, based upon the most conservative of the effects determinations. Summation by specific crops, more specific to on-site usage, is provided in the following text.

Table 27 Summarizes the effects determinations for effects to the critical habitat the CRLF in recovery units one thru eight.

The effects entail effects to growth and survival of terrestrial and aquatic plant and animal components.

Recovery Unit	Effects Determination	Basis for Effects Determination Conclusion
1	LAA	Based on direct effects to terrestrial and aquatic animals which are components of the critical habitat.
2	NE	No designated critical habitat in Recovery Unit (RU)
3	NE	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to animals components of the critical habitat
4	NE	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to animals components of the critical habitat
5	LAA	Based on direct effects to terrestrial and aquatic animals which are components of the critical habitat.
6	LAA	Based on direct effects to terrestrial and aquatic animals which are components of the critical habitat.
7	NE	Based on lack of spatial overlap with AA, frog habitat, and occurrence sightings, CAL DPR PUR data despite LOC exceedances to animals components of the critical habitat..
8	NE	No designated critical habitat in RU

Aquatic Phase CRLF and Critical Habitat

No Effect

Soybean (in-furrow and/or positive displacement applications only), Citrus, and Sorghum

Citrus, sorghum and soybean (but only when applied in-furrow with immediate soil incorporation or in-furrow with positive displacement) uses were determined to have “no effect” directly or indirectly on the aquatic-phase of the CRLF or the aquatic-phase of the critical habitat. This determination was based on the results of the risk assessment where all direct and indirect assessment endpoints of the aquatic-phase CRLF and its aquatic-phase critical habitat were either below endangered LOCs (i.e., no exceedences of LOCs for aquatic animals) or judged based on the best available information to not be affected (i.e., off-field terrestrial plant components of critical habitat and aquatic plants judged to not be affected, based on estimated exposure concentrations that were lower than a ‘no observable effect’ level for limited toxicity data). Although application rates for citrus are fairly high (4.95 lb a.i./A) and incorporation efficiency only 85%, low rainfall rates and other factors in citrus production areas of California contribute to relatively low aquatic exposure and risk estimates. For Sorghum use, low application rates (1 lb a.i./A) and high incorporation efficiency (in-furrow application, 99%) contribute to minimal aldicarb residues being exported into surface waters or off-field terrestrial habitat. When compared to less efficient application methods with approximately 85% soil incorporation (e.g., banded applications), the use of more efficient application techniques (e.g., in-furrow, positive displacement) results in higher incorporation efficiencies (99%), and concomitant exposure estimations well below LOCs for soybean.

Ornamentals (container grown) indoors

There is no exposure pathway by which aldicarb applied to ornamentals in containers grown indoors may reach and expose the aquatic-phase of the CRLF or its critical habitat (i.e., no run-off, no atmospheric transport, no CRLF or its critical habitat indoors). Therefore this use is determined to have “no effect” on the aquatic-phase of the CRLF or its critical habitat.

May Affect but Not Likely to Adversely Affect

Ornamentals (field grown—no containers) and Sweet Potato

Aldicarb registered uses on containerless field-grown ornamentals and sweet potato were identified as “may affect” because the acute RQ values for aquatic invertebrates exceeded the acute endangered LOC, the chronic RQ values exceeded the chronic LOC, and the chronic RQ for aquatic invertebrates exceeded the chronic LOC for sweet potato use. However, based on consideration of a number of factors, the level of effect both directly and indirectly to the aquatic-phase of the CRLF and its aquatic critical habitat for these assessment endpoints was determined to be discountable. Off-site terrestrial plant components of critical habitat and aquatic plants were judged to not be affected based on the best available information that estimated exposure concentrations were lower than 'no observable effect levels' for limited toxicity data. Therefore, aldicarb uses on containerless field-grown ornamentals and sweet potato were determined to "not likely adversely affect" the aquatic-phase of the CRLF and its critical habitat.

Direct effects to the aquatic-phase of the CRLF were considered discountable because the acute endangered RQ values did not exceed the endangered species LOC; while the chronic RQ value of 1 was exceeded, this exceedence was considered not significant and essentially indistinguishable from the no observable effect level. For example, the chronic RQ of 1.1 for containerless field grown ornamentals based on significant figures is not distinguishable from 1 (*i.e*., EEC/NOAEC = 0.49/0.46 ≅ 0.5/0.5 = 1), the level equivalent to no observable effects. In addition, ornamental usage is not extensive, and any potential impact on a water body adjacent to an application area would likely be minor, fleeting, and spatially very limited.

Loss of aquatic fish or invertebrates as dietary resources was considered discountable based on several factors affecting the frequency and duration of exposure and the magnitude of effect. For example, both of these uses are limited to a single application per year, with sweet potato application occurring at plant and ornamentals occurring at any time prior to or during an infestation but again limited by the label to a single application per year. Therefore, any potential impact on a water body adjacent to an application area would likely be minor and fleeting. The acute endangered LOC for fish is not exceeded for either use. Although the chronic LOC is exceeded, as discussed in the preceding paragraph these exceedences are essentially equivalent to the no observable adverse effect level. Additionally, other fish species are not as sensitive (*e.g*., fathead minnow), so any potential impact would be limited in both magnitude and number of species involved. For aquatic invertebrates, while the acute endangered LOC was exceeded, the likelihood that an individual would be affected for the most sensitive species was one-in-over a million (based on default slope of 4.5). Additionally, based on the invertebrate species sensitivity distribution, over 80 percent of the aquatic invertebrates would be even less sensitive. The chronic LOC was not exceeded for the ornamentals and was at the LOC of 1 for sweet potato use, which is equivalent to no observable effect on invertebrates.

Ornamentals (container grown) outdoors

Outdoor container grown ornamental use was considered to "not likely adversely affect" the aquatic-phase CRLF or its aquatic-phase critical habitat. This determination was based on the determination for containerless field grown ornamentals used as a surrogate. Surface water exposure concentrations are expected to be lower than that for containerless field grown ornamentals. This reduction is attributable to containers which are expected to physically reduce run-off of aldicarb and its major toxic degradates and lower application rates as compared to containerless field grown ornamentals. In addition, ornamental usage is not extensive, and any potential impact on a water body adjacent to an application area would likely be minor, fleeting, and spatially very limited.

May Affect and Likely to Adversely Affect

Dried Beans, Soybean (banded applications), Peanut, Pecans, Cotton, Alfalfa, Sugar beet

Aldicarb registered uses on dried beans, soybean, peanut, pecan, cotton, alfalfa, and sugar beet were identified as "may affect" and "likely to adversely affect" the CRLF directly because both the acute endangered LOC and chronic LOC were exceeded for amphibian assessment endpoints (fish used as surrogate) and indirectly because fish and aquatic invertebrate acute and chronic LOC values were exceeded.

It should be noted that for many of these crops, use of more efficient application techniques (99% vs. 85% incorporation) would result in exposure estimations well below the LOC for most categories (see Table 12). Although this might be impractical or impossible for some current uses (e.g., peanut application post-pegging, cotton application at bloom, pecan), in other cases (e.g., soybean, dried bean) achieving an incorporation efficiency of 99% results in acceptable levels of risk should be possible with appropriate application techniques.

Terrestrial Phase CRLF and Critical Habitat

No Effect

Ornamentals (container grown) indoors

There is no exposure pathway by which aldicarb applied to ornamentals in containers grown indoors may reach and expose the terrestrial-phase of the CRLF or its terrestrial critical habitat (*i.e*., no run-off, no atmospheric transport, no CRLF or its critical habitat indoors). Therefore this use is determined to have "no effect" on the aquatic-phase of the CRLF or its critical habitat.

May Affect but Not Likely to Adversely Affect

Off-site All Outdoor Uses

Off-site exposure for all outdoor registered uses was identified as "may affect" because an individual terrestrial-phase CRLF that ingested a granule transported off-site in the gut (incidental ingestion) or on the fur of a small mammal would potentially be effected. All other off-site exposure of the terrestrial-phase CRLF (*i.e*., bioaccumulation in terrestrial invertebrates or mammalian dietary items) and its critical habitat (*i.e*., loss of dietary resources, riparian or upland plants) to aldicarb and its major toxic residues are below LOCs. Because exposure of a terrestrial-phase CRLF to a granule carried in a small-mammal off-field was considered unlikely and no other off-site exposure of the terrestrial-phase CRLF or its critical habitat were above LOCs, exposure off-site for all outdoor uses was considered discountable and therefore "not likely to adversely affect" either directly or indirectly the terrestrial-phase of the CRLF or its critical habitat.

Risks to terrestrial environments outside the zone of application for granular aldicarb are mainly limited to re-deposition of aldicarb residues in lower-lying areas affected by aldicarb runoff from nearby fields. However, calculations of the approximate amount of aldicarb potentially deposited as a result of registered aldicarb use (based on the highest risk scenario, cotton at 5 lbs a.i./A) indicate that concentrations (~ 10^{-6} mg a.i./kg soil) would be several orders of magnitude below those that would exceed the LOC.

Exposure off-site of a CRLF to a granule in the gut or on the fur of small mammal was considered unlikely because it is doubtful that the series of events needed to coincide for an actual exposure event to occur would be frequent, if they occurred at all. First, aldicarb is applied to most crops once per year, and infrequently for the others (*i.e.*, cotton at most three times and sugar beets and peanuts at most two times per year). Second, the duration of the integrity of a granule in the field is limited as it readily dissolves in water— irrigation or rainfall dissolves the granule and moves it down into the soil profile. Therefore the window of opportunity for a small mammal to be exposed on field to a granule (in terms of subsequent exposure of a CRLF to a granule) is limited to a few days a year. While it is considered likely that some small mammals may be exposed to aldicarb during this window, it is unlikely that a significant number of small mammals would then subsequently move off-site, and not die before encountering a CRLF (biological description does not indicate it feeds on carrion).

May Affect and Likely to Adversely Affect

On-site All Crops

On-site exposure for all outdoor registered uses was identified as "may affect" and "likely to adversely affect" the terrestrial-phase of the CRLF because the acute LOC was exceeded for the direct amphibian measurement endpoint (birds) and for indirect effects (*i.e.*, loss of small mammals, and on-site terrestrial invertebrates) for all uses. Bioaccumulation was demonstrated to not be a pathway of concern. This effects determination is based on the assumption that terrestrial-phase CRLF will come onto the treated site and that on-site resources are considered a critical component that supports CRLF (*i.e.*, invertebrates and insects on the field that the farmer is trying to eliminate are considered critical to the support of the CRLF) and that the field is considered part of the critical habitat. A number of the uses are applied on fields that have been prepared for planting and should be relatively barren of cover for the CRLF at the time of aldicarb application (i.e., sorghum, sweet potato, dried bean, and soybean).

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 adverse modification to critical habitat.

6. Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

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

6.1.2 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).

6.1.2.1 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.

6.2.1.2 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.

6.1.2.3 PRZM Modeling Inputs and Predicted Aquatic Concentrations

The inputs selected for use in the PRZM model were based upon the best available information regarding persistence, mobility, and formation and dissipation of major degradates. Nevertheless, there is intrinsic uncertainty related to the quality of data that were used to determine these parameters. In addition, there are issues involved in selecting appropriate incorporation efficiencies. Agency assumes (as stated in the 2006 RED) that the incorporation efficiency for granular aldicarb leaves 15% on the surface, except for certain highly efficient application methods – specifically: 1) in-furrow applications, and; 2) banded applications that include simultaneous soil incorporation (and that also make use of state-of-the-art applicator tools, such as positive displacement) – for which an incorporation efficiency leaving only 1% available at the surface is assigned. Both sets of model results are presented in this document (Tables 11 & 12). The Agency believes that these data and input values are the best available and were adequate for the purposes of this (and other) aldicarb assessments.

6.3 Effects Assessment Uncertainties

6.3.1 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 pesticidal active ingredients, such as aldicarb, that act directly (without metabolic transformation) because younger age classes may not have the enzymatic systems associated with detoxifying xenobiotics. Insofar 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.

6.3.2 Use of Acute Freshwater Invertebrate Toxicity Data for the Midge

The initial acute risk estimate for freshwater invertebrates was based on the lowest toxicity value from *Chironomus tetans* studies, which showed a greater sensitivity than other species that are equally or more likely to be part of the diet of an adult CRLF. Therefore, acute RQs based on the most sensitive toxicity endpoint for freshwater invertebrates may represent an overestimation of potential direct risks to freshwater invertebrates and indirect effects to the California Red Legged Frog via a reduction in available food.

6.3.3 Extrapolation of Long-term Environmental Effects from Short-Term Laboratory Tests

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

6.3.4 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.

6.3.5 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.

6.3.6 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.

6.3.7 Location of Wildlife Species

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

6.4 Assumptions Associated with the Acute LOCs

The risk characterization section of this endangered species assessment includes an evaluation of the potential for individual effects. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose response relationship for the effects study corresponding to the taxonomic group for which the LOCs are exceeded.

Sufficient dose-response information was not available to estimate the probability of an individual effect on freshwater fish or freshwater invertebrates (two of the dietary food items of the CRLF). Acute ecotoxicity data from the bluegill sunfish and midge were used to derive RQs for freshwater fish and invertebrates. Based on a lack of dose-response information for both species, the probability of an individual effect was calculated using the lowest and highest probit dose response curve slope value (2 and 9, respectively) to bound probability of individual effect to prey for technical grade aldicarb. It is unclear whether the probability of an individual effect for freshwater animals would be higher or lower, and therefore, the lowest slope value was chosen when effects determinations were made for direct effects to the prey of the CRLF.

6.5 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.

7. References

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

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

Bromilow, R.H., Briggs, G.G., Williams, M.R., Smelt, J.H., Tuinistra, Th.L.G.M., and W.A. Traag. 1986. The role of ferrous ions in the rapid degradation of oxamyl, methomyl, and aldicarb in anaerobic soils. Pesticide Science 17:535-547.

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

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

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

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

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

Foran, J.A., Germuska, P.J., and J.J. Delfino. 1985. Acute toxicity of aldicarb, aldicarb sulfoxide, and aldicarb sulfone to Daphnia laevis. Bulletin of Environmental Contamination and Toxicology 35:546-550.

Haskell, J.P., Ritchie, M.E., Olff, H. 2002. Fractal geometry predicts varying body size scaling relationships for mammal and bird home ranges. Nature, Vol 418(1): 527-530

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

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

Huang, M.N. 2001. Anaerobic aquatic metabolism of [S-methyl-14C]-aldicarb sulfone under laboratory conditions at 25°C. Unpublished study performed and submitted by Aventis CropScience, Research Triangle Park, NC. Study No.: 605YT. Experiment initiated on April 9, 2001, and completed on August 22, 2001 (p. 6). Final report issued December 13, 2001.

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

Jennings, Mark R. 1988. Natural history and decline of native ranids in California. Pp. 61-72. *In* Proceedings of the conference on California herpetology. H.F. DeLisle, P.R. Brown, B. Kaufman, and H.M. McGurty (eds). Southwestern Herpetologists Society Special Publication (4): 1-143.

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

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

Jesudason, P.A. 2001. Aerobic aquatic metabolism of [S-methyl-14C]-aldicarb sulfone under laboratory conditions at 25°C. Unpublished study performed by Aventis CropScience, Research Triangle Park, NC, and Agvise Laboratories, Inc., Northwood, ND, and submitted by Aventis CropScience, Research Triangle Park, NC. Study No.: 603YT. Experiment initiated on May 7, 2001, and completed on November 16, 2001 (p. 6). Final report issued December 20, 2001.

Jones, R.L. and T.L. Estes. 1995. Summary of aldicarb monitoring and research programs in the U.S.A. Journal of Contaminant Hydrology 18:107-140.

Jones, R.L. and T. E. Marquardt. 1987. Monitoring of aldicarb residues in Long Island, New York potable wells. Archives of Environmental Contamination and Toxicology 16: 643-647.

Karvonen, T., Koivusalo, H., Jauhiainen, M., Palko, J. and Weppling, K. 1999. A hydrological model for predicting runoff from different land use areas, Journal of Hydrology, 217(3-4): 253-265.

Kennedy, C.W. Phytotoxicity in pearl millet varies among in-furrow insecticides. 2002. Crop Protection, 21:799-802.

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

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

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

Lightfoot, E.N., Thorne, P.S., Jones, R.L., Hansen, J.L., and R.R. Romine. 1987. Laboratory studies on mechanisms for the degradation of aldicarb, aldicarb sulfoxide, and aldicarb sulfone. Environmental Toxicology and Chemistry. 6:377-394.

Liu, A.C. 2001. Aerobic aquatic metabolism of [S-methyl-14C]-aldicarb sulfoxide under laboratory conditions at 25□C. Unpublished study performed and submitted by Aventis CropScience, Research Triangle Park, NC. Study No.: 604YT. Experiment initiated on April 17, 2001, and completed on August 21, 2001 (p. 6). Final report issued December 13, 2001

Miller Maes, C., M. Pepple, J. Troiano, D. Weaver, W. Kimaru. 1992. Sampling for pesticide residues in California well water. Seventh Annual Report to the Legislature, State Department of Health Services, Office of Environmental Health Hazard Assessment, and the State Water Resources Control Board. California Environmental Protection Agency – Department of Pesticide Regulation.

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

McDonald M.A.1; Healey J.R.; Stevens P.A. 2002. The effects of secondary forest clearance and subsequent land-use on erosion losses and soil properties in the Blue Mountains of Jamaica. Agriculture, Ecosystems & Environment, Volume 92, Number 1: 1-19.

Okisaka S.; Murakami A.; Mizukawa A.; Ito J.; Vakulenko S.A.; Molotkov I.A.; Corbett C.W.1; Wahl M.; Porter D.e.; Edwards D.; Moise C. 1997. Nonpoint source runoff modeling: A comparison of a forested watershed and an urban watershed on the South Carolina coast. Journal of Experimental Marine Biology and Ecology, Volume 213, Number 1: 133-149.

Phuong V.T. and van Dam J. Linkages between forests and water: A review of research evidence in Vietnam. ***In***: Forests, Water and Livelihoods European Tropical Forest Research Network. ETFRN NEWS (3pp).

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

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

Rhone-Poulenc. 1998. Small-Scale Prospective Groundwater Monitoring Study Data, 1979-1994.

Rupprecht, J.K. and P.B. Abbott. 2001. Anaerobic aquatic metabolism of [S-methyl-14C]-aldicarb sulfoxide under laboratory conditions at 25°C. Unpublished study performed and submitted by Aventis CropScience, Research Triangle Park, NC. Study No.: 606YT. Experiment initiated on April 17, 2001, and completed on July 19, 2001 (p. 6). Final report issued December 13, 2001.

Schuette, J., D. Weaver, J. Troiano, M. Pepple and J. Dias. 2003. Sampling for pesticide residues in California well water. Eighteenth Annual Report to the Legislature, State Department of Health Services, Office of Environmental Health Hazard Assessment, and the State Water Resources Control Board. California Environmental Protection Agency – Department of Pesticide Regulation.

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

Skinner, W.S. 1995. Aerobic aquatic metabolism of [14C]aldicarb. PTRL Project No.: 467W; Rhône-Poulenc Ag Company Study No.: EC-94-274. Unpublished study performed by PTRL West, Inc., Richmond, CA; and submitted by Rhône-Poulenc Ag Company, Research Triangle Park, NC.

Skinner, W. S. and N. Jao. 1995. Anaerobic aquatic metabolism of [14C]aldicarb. Laboratory Project No. 468W. Laboratory Report No. 468W-1. Unpublished study performed by PTRL West, Inc., Richmond, CA; and submitted Rhône-Poulenc Ag Company, Research Triangle Park, NC.

Skinner, W. 1995. Soil adsorption/desorption of [14C]aldicarb sulfoxide by the batch equilibrium method. Laboratory Project ID: 463W. Sponsor Project ID: EC-94-276. Unpublished study performed by PTRL West, Inc., Richmond, CA; and submitted by Rhône-Poulenc Ag Company, Research Triangle Park, NC.

Skinner, W. 1995. Soil adsorption/desorption of [14C]aldicarb sulfone by the batch equilibrium method. Laboratory Project ID: 464W. Sponsor Project ID: EC-94-277. Unpublished study performed by PTRL West, Inc., Richmond, CA; and submitted by Rhône-Poulenc Ag Company, Research Triangle Park, NC.

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

Suffolk County Dept. of Health Services. 1999. Water Quality Monitoring Program to Detect Pesticide Contamination in Groundwaters of Nassau and Suffolk Counties, NY, June, 1999.

Suffolk County Dept. of Health Services. 2000. Water Quality Monitoring Program to Detect Pesticide Contamination in Groundwaters of Nassau and Suffolk Counties, NY, December, 2000.

Suorsa, K. E. and Fisher, S. W. 1986. Effects of pH on the Environmental Fate of [14C]Aldicarb in an Aquatic Microcosm. Ecotoxicol.Environ.Saf. 11: 81-90.

Tetrahedron, Inc. 1999. Distribution of Aldicarb in Groundwater in the USA, Final Report, Tetrahedron, Inc., Baltimore, MD, February 11, 1999.

Troiano, J., D. Weaver, J. Marade, F.Spurlock, M. Pepple, C. Nordmark, D. Bartkowiak. 2001. Summary of Well Water Sampling in California to Detect Pesticide Residues Resulting from Nonpoint-Source Applications. J. Environ. Qual. 30:448–459.

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

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

U.S. EPA. 2006. Aldicarb Ecological Risk Assessment (RED). Office of Prevention, Pesticides, and Toxic Substances. Office of Pesticide Programs, EFED. Washington, D.C. September 2006.

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

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

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

USFWS/NMFS 2004. Memorandum to Office of Prevention, Pesticides, and Toxic Substances, U.S. EPA conveying an evaluation by the U.S. Fish and Wildlife Service and National Marine Fisheries Service of an approach to assessing the ecological risks of pesticide products.

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

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

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

USGS, Western Ecological Research Center. 2004. California Red Legged Frog Surveys of Lower Redwood Creek, Golden Gate National Recreation Area.

Vink, J.P.M. and S.E.A.T.M. Van der Zee. 1997. Pesticide biotransformation in surface waters: multivariate analyses of environmental factors at field sites. Water Research 31(11):2858-2868.

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

Wells, David and Estella Waldman. 1991. County Level Assessment of Aldicarb Leaching Potential. Groundwater Technology Section. Environmental Fate and Ground Water Branch. Office of Pesticide Programs. Environmental Protection Agency.

Williams, Shannon D., and Robin M. Harris. 1996. Nutrient, Sediment, and Pesticide Data Collected at Four Small Agricultural Basins in the Beaver Creek Watershed, West Tennessee, 1990– 1995. U.S. Geological Survey Open-File Report 96-366.