Risks of Norflurazon Use to Federally Threatened California Red-legged Frog

(*Rana aurora draytonii*)

Pesticide Effects Determination

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

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

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

Norflurazon was registered in the United States in 1974 as a broad spectrum pre-emergent herbicide used to control germinating annual grasses and broadleaf weeds in certain crop and noncrop areas. Norflurazon is currently labeled for use on alfalfa, avocado, cranberries, cotton, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, caneberries, citrus, grapes, hops, soybeans and non-agricultural uses (*e.g.* industrial areas (outdoors), rights-of-way (ROWs), refuse/solid waste sites) and nursery stock. All of the current uses are considered as part of the federal action evaluated in this assessment, with the exception of soybeans and cranberries because these crops are not grown in California and cotton because norflurazon is not registered for this use in the state of California.

Norflurazon is formulated as a liquid concentrate. Application method for most uses of norflurazon is limited to ground spray. Aerial application is permitted for alfalfa, at a much lower application rate. Risks from ground boom and aerial applications are expected to result in the highest off-target levels of norflurazon due to generally higher spray drift levels.

Norflurazon is persistent and weakly sorbs to soil. According to the Food and Agriculture Organization (FAO) classification scheme the compound would be classified as moderately mobile and may readily move into ground water (depending on the permeability of the soil) and surface water. The primary route of dissipation appears to be photodegradation in water and on soil. Norflurazon is stable to hydrolysis and biodegrades slowly in soil and water under aerobic and anaerobic conditions. Norflurazon has relatively low volatility and is soluble in water. Therefore, potential transport mechanisms considered in this assessment are limited to spray drift, groundwater discharge and runoff, as volatilization and atmospheric transport are not expected to occur. Because of its persistence, substantial fractions of applied norflurazon could be available for runoff for several months post-application. The moderate soil/water partitioning of norflurazon indicates that norflurazon runoff may occur through runoff of dissolved and sediment-bound residues (erosion).

This assessment quantitatively considers exposure from parent norflurazon as well as the desmethyl degradation product. Desmethyl norflurazon is a major degradate that is slowly formed from biodegradation under aerobic and anaerobic conditions in soil and aquatic systems. Desmethyl norflurazon was still increasing at the end of the aerobic soil metabolism and anaerobic aquatic metabolism study and may be more stable than the parent compound. Desmethyl norflurazon was detected in 50% of surface water samples nationwide in the NAWQA monitoring program further suggesting that it is more persistent than the parent compound. Laboratory data on the mobility of desmethyl norflurazon are limited to peat soils, in which it was found to be moderately mobile.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey and its habitats to norflurazon are assessed separately for the two habitats. The Tier-II aquatic exposure models Pesticide Root Zone Model (PRZM) and EXposure Analysis Modeling System (EXAMS) are used to estimate high-end exposures of norflurazon in aquatic habitats resulting from runoff and spray drift from different uses. Peak aquatic model-estimated environmental concentrations (EEC) of total toxic residues (norflurazon and desmethyl norfluazon) range from 5.0 to 79 µg/L for various uses. These estimates are supplemented with analysis of available California surface water monitoring data from U. S. Geological Survey's National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation. Surface water monitoring studies which specifically targeted norflurazon use (application period and/or sites) were not available for analysis as part of this assessment. The maximum concentration of norflurazon reported by NAWQA for California surface waters with agricultural watersheds is 0.62 µg/L. This value is approximately 127 times less than the maximum model-estimated environmental concentration. The maximum concentration of norflurazon reported by the California Department of Pesticide Regulation surface water database (0.98 µg/L) is roughly 81 times lower than the highest 1-in10 year peak model-estimated environmental concentration. It is important to note these are detections of parent norflurazon only. Although not an analyte in the California monitoring program, NAWQA reports that the desmethyl degradate was detected in 50% of surface water samples nationwide at concentrations up to 6.1 µg/L. A Prospective Groundwater (PGW) study in the Central Ridge of Florida had detections of norflurazon and the desmethyl degradate at peak concentrations of 29.9 and 23.8 µg/L, respectively.

The T-REX model is used to estimate forage item residues of norflurazon for exposures to the terrestrial-phase CRLF and its potential prey. The AgDRIFT model is used to estimate deposition of norflurazon on terrestrial and aquatic habitats from spray drift. The TerrPlant model is used to estimate norflurazon exposures to terrestrial-phase CRLF habitat, including plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar applications. The T-HERPS model is used to characterize dietary exposures of terrestrial-phase CRLFs relative to birds.

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

Norflurazon is practically nontoxic on an acute exposure basis to aquatic and terrestrial animal species. No chronic effects to aquatic fauna were observed in the available toxicity studies, although chronic effects are present for birds (and by extension terrestrial-phase CRLFs) and mammals. As expected with an herbicide, there are deleterious effects to plants, both aquatic and terrestrial. Given the structural similarities between the desmethyl degradate and parent norflurazon, equal toxicity is assumed in the absence of data indicating otherwise.

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

Analysis indicates there is an overlap between norflurazon use areas and CRLF habitat. Based on the best available information, the Agency makes a may affect and likely to adversely affect determination for the CRLF from the use of norflurazon. Additionally, the Agency has determined that there is potential for modification of CRLF designated critical habitat from the use of the chemical. This determination is based on direct chronic effects to the terrestrial-phase CRLF and, indirectly, to its terrestrial-phase amphibian and mammalian prey base. Potential effects to aquatic nonvascular plants and terrestrial plants may result in disruption of the CRLF food source and critical habitat. A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat is presented in **Table 1.1** and **Table 1.2**. Further information on the results of the effects determination is included as part of the Risk Description in Section 5.2.

Table 1.1 Effects Determination Summary for Norflurazon Use and the CRLF

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Survival, growth, and/or reproduction of CRLF individuals	LAA	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults): No effects to freshwater fish (as a surrogate to the aquatic-phase frog) that result in acute and/or chronic risk LOC exceedances
		Terrestrial-phase (Juveniles and Adults): Chronic effects to birds (as a surrogate to the terrestrial-phase frog) result in exceedance of the chronic risk LOC
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity No effects to freshwater invertebrates, fish or frogs or are expected. Effects to non-vascular aquatic plants result in exceedance of the LOC, and for locations proximal to ROWs, effects to vascular aquatic plants may occur.
		Terrestrial prey items, riparian habitat Chronic effects to small terrestrial vertebrates including mammals and terrestrial-phase amphibians (using birds as a surrogate), and effects to terrestrial plants, result in LOC exceedances

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

Table 1.2 Effects Determination Summary for Norflurazon Use and CRLF Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Modification of aquatic-phase PCE	HM[1]	Effects to riparian vegetation (terrestrial plants) and aquatic nonvascular plants result in LOC exceedances. Exposure to aquatic vascular plants proximal to use on ROWs may be sufficient to elicit deleterious effects. These effects may indirectly affect the CRLF via reduction in food supply, changes in available cover, physical parameters of the waterbody *(e.g.* increase temperature or turbidity)
Modification of terrestrial-phase PCE		Effects to riparian vegetation (terrestrial plants) result in LOC exceedances, based on the seedling emergence study. Effects may result in changes in community composition or relative abundance of riparian plant species, possibly altering terrestrial – phase CRLF habitat

[1] Habitat Modification or No Effect (NE)

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

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

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

2.0 Problem Formulation

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

2.1 Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog (*Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of norflurazon on alfalfa, avocado, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, caneberries, citrus, grapes, hops and non-agricultural uses (*e.g.* industrial areas (outdoors), rights-of-way, refuse/solid waste sites, nursery stock). In addition, this assessment evaluates whether these uses are expected to result in modification of the species' designated critical habitat. This ecological risk assessment has been prepared consistent with a settlement agreement in the case Center for Biological Diversity (CBD) vs. EPA et al. (Case No. 02-1580-JSW(JL)) entered in Federal District Court for the Northern District of California on October 20, 2006.

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

In accordance with the Overview Document, provisions of the ESA, and the Services' Endangered Species Consultation Handbook, the assessment of effects associated with registrations of norflurazon is based on an action area. The action area is the area directly or indirectly affected by the federal action, as indicated by the exceedances of the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of norflurazon 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 specific uses of norflurazon in accordance with current labels:

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

Designated critical habitat identifies specific areas that have the physical and biological features, (known as primary constituent elements or PCEs) essential to the conservation of the listed species. The PCEs for CRLFs are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat.

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

If a determination is made that use of norflurazon within the action area(s) associated with the CRLF "may affect" this species or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to the CRLF and other taxonomic groups upon which these species depend (e.g., aquatic and terrestrial vertebrates and invertebrates, aquatic plants, riparian vegetation, etc.). Additional information, including spatial analysis (to determine the geographical proximity of CRLF habitat and norflurazon use sites) and further evaluation of the potential impact of norflurazon on the PCEs is also used to determine whether modification of designated critical habitat may occur. Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the CRLF 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 norflurazon is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for norflurazon is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically-mediated processes (i.e., the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of norflurazon that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the CRLF's designated critical habitat have been identified by the Services and are discussed further in Section 2.6.

2.2 Scope

Norflurazon is a pre-emergent herbicide with broad spectrum activity on grasses, broad leaf weeds and sedges. It is registered for use on 25 crops, 27 field grown ornamental trees and shrubs, and non-cropland uses. Primary use sites in California include alfalfa, avocado, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, caneberries, citrus, grapes, hops, and, to a lesser extent, non-agricultural uses (*e.g.* industrial areas (outdoors), rights-of-way, refuse/solid waste sites, nursery stock).

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

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

This assessment quantitatively considers exposure from parent norflurazon as well as the desmethyl degradation product. Desmethyl norflurazon is a major degradate that is slowly formed from biodegradation under aerobic and anaerobic conditions in soil and aquatic systems. Desmethyl norflurazon was still increasing at the end of the aerobic soil metabolism and anaerobic aquatic metabolism study and may be more stable than the parent compound. Desmethyl norflurazon was detected in 50% of surface water samples nationwide from NAWQA further suggesting that it is more persistent than the parent compound. Laboratory data on the mobility of desmethyl norflurazon are limited to peat soils, in which it was found to be moderately mobile. Although there are no data on the toxicity of desmethyl norflurazon, given the similarity in chemical structure to the parent this assessment assumes equal toxicity and uses a total toxic residues approach.

2.3 Previous Assessments

Norflurazon was registered in the United States in 1974 as a broad spectrum pre-emergent herbicide used to control germinating annual grasses and broadleaf weeds in certain crop and noncrop areas. The Registration Standard was issued in December 1984. A Reregistration Eligibility Decision (RED) was issued in 1995 and concluded that data suggest that norflurazon leaches to ground water as a result of normal agricultural use triggering the requirement of a Prospective Groundwater (PGW) Study. For this reason, norflurazon product labels carry a ground water advisory.

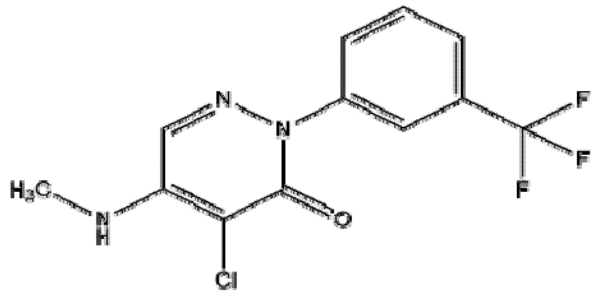
2.4 Stressor Source and Distribution

2.4.1 Environmental Fate Assessment

Norflurazon (4-chloro-5-(methylamino)-2-(α,α,α-trifluoro-m-tolyl)-3-(2H)-pyridazinon) is persistent and weakly sorbs to soil. According to the Food and Agriculture Organization (FAO) classification scheme, norflurazon would be classified as moderately mobile and may readily move into ground water (depending on the permeability of the soil) and surface water. The primary route of dissipation appears to be photodegradation on soil and in water when the compound is present on the surface of the soil or in clear and shallow surface water under favorable light conditions. Norflurazon degrades slowly in aerobic soil conditions. In addition, norflurazon is resistant to biotic degradation under aerobic and anaerobic aquatic conditions and is stable to hydrolysis. Norflurazon has relatively low volatility (1.5×10^{-5} torr) and is soluble in water (28 ppm, at 20^{o}C).

The Log K_{ow} of norflurazon is 2.3 indicating the compound has a low potential to bioaccumulate; a fish bioconcentration study also indicates that norflurazon has a low potential to bioconcentrate. Bioconcentration factors ranged from 6 to 8X, 16 to 28X, and 30 to 59X for fillet, whole fish and viscera, respectively. Tissue residues decreased (depurated) rapidly when fish were moved to clean water; greater than 90%, 96%, and 97% of the radio-labeled norflurazon was eliminated from fillet, whole fish, and viscera, respectively after 14 days. General chemical properties of norflurazon are summarized in **Table 2.1.**

Table 2.1. General Chemical Properties

Parameter	Value	Reference
PC code	105801	
CAS No.	27314-13-2	
Structure		
Chemical name	4-chloro-5-(methylamino)-2-(α,α,α-trifluoro-m-tolyl)-3-(2H)-pyridazinon	
Chemical formula	$C_{12}H_9ClF_3N_3O$	
Molecular weight	303.7 g/mol	
Water solubility (20 °C)	28 mg/L	Product chemistry
Vapor pressure	1.5 $x10^{-5}$ torr	Product chemistry
Henry's law constant	2.1 x 10^{-7} atm-m^3/mol	Calculated
Log K_{OW}	2.3	U.S. EPA 1998

Photodegradation of norflurazon is rapid in clear, shallow surface water ($t_{1/2}$ = 2-3 d, pH 7) and on soil ($t_{1/2}$ = 12-15 d) resulting in the formation of a dimer (two molecules covalently bonded) and the degradates desmethyl norflurazon, and deschloronorflurazon. However, direct photolytic degradation of the parent or its degradates in turbid and/or deeper waters will be limited by the attenuation of sunlight. Norflurazon degrades slowly under aerobic soil conditions ($t_{1/2}$ = 130 d in loam) forming desmethyl norflurazon and carbon dioxide. In addition, norflurazon is resistant to biotic degradation under aerobic and anaerobic aquatic conditions with half lives ranging from six to eight months and is stable to hydrolysis at pH 5, 7 and 9.

Norflurazon is moderately to slightly mobile (based on the Food and Agricultural Organization classification scheme), with Freundlich adsorption coefficients (K_f) that range from 0.14 (in sand) to 72.5 ml/g (in peat) (K_{foc} = 205 to 1,532 ml/g_{oc}) for 13 soils. The K_{foc} numbers were calculated using the soil-organic matter basis rather than the soil-organic carbon basis, therefore, a conversion factor of 1.724 was applied to the organic matter partition coefficient (K_{om}) to arrive at the $K_{foc.}$ Adsorption of norflurazon to these 13 soils is correlated to organic carbon content and cation exchange capacity (CEC).

In the aqueous photolysis study, the only major transformation product was the norflurazon dimer that was detected at 16% of the parent at 3 days. In addition, two minor degradates, desmethyl norflurazon and deschloroflurazon accounted for 7% and 8% of parent at 3 days, respectively. Desmethyl norflurazon and carbon dioxide are major degradates that are slowly formed under aerobic soil conditions, accounting for approximately 31-36% and 23-31%, respectively of parent at 365 days. Desmethyl norflurazon was still increasing at the end of the aerobic soil metabolism and anaerobic aquatic metabolism studies and may be more stable than the parent compound. Desmethyl norflurazon and carbon dioxide are also formed via anaerobic aquatic metabolism accounting for 19 % and 8% of parent at 365 days. Desmethyl norflurazon is formed under aerobic aquatic conditions at 11% of parent by 90 days. The mobility of the major degradate, desmethyl norflurazon, is not currently well defined except in peat soils. Freundlich K_{ads} were 22 and 41 mL/g and Freundlich K_{oc} were 329 and 60 mL/g_{oc}, for a Wisconsin peat and a Washington peat, respectively. Based on these data, it can be concluded that desmethyl norflurazon is moderately mobile in high organic content peat soils. No laboratory data are available for the mobility of desmethyl norflurazon in any additional soils, however, it has been detected in 50% of NAWQA surface water monitoring samples nationwide. Additionally, a Prospective Groundwater (PGW) study conducted in 1994 on the Central Ridge of Florida had detections of norflurazon and the desmethyl degradate at peak concentrations of 29.9 and 23.8 µg/L, respectively. **Table 2.2** lists the environmental fate properties of norflurazon, along with the major and minor degradates detected in the submitted environmental fate and transport studies.

Table 2.2. Summary of Norflurazon Environmental Fate Properties

Study	Value (units)	Major Degradates *Minor Degradates*	MRID #	Study Status
Hydrolysis	Stable at pH 5, 7 and 9	--	00146165	Acceptable
Direct Aqueous Photolysis	pH 7: DT_{50} = 2-3 d (parent) pH 7: $t_{1/2}$ = 3 d (parent and desmethyl)	Norflurazon dimer *(Desmethyl norflurazon and Deschloronorflurazon)*	00148311	Acceptable
Soil Photolysis	DT_{50} = 12-15 d	*(Desmethyl Norflurazon)*	00148311	Acceptable
Aerobic Soil Metabolism	$t_{1/2}$ = 130 d (loam; parent) $t_{1/2}$ = 375 d (parent and desmethyl)	Desmethyl Norflurazon, Carbon Dioxide	40079601	Acceptable
Anaerobic Soil Metabolism	No data	--	--	--
Anaerobic Aquatic Metabolism	DT_{50} = 8 months (loam) $t_{1/2}$ = 678 d (parent and desmethyl)	Desmethyl Norflurazon, Carbon Dioxide	40079601	Acceptable
Aerobic Aquatic Metabolism	DT_{50} = 6-8 months (loam) $t_{1/2}$ = 275 d (parent and desmethyl)	Desmethyl Norflurazon	40079601	Acceptable
Freundlich K_{ads} (mL/g), $K_{oc-\ ads}$ (mL/g_{oc})	**1)** 0.716 (1/n = 0.939), 206 (sand) 2.37 (1/n = 0.802), 681 (sandy loam) 2.51 (1/n = 0.863), 618 (silt loam)	--	**1)** 41986904 **2)** 00148312 **3)** 42710901 **4)** 43681001	**1)** Acceptable **2)** Acceptable **3)** Acceptable **4)** Supplemental

Study	Value (units)	Major Degradates *Minor Degradates*	MRID #	Study Status
	2.77 (1/n = 0.825), 531 (sediment) 7.11(1/n = 0.786), 1532 (clay loam) **2)** 1.9 (1/n = 0.75), 1092 (loam) 2.3 (1/n = 0.80), 441 (loam) 1.9 (1/n = 0.75), 1092 (sediment) 2.2 (1/n = 0.79), 1264 (sandy loam) 26 (1/n = 0.74), 393 (clay) 0.14 (1/n = 0.84), 241(sand) **3)** 72.5, 1082 (peat) 62.6, 915 (peat) **4)** 22.1 (1/n = 0.914), 330 (peat) 41.4 (1/n = 0.912), 605 (peat) (desmethyl norflurazon only)			

2.4.2 Environmental Transport Assessment

Potential transport mechanisms include pesticide surface water runoff, groundwater recharging surface water, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. Surface water runoff and spray drift are expected to be the major routes of exposure for norflurazon; although under certain soil conditions, i.e., high organic content, the compound could move via runoff of sediment-bound residues (erosion).

In general, deposition of drifting pesticides is expected to be greatest close to the site of application. The computer model of spray drift (AgDRIFT) is used to determine potential exposures to aquatic and terrestrial organisms via spray drift at distance from the use site.

2.4.3 Mechanism of Action

Norflurazon is a pre-emergent herbicide with broad spectrum activity on grasses, broad leaf weeds and sedges. Norflurazon is a carotenoid synthesis inhibitor that disrupts the plant's ability to produce carotenoid pigments. Carotenoids absorb blue light energy for photosynthesis and protects chlorophyll from damage. Norflurazon is generally active only through root uptake.

2.4.4 Use Characterization

Nationally, uses include alfalfa, avocado, cranberries, cotton, orchard crops (*e.g.* almonds, walnuts, apples, cherries), blueberries, caneberries, citrus, grapes, hops, soybeans and non-agricultural uses (*e.g.* industrial areas (outdoors), rights-of-way, refuse/solid waste sites, nursery stock). All of the current uses are considered as part of the federal action evaluated in this assessment, with the exception of soybeans and cranberries because these crops are not grown in California and cotton because norflurazon is not registered for this use in the state of California.

Norflurazon is formulated as a liquid concentrate. Application method for most uses of norflurazon is limited to ground spray. Aerial application is permitted for alfalfa, at a much lower application rate. Risks from ground boom and aerial applications are expected to result in the highest off-target levels of norflurazon due to generally higher spray drift levels.

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for norflurazon represent 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. **Table 2.3** presents the uses and corresponding application rates and methods of application considered in this assessment. In cases where application parameters are not explicitly prescribed on the labels, reasonable conservative assumptions were employed. For instance, the label for the alfalfa application does not specify a re-application interval. For this assessment, a seven day re-application interval was assumed to be a reasonable period of time between when a farmer would re-apply a pre-emergent herbicide treatment to a field. In addition, for uses such as tree nuts (*i.e.* almonds, pecans, etc.), grapes, hops, and tree fruits (*i.e.* apples, apricots, etc.) one application was assumed because the label specifies that no more than 3.93 lb ai/A should be applied per year. There are no multiple a.i. products formulated with norflurazon.

Table 2.3. Norflurazon Uses Assessed for the CRLF

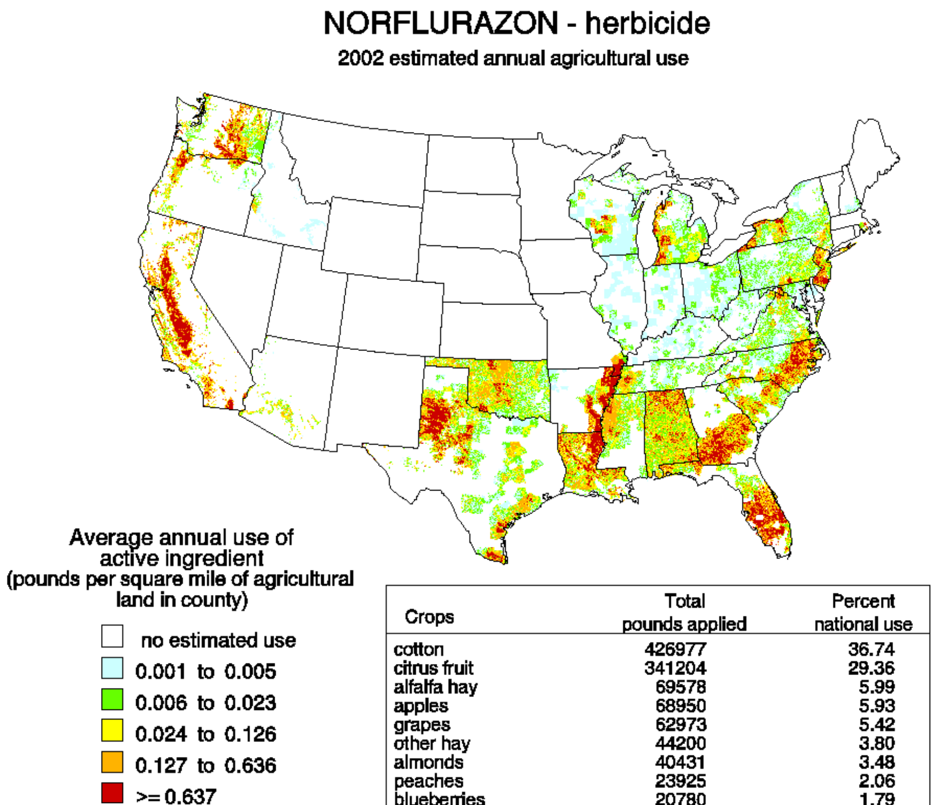
Use(s)	Maximum Single Application Rate (lbs a.i./A)	Number of Applications Per Year	Annual Application Rate (lbs a.i./A)	Application Interval (days)	Application Method
Alfalfa	0.983	2	1.966	7 (assumed)	Aerial, Ground boom sprayer
Almonds, walnuts, filberts, pecans	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Avocado	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Blueberries	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Caneberries (Raspberries and Blackberries)	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Citrus	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer, drip/sprinkler irrigation
Apples, Apricots, nectarines, peaches, pears, cherries, plums, prunes	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Grapes	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Hops	3.93	NS[1] (1 assumed)	3.93	NA[1]	Ground boom sprayer
Nursery Stock	2.358	1	2.358	NA[1]	Ground boom sprayer
Industrial Areas, Refuse/Solid Waste Sites (outdoors), Non Agricultural ROW/fencerows/hedgerows, Non Agricultural uncultivated areas/soils	3.93	1	3.93	NA[1]	Ground boom sprayer

1 NS = not specified, but implied from annual maximum application rate, NA = not applicable

Figure 2.4.4-1 presents the national agricultural usage pattern of norflurazon in 2002[1]. Usage was concentrated in California, the Pacific Northwest, the lower Midwest, and in portions of the eastern and southeastern United States. Cotton and citrus fruit dominated the agricultural use patterns at that time accounting for an estimated 36% and 29% of

1 The map was downloaded from a U.S. Geological Survey (USGS), National Water Quality Assessment Program (NAWQA) website. (http://water.usgs.gov/nawqa/pnsp/usage/maps/compound_listing.php?year=02)

norflurazon usage, respectively (USGS 2007); however, as noted previously, norflurazon is not registered for use on cotton in California.



Crops	Total pounds applied	Percent national use
cotton	426977	36.74
citrus fruit	341204	29.36
alfalfa hay	69578	5.99
apples	68950	5.93
grapes	62973	5.42
other hay	44200	3.80
almonds	40431	3.48
peaches	23925	2.06
blueberries	20780	1.79
asparagus	9827	0.85

Figure 2.4.4-1 Norflurazon Use in Total Pounds per County

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (Kaul and Jones, 2006) using state-level usage data obtained from USDA-NASS[2], 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[3]. The CDPR PUR database is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for norflurazon by county in this California-specific assessment were obtained using CDPR PUR data. Usage data for the years 1999-2006 of were included in this analysis. Data from CDPR PUR were obtained for every pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system. BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved

[2] 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.
[3] 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.

summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county-level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across eight years (1999-2006). The units of area treated are also provided where available.

A summary of norflurazon usage for all California use sites based on CDPR PUR data is provided below in **Table 2.4.** The highest average annual usages in California include almond (2,409 lbs) and alfalfa (1,823 lbs). These use sites are followed by grape (1,479 lbs) and orange (1,355 lbs). Rights-of-way and industrial uses combined totaled only an annual average of 320 lbs. Further details are in **Appendix A**.

Table 2.4. Summary of CDPR PUR Data from 1999 to 2006 for Currently Registered Norflurazon Uses

Site Name	Avg Annual App. (lbs a.i.)	Avg App Rate (lbs a.i./A)	95th %-ile App Rate (lbs a.i./A)	99th %-ile App Rate (lbs a.i./A)	Max App Rate (lbs a.i./A)
Alfalfa	1823	1.44	2.96	3.68	31.44
Almond	2409.45	1.19	2.41	3.07	9.01
Apple	117.87	1.50	2.20	2.32	8.0
Apricot	101.03	1.07	2.70	3.21	7.86
Asparagus	195.56	2.18	2.67	3.44	8.84
Avocado	242.28	2.60	5.99	6.03	29.48
Blackberry	0.55	0.63	0.63	0.63	0.63
Blueberry	19.87	1.16	1.50	1.50	2.75
Buildings/ Non-Ag Outdoor	0.49	0.79	0.79	0.79	0.79
Cherry	95.03	1.23	2.03	3.39	11.79
Citrus	98.39	1.89	3.14	3.73	4.72
Grape	1478.97	0.95	1.80	2.51	13.36
Grapes, wine	432.15	1.48	2.30	3.38	18.08
Grapefruit	53.31	1.65	2.49	2.83	6.29
Lemon	161.19	1.41	2.62	2.98	3.93
Nectarine	272.95	1.13	2.08	2.53	8.52
Orange	1355.48	1.34	2.71	3.02	23.58
Non-Agriculture: rights of way/fencerow/hedgerows	314.10	1.56[1]	1.56[1]	1.56[1]	1.56[1]
Non-Agriculture Areas	6.59	2.30	2.58	2.58	6.29
Peach	349.38	1.35	2.65	3.24	15.72
Pear	49.84	1.62	2.41	2.44	3.93
Pecan	12.94	1.63	1.87	1.87	3.93
Plum	465.53	1.19	2.23	2.49	12.58
Prune	317.71	1.69	2.71	3.95	14.15
Tangelo	39.28	1.47	2.66	3.83	9.83
Tangerine	618.64	1.72	2.35	2.91	30.71
Uncultivated agriculture	24.35	1.74	2.16	2.16	3.93

Site Name	Avg Annual App. (lbs a.i.)	Avg App Rate (lbs a.i./A)	95th %-ile App Rate (lbs a.i./A)	99th %-ile App Rate (lbs a.i./A)	Max App Rate (lbs a.i./A)
Walnut (English, black)	303.82	1.51	2.70	3.74	15.72
Average	11359.75	1.48	2.39	2.85	10.98

1 = Indicates an incomplete data set because most records lacked usage data.

There are some inconsistencies between the current product labels and the CDPR PUR data. Some uses reported in the CDPR PUR data are not currently allowed by label in California for these uses. This assessment is conducted on the current labeled uses for California. Additionally, the maximum application rates reported often exceed the maximum allowed by the current label. The current legal uses upon which this assessment is based, are listed in table 2.3.

2.5 Assessed Species

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

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

2.5.1 Distribution

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

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

The distribution of CRLFs within California is addressed in this assessment using four categories of location including recovery units, core areas, designated critical habitat, and known occurrences of the CRLF reported in the California Natural Diversity Database (CNDDB) that are not included within core areas and/or designated critical habitat (see **Figure 2.5.1-1**). Recovery units, core areas, and other known occurrences of the CRLF from the CNDDB are described in further detail in this section and **Attachment 1**; 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.

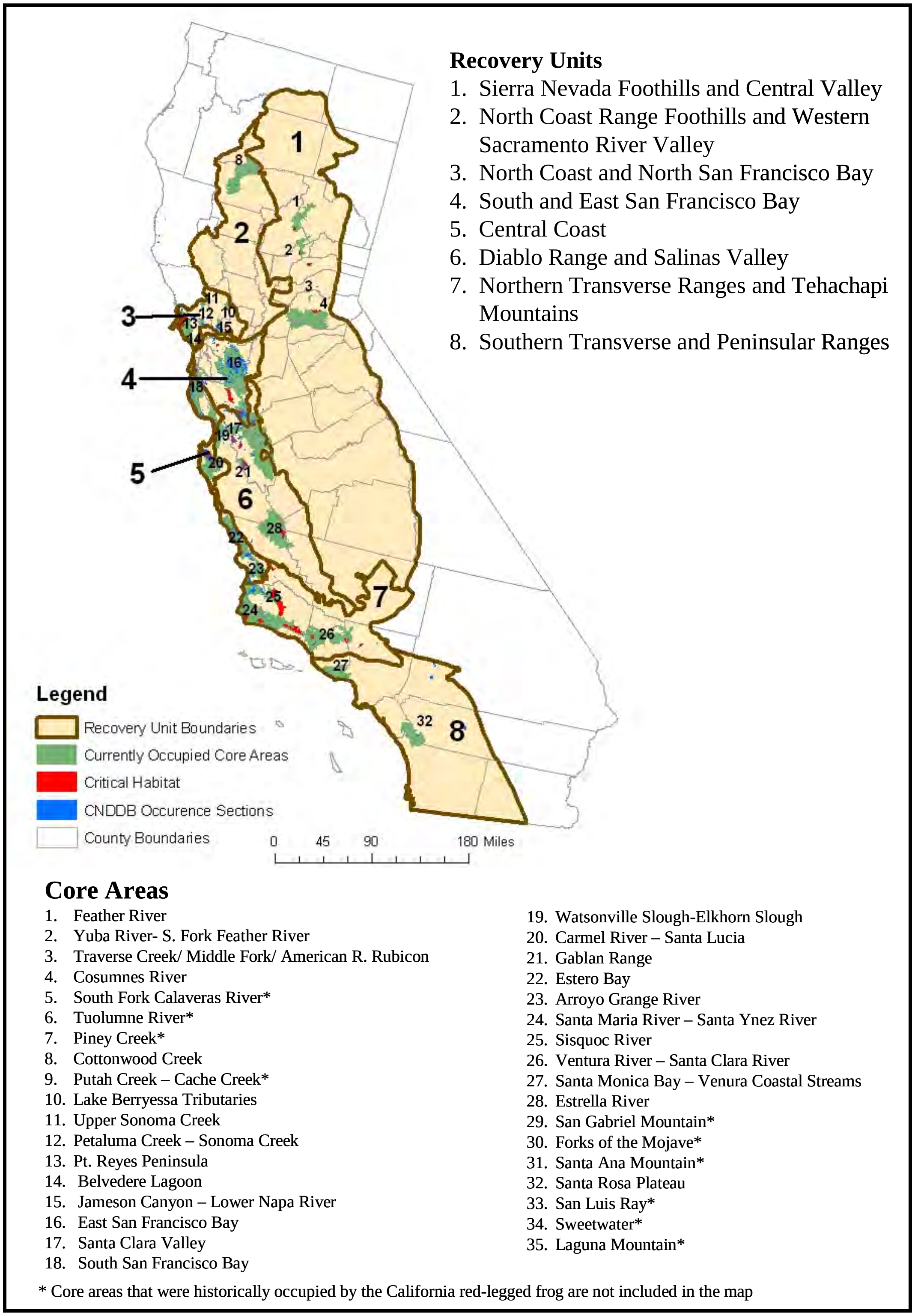


Figure 2.5.1-1 Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

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 2.5.2-1** depicts CRLF annual reproductive timing.

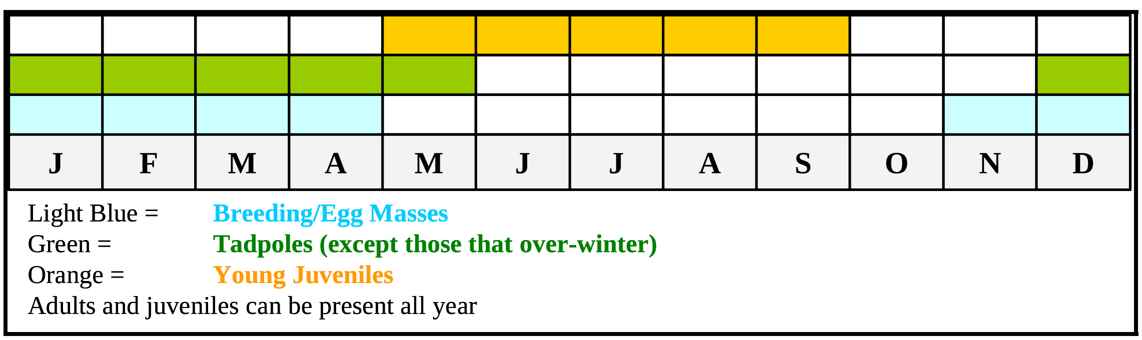


Figure 2.5.2-1 CRLF Reproductive Events by Month

2.5.3 Diet

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

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

2.5.4 Habitat

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

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

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

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

2.6 Designated Critical Habitat

In a final rule published on April 13, 2006, 34 separate units of critical habitat were designated for the CRLF by USFWS (USFWS 2006; FR 51 19244-19346).

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

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

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

Further description of these habitat types is provided in **Attachment 1**.

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, 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 norflurazon that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to USFWS (2006), activities that may affect critical habitat and therefore result in adverse effects to the CRLF include, but are not limited to the following:

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

As previously noted in **Section 2.1**, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because norflurazon is expected to directly impact living organisms within the action area, critical habitat analysis for norflurazon 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 norflurazon is likely to encompass considerable portions of the United States based on the large array of agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the state of California. The Agency's approach to defining the action area under the provisions of the Overview Document (USEPA 2004) considers the results of the risk assessment process to establish boundaries for that action area with the understanding that exposures below the Agency's defined Levels of Concern (LOCs) constitute a no-effect threshold. For the purposes of this assessment, attention will be focused on the footprint of the action (i.e., the area where pesticide application occurs), plus all areas where offsite transport (i.e., spray drift, downstream dilution, etc.) may result in potential exposure within the state of California that exceeds the Agency's LOCs.

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

The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for norflurazon. An analysis of labeled uses and review of available product labels was completed. Several of the currently labeled uses are special local needs (SLN) uses or are restricted to specific states and are excluded from this assessment. In addition, a distinction has been made between food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the CRLF, the analysis indicates that, for norflurazon, the following agricultural uses are considered as part of the federal action evaluated in this assessment:

- alfalfa, avocado, orchard crops (*e.g.* almonds, filbert, walnuts, apples, apricot, cherries, nectarines), blueberries, caneberries, citrus, grapes and hops.

In addition, the following non-food or non-agricultural uses are allowed:

- industrial areas (outdoors), non agricultural rights-of-way, fencerows, hedgerows, non agricultural uncultivated areas/soils, refuse/solid waste sites and nursery stock

Following a determination of the assessed uses, an evaluation of the potential “footprint” of norflurazon use patterns (i.e., the area where pesticide application occurs) is determined. This “footprint” represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above. A map representing all the land cover types that make up the initial area of concern for norflurazon is presented in **Figure 2.5.4-1.**

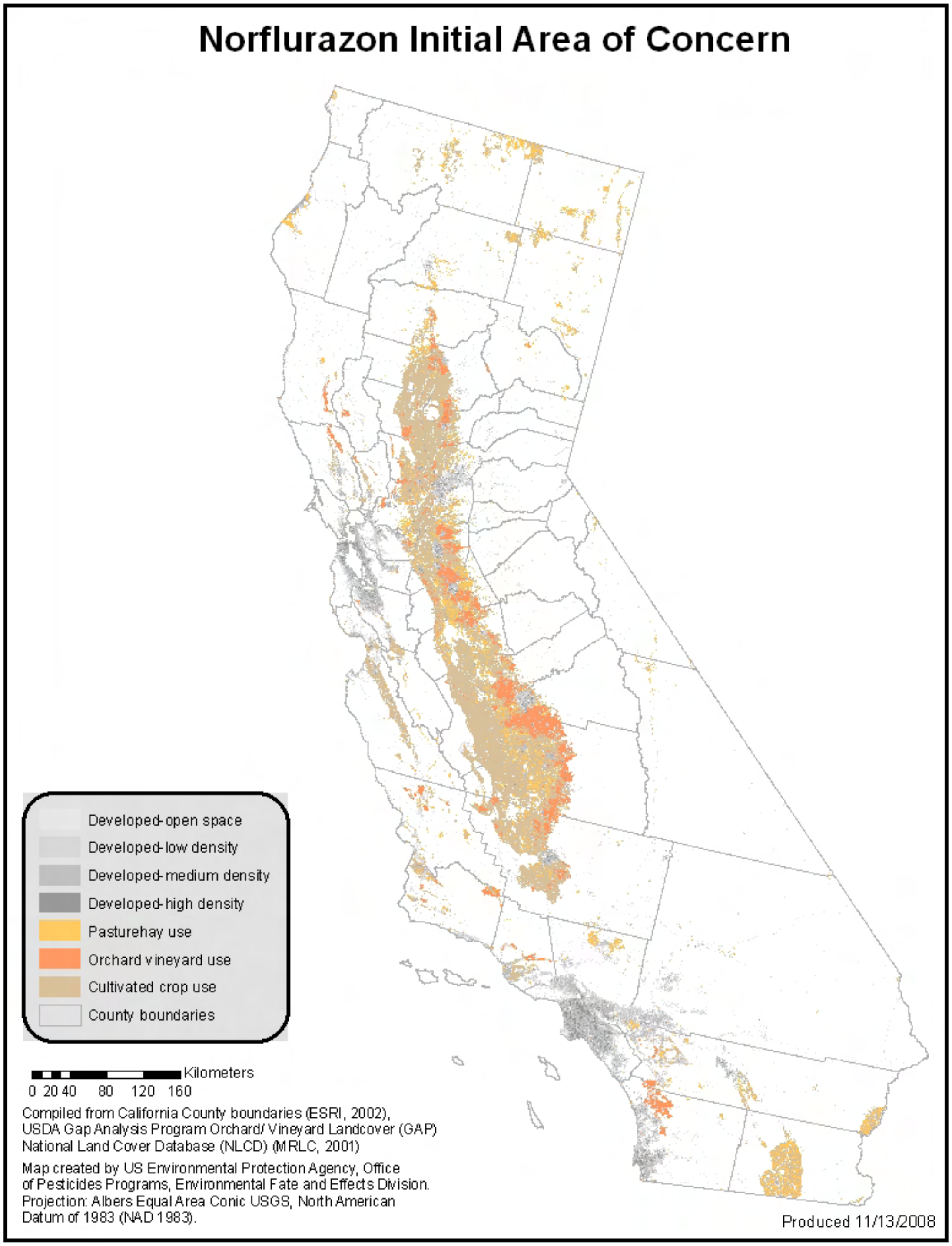


Figure 2.5.4-1. Initial area of concern, or "footprint" of potential use, for norflurazon.

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

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

Due to the lack of a defined no observed adverse effect concentration for the most sensitive reported chronic toxicity endpoint (maternal body weight) in mammals from a rat developmental toxicity study (MRID 00063621), the spatial extent of the action area (i.e., the boundary where exposures and potential effects are less than the Agency's LOC) for norflurazon cannot be determined. Therefore, it is assumed that the action area encompasses the entire state of California, regardless of the spatial extent (*i.e.*, initial area of concern or footprint) of the pesticide use(s).

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."[4] Selection of the assessment endpoints is based on valued entities (e.g., CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (e.g., waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of norflurazon (e.g., runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to norflurazon (e.g., direct contact, etc.).

2.8.1 Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base or modification of its habitat. In addition, potential modification of critical habitat is assessed by evaluating potential effects to PCEs, which are components of the habitat areas that provide essential life cycle needs of the CRLF. Each assessment endpoint requires one or more "measures of ecological effect," defined as changes in the attributes of an assessment endpoint or changes in a surrogate entity or attribute in response to exposure to a pesticide. Specific measures of ecological effect are generally evaluated based on acute and chronic toxicity information from registrant-submitted guideline tests that are performed on a limited number of organisms. Additional ecological effects data from the open literature are also considered. It should be noted that assessment endpoints are limited to direct and indirect effects associated with survival, growth, and fecundity, and do not include the full suite of sublethal effects used to define the action area. According the Overview Document (USEPA 2004), the Agency relies on acute and chronic effects endpoints that are either direct measures of impairment of survival, growth, or fecundity or endpoints for which there is a scientifically robust, peer reviewed relationship that can quantify the impact of the measured effect endpoint on the assessment endpoints of survival, growth, and fecundity.

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

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in Section 4.0 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to norflurazon is provided in **Table 2.5.**

Table 2.5 Assessment Endpoints and Measures of Ecological Effects

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

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

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

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

Measures of such possible effects by labeled use of norflurazon on critical habitat of the CRLF are described in **Table 2.6**. Some components of these PCEs are associated with physical abiotic features (e.g., presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 2.6 Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat[a]

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

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

2.9 Conceptual Model

2.9.1 Risk Hypotheses

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

The labeled use of norflurazon within the action area may:

- directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect the CRLF by reducing or changing the composition of food supply;
- indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;
- indirectly affect the CRLF or modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- 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);
- modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- 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.
- 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.
- 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 norflurazon release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for terrestrial and aquatic exposures are shown in **Figure 2.9.2-1** and **Figure 2.9.2-2**, respectively, which include the conceptual models for the aquatic and terrestrial PCE components of critical habitat.

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

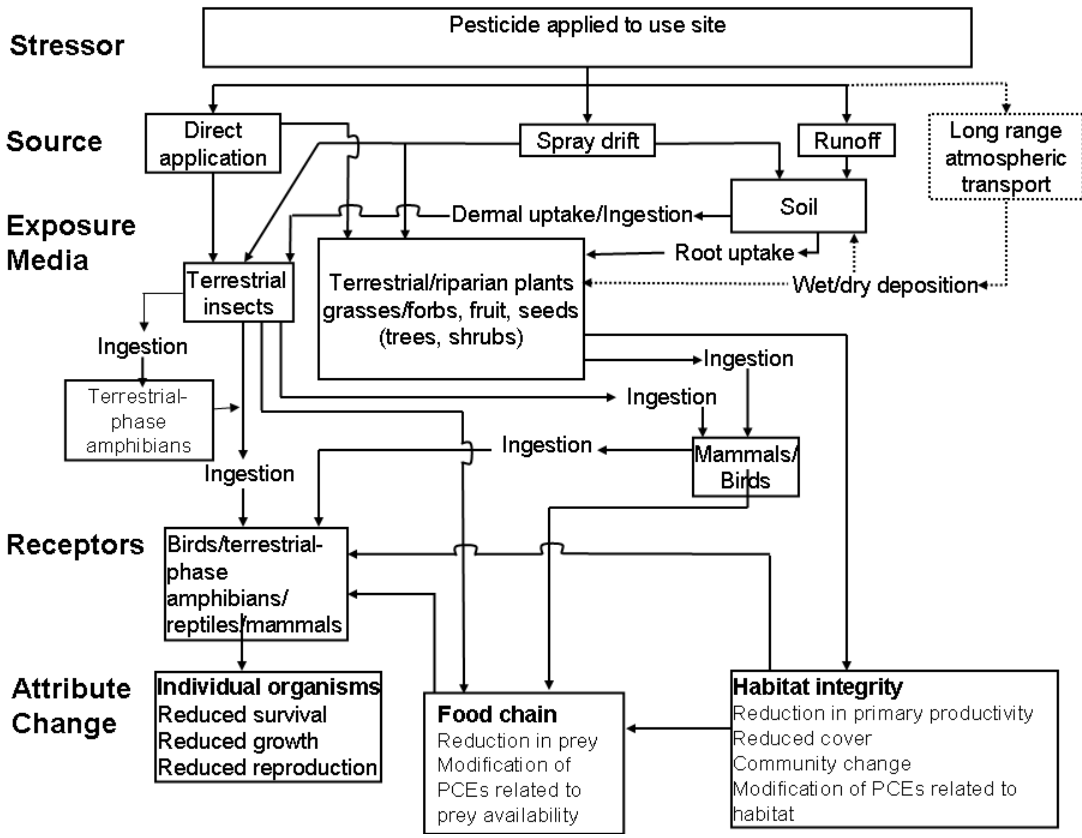


Figure 2.9.2-1 Conceptual Model for Norflurazon Effects on Terrestrial Phase of the CRLF

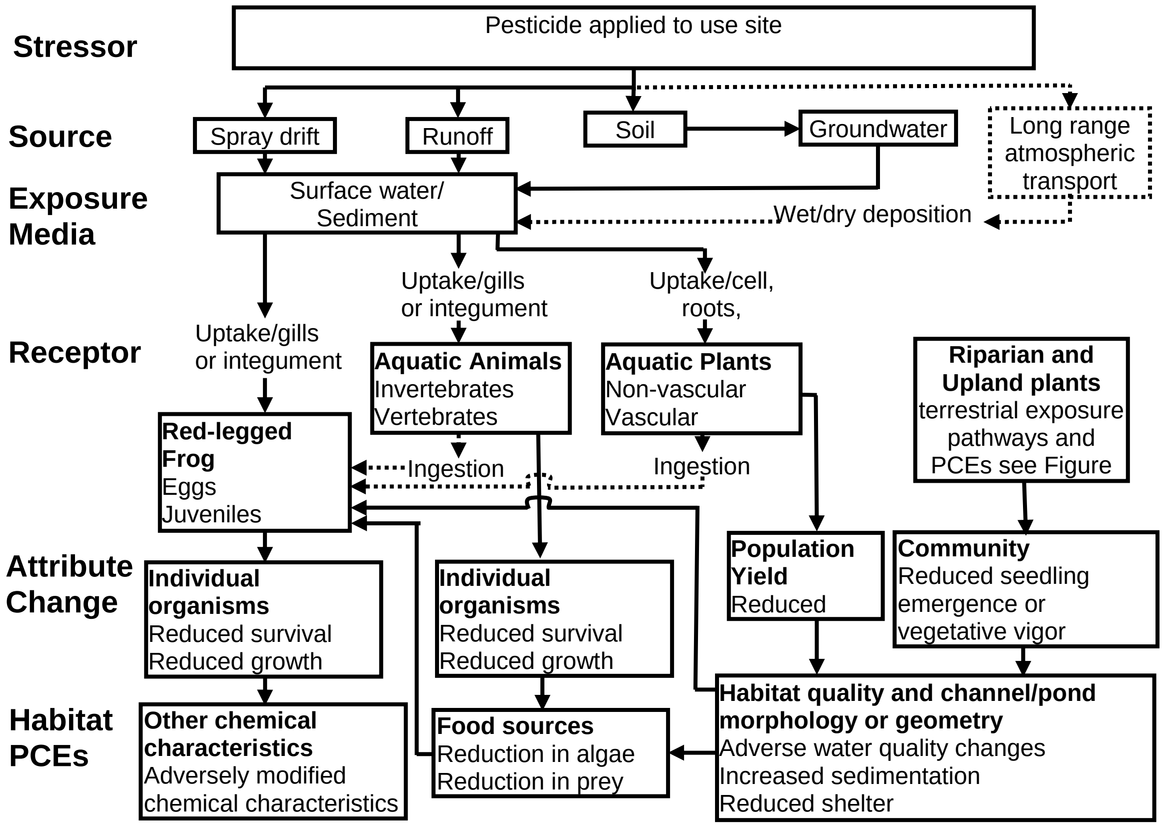


Figure 2.9.2-2 Conceptual Model for Norflurazon Effects on Aquatic Phase of the CRLF

2.10 Analysis Plan

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

2.10.1 Measures to Evaluate the Risk Hypothesis and Conceptual Model

2.10.1.1 Measures of Exposure

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

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

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

Exposure estimates for the terrestrial-phase CRLF and terrestrial invertebrates and mammals (serving as potential prey) assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.4.1, 10/2008). This model incorporates the Kenega nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenega, 1972). For modeling purposes, direct exposures of the CRLF to norflurazon through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey (small mammals) are assessed using the small mammal (15 g) which consumes short grass. The small bird (20g) consuming small insects and the small mammal (15g) consuming short grass are used because these categories represent the largest RQs of the size and dietary categories in T-REX that are appropriate surrogates for the CRLF and one of its prey items. Estimated exposures of terrestrial insects to norflurazon are bound by using the dietary based EECs for small insects and large insects.

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

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

The spray drift model AgDRIFT (v2.01) is used to assess exposures of terrestrial-phase CRLF and its habitat to norflurazon deposited on terrestrial habitats by spray drift. In addition to the buffered area from the spray drift analysis, the downstream extent of norflurazon that exceeds the LOC for the effects determination is also considered. Additional information is provided in **Appendix B.**

2.10.1.2 Measures of Effect

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

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

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

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

2.10.1.3 Integration of Exposure and Effects

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

For this endangered species assessment, listed species LOCs are used for comparing RQ values for acute and chronic exposures of norflurazon directly to the CRLF. If estimated exposures directly to the CRLF of norflurazon resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is "may affect". When considering indirect effects to the CRLF due to effects to animal prey (aquatic and terrestrial invertebrates, fish, frogs, and mice), the listed species LOCs are also used. If estimated exposures to CRLF prey of norflurazon resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is a "may affect." If the RQ being considered also exceeds the non-listed species acute risk LOC, then the effects determination is a LAA. If the acute

RQ is between the listed species LOC and the non-listed acute risk species LOC, then further lines of evidence (*i.e*. probability of individual effects, species sensitivity distributions) are considered in distinguishing between a determination of NLAA and a LAA. When considering indirect effects to the CRLF due to effects to algae as dietary items or plants as habitat, the non-listed species LOC for plants is used because the CRLF does not have an obligate relationship with any particular aquatic and/or terrestrial plant. If the RQ being considered for a particular use exceeds the non-listed species LOC for plants, the effects determination is “may affect”.

2.10.2 Data Gaps

All ecological effects data relevant to this assessment have been submitted, reviewed and used in this assessment. There are no acceptable anaerobic soil metabolism studies or terrestrial field dissipation studies available for norflurazon.

3.0 Exposure Assessment

Norflurazon is formulated as a liquid concentrate. Application method for most uses of norflurazon is limited to ground spray. Aerial application is permitted for alfalfa, at a much lower application rate. Risks from ground boom and aerial applications are expected to result in the highest off-target levels of norflurazon due to generally higher spray drift levels. The maximum total annual application rate for current norflurazon uses in California is 3.93 lbs ai/A.

Norflurazon labels may be categorized into two types: labels for manufacturing uses (including technical grade norflurazon) and end-use products. While technical products, which contain norflurazon of high purity, are not used directly in the environment, they are used to make formulated products, which can be applied in specific areas to control grasses, broad leaf weeds and sedges. The formulated product labels legally limit potential norflurazon use to only those sites that are specified on the labels.

Currently registered agricultural and non-agricultural uses of norflurazon within California and being assessed are summarized in **Table 2.3.**

3.1 Aquatic Exposure Assessment

3.1.1 Modeling Approach

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

EPA modeled Total Toxic Residues which includes the parent compound (norflurazon) and the degradate desmethyl norflurazon. The aqueous photolysis, aerobic soil metabolism and the aerobic and anaerobic aquatic metabolism half-lives determined for the parent compound in the guideline studies were recalculated using concentration data for the parent compound plus desmethyl norflurazon when the latter compound was present in the study samples. Additionally, there are soil adsorption data for the parent compound and limited adsorption data for the degradate desmethyl norflurazon which indicates that desmethyl norflurazon approaches the mobility of the parent compound. Regardless, because the parent data were used in lieu of definitive adsorption coefficient data for the degradate, this introduces an uncertainty in relation to the EECs.

3.1.2 Model Inputs

The model input parameters used in PRZM/EXAMS to simulate norflurazon application-specific and chemical-specific parameters are listed in **Table 3.1** and **Table 3.2.** Crop-specific management practices for all of the assessed uses of norflurazon were used for modeling, including application rates, number of applications per year, application intervals, and the first application date for each crop. The date of first application was based on several sources of information including data provided by BEAD and Crop Profiles maintained by the USDA. When a range of application dates was possible, the first application was chosen to correspond to the wetter portion of the year, winter/early spring. Standard and CRLF-specific PRZM crop scenarios, which consist of location-specific soils, weather, and cropping practices, were used in the simulations to represent labeled uses of norflurazon. These scenarios were developed to represent high-end exposure sites in terms of vulnerability to runoff and erosion and subsequent off-site transport of pesticide.

Registered uses were grouped into categories according to similarity of crop growth and morphology, product use and cropping area; representative PRZM scenarios for each category were used for modeling. Particular attention was given to grouping crops according to the areas in which they are grown because rainfall is understood to be a driving variable in the PRZM model. Modeling inputs were selected according to EFED’s Input Parameter Guidance (USEPA 2002). Pesticide applications were simulated as ground spray applications as prescribed by product labels and default spray drift estimates were assumed. The dates chosen for “foliar application” were based on when weed pressure was expected to be present since the herbicide is applied to the ground and not to the crop directly. The disposition of the pesticide remaining on foliage after harvest was determined to be not applicable because the herbicide is not applied to the crop directly and therefore post-harvest practices would not impact modeling.

For the rights-of way (ROW) scenario, the conceptual modeling integrates simultaneous modeling of the individual scenario (ROW) and an impervious surface. This approach assumes that no watershed is completely covered by either the undeveloped land of the rights-of-way or an impervious surface. Post-processing of the output was performed two ways: first a conservative assumption was made for a 10.0% overspray of impervious surfaces within the rights-of-way with a resulting peak EEC of 79 (µg/L). A second run was performed for the rights-of-way scenario which had a less conservative approach of a 1.0% overspray of impervious surfaces and resulted in a slightly lower peak EEC of 65 (µg/L).

Table 3.1. Norflurazon Uses, Scenarios, and Application Information for the CRLF risk assessment[1]

Category	Uses	PRZM Scenario	App. rate (lbs ai/A)	# Apps/ year	Min. interval	Date of 1st App	App. Date Comment
Alfalfa	Alfalfa	CA alfalfa_WirrigOP	0.983	2	7[2]	January 1st	Winter/Dormant application based on label directions
Almonds	Almonds, filberts, , walnut, pecans	CAalmond_WirrigSTD	3.93	1 (assumed)[3]	NA	August 15th	Pre-Harvest application based on label directions
Avocado	Avocado	CAavocadoRLF_v2	3.93	1 (assumed)[3]	NA	March 15th	Foliar Application based on label directions; spring application assumed
Citrus	Citrus	CAcitrus _WirrigSTD	3.93	1 (assumed)[3]	NA	March 15th	Foliar Application based on label directions; spring application assumed
Fruit tree	Apples, apricots, nectarines, peaches, pears, cherries, plums, prunes	CAfruit _WirrigSTD	3.93	1 (assumed)[3]	NA	March 15th	Foliar Application based on label directions; spring application assumed
Grapes	Grapes, Blueberries, Caneberries, Hops	CAWineGrapesRLF_v2	3.93	1 (assumed)[3]	NA	March 15th	Foliar Application based on label directions; spring application assumed
Nursery	Nursery Stock	CAnurserySTD	2.36	1 (assumed)[3]	NA	March 15th	Foliar Application based on label directions; spring application assumed
Rights of Way	Industrial Areas, Refuse/Solid Waste Sites (outdoors), Non Agricultural ROW/fencerows/hedgerows, Non Agricultural uncultivated areas/soils	CArightofwayRLF_V2.	3.93	1 (assumed)[3]	NA	March 15th	Foliar Application based on label directions; spring application assumed

[1] Uses assessed based on memorandum from SRRD dated 9/3/08.
[2]Minimum interval not specified on label.
[3] Maximum number of application per year not specified on label and one cropping season was assumed based on maximum amount of active ingredient allowed per calendar year.

Table 3.2. Chemical-Specific PRZM/EXAMS Input Parameters Used in Aquatic Exposure Modeling for Norflurazon and Desmethylnorflurazon.

Input Parameter	Value	Source	Comment
Molecular mass (g/mol)	303.7	Product chemistry	
Vapor pressure (Torr)	1.5 $x10^{-5}$ torr	Product chemistry	
Henry's law constant (atm-m^3/mol)	2.1 x 10^{-7}	Calculated	HLC = (VP/760) / (SOL/MWT)
Water solubility (mg/L)	280	Product chemistry	multiplied by 10[1]
Adsorption partition coefficient (K_d, ml/g)	14.2	MRID 41986904, 00148312,42710901	Average Kd[1]
Aerobic soil metabolism $t_{1/2}$ (d)	1,125	MRID 40079601	Value calculated from data for parent plus desmethyl norflurazon and represents 3x aerobic soil $t_{1/2}$ [1]
Aerobic aquatic metabolism $t_{1/2}$ (d)	825	MRID 40079601	Value calculated from data for parent plus desmethyl norflurazon and represents 3x aerobic aquatic $t_{1/2}$ [1]
Anaerobic aquatic metabolism $t_{1/2}$ (d)	2,034	MRID 40079601	Value calculated from data for parent plus desmethyl norflurazon and represents 3x anaerobic aquatic $t_{1/2}$ [1]
Hydrolysis $t_{1/2}$ (d)	0	MRID 00146165	Stable at pH 7.
Photolysis $t_{1/2}$ (d)	3	MRID 00148311	Value calculated from data for parent plus desmethyl norflurazon.

[1] EFED input parameter guidance is located at: http://www.epa.gov/oppefed1/models/water/input_guidance2_28_02.htm.

3.1.3 Results

Aquatic EECs using PRZM/EXAMS for the various use categories are listed in **Table 3.3**. Tier II peak aquatic EECs range from 5 to 79µg/L for citrus and rights-of-way, respectively. The variability in EECs is driven by yearly application rate, application timing relative to rainfall events, and variability in the vulnerability of the PRZM scenario (rainfall and soils) selected.

Table 3.3. Aquatic Total Toxic Residue EECs (µg/L) for Norflurazon Uses in California

Scenario	Application Rate	Date of First Application	Crops Represented	Peak EEC	21-day average EEC	60-day average EEC
California fruit trees	3.93	March 15	Apples, apricots, cherries, nectarines, peaches, pears, plums and prunes	7.4	7.0	6.5
Alfalfa	0.983x2	January 1	Alfalfa	27.3	26.5	25.6
Avocado	3.93	March 15	Avocado	36.4	35.1	33.4
Almond	3.93	August 15	Almonds, filberts (hazelnuts) and walnuts (black and English)	34.7	34.0	32.7
Citrus	3.93	March 15	Citrus	5.0	4.8	4.6
Grapes	3.93	March 15	Grapes, blueberries, caneberries, hops	14.4	14.1	13.5
Nursery	2.36	March 15	Nursery Stock	41.8	40.8	39.3
Rights-of-Way	3.93	March 15	Industrial areas, refuse/solid waste sites (outdoors), non agricultural ROW/fencerows/hedgerows, non agricultural uncultivated areas/soils	79	78	78

3.1.4 Existing Monitoring Data

Norflurazon has a limited set of surface and ground water monitoring data relevant to the CRLF assessment. Surface water monitoring studies which specifically targeted norflurazon use (application period and/or sites) were not available for analysis as part of this assessment. Generally, targeted monitoring data are collected with a sampling program designed to capture, both spatially and temporally, the maximum use of a particular pesticide and as such, peak residue levels. Typically, sampling frequencies employed in monitoring studies are insufficient to document peak exposure values. The lack of targeted sampling data, coupled with the fact that these data are not temporally or spatially correlated with pesticide application times and/or areas, limit the utility of these data in estimating peak exposure concentrations for risk assessment purposes. Therefore model-generated values are used for estimating both acute and chronic exposure values, and the non-targeted monitoring data are typically used for qualitative characterizations of environmental concentrations. Included in this assessment are norflurazon data from the USGS NAWQA program (http://water.usgs.gov/nawqa) and data from the California Department of Pesticide Regulation (CDPR). In addition, a targeted Prospective

Groundwater (PGW) study has been conducted for parent norflurazon and desmethylnorflurazon and the results are discussed below.

3.1.4.1 USGS NAWQA Surface Water Data

Surface water monitoring data from the United States Geological Survey (USGS) NAWQA program were obtained on November 24, 2008. A total of 8,026 water samples across various sites throughout the U.S. were analyzed for norflurazon. This included 346 samples taken in CA at 31 sites located in 11 counties (Alpine, El Dorado, Merced, Nevada, Orange, Sacramento, San Bernadino, San Joaquin, Stanislaus, Sutter and Yolo) between March 1993 and September 2005. There were 334 (4%) detections of norflurazon nationwide ranging in concentration from 0.007 to 1.4 µg/L and 74 (21%) detections in the state of California ranging in concentrations from 0.0031 to 0.62 µg/L. Levels of detection (LOD) varied over time ranging from 0.0008 to 0.53 µg/L. Of the detections in California, sites were classified as agricultural land use (25 sites), mixed land use (46 sites), and urban (three sites).

A total of 635 water samples across various sites throughout the U.S. were analyzed for desmethyl norflurazon. Of these samples, 317 (50%) samples had positive detections with estimated concentrations ranging from 0.05 to 6.1 µg/L. None of the samples collected from sites in California were analyzed for desmethyl norflurazon.

3.1.4.2 USGS NAWQA Groundwater Data

Ground water monitoring data from the United States Geological Survey (USGS) NAWQA program were obtained on December 1, 2008. A total of 6,102 water samples across various sites throughout the US were analyzed for norflurazon. This included 429 samples taken in CA at sites located in 20 counties (Butte, Colusa, Fresno, Glenn, Kern, Kings, Los Angelos, Madera, Merced, Orange, Placer, Riverside, Sacramento, San Bernadino, San Joaquin, Stanislaus, Sutter, Tulare, Yolo and Yuba) between August 1993 and September 2006. There were 14 detections of norflurazon which ranged from 0.0037 to 0.24 µg/L. Sites were classified as agricultural land use (210 sites), mixed use (111 sites), urban (70 sites) and other (38 sites).

A total of 45 water samples across various sites throughout the US were analyzed for desmethyl norflurazon. Of these samples, 10 (22%) samples had positive detections with estimated concentrations ranging from 0.05 to 1.91 µg/L. None of the samples collected from sites in California were analyzed for desmethyl norflurazon.

3.1.4.3 California Department of Pesticide Regulation (CPR) Data

Surface water monitoring data were obtained from the California Department of Pesticide regulation (CDPR) on November 24, 2008, and all data with analysis for norflurazon were extracted. A total of 199 water samples were analyzed for norflurazon. There were

28 (14%) detections of norflurazon ranging from 0.05 and 0.98 µg/L. Detections of norflurazon were reported from eight sites on the Highline Spillway to the San Joaquin.River in Merced County on March 7, 2002; from one site on the Colusa Basin Drain above Knights Landing in Yolo County on April 15, 1998; from 14 sites in Wadsworth Canal at South Butte Road in Sutter County between January 8, 2001 and March 14, 2001; from four sites on Sutter Bypass at Karnak Pumping Station between January 15, 2001 and March 7, 2001; and at one site on the Sacramento River at Alamar Marina Dock, 9 mi below the confluence of the Feather River on January 12, 2001.

3.1.4.4 Prospective Groundwater Study

A Prospective Groundwater (PGW) study was conducted on a citrus grove located on the Central Ridge in Florida (US EPA, 2002). Two applications of norflurazon were made March and July 1994, at a reported total rate of 5 to 10 lbs a.i./A. The study was conducted for approximately two years. Both norflurazon and desmethylnorflurazon were measured in multiple wells at the site throughout the duration of the study, with peak concentrations of 29.9 and 23.8 µg/L, respectively in two separate sampling events. Several samples contained residues of both parent and degradate in relatively high concentrations (greater than 20 ppb) and were observed to persist more than 700 days after application.

The maximum concentrations from the PGW study are within the range of peak, 21-day and 60-day concentrations estimated from surface water (4.6 – 79 µg/L) for various uses of norflurazon. Exposure resulting from discharging groundwater to surface water is therefore reasonably represented by the concentrations estimated for surface water. Particularly since attenuation and retardation of the chemical would occur prior to discharge.

3.1.4.5 Atmospheric Monitoring Data

Atmospheric monitoring data is not available for norflurazon.

3.2 Terrestrial Exposure Assessment

3.2.1 Terrestrial Animal Exposure Assessment

T-REX (Version 1.4.1) is used to calculate dietary and dose-based EECs of norflurazon for the CRLF and its potential prey (*e.g.* small mammals and terrestrial insects) inhabiting terrestrial areas. EECs used to represent the CRLF are also used to represent exposure values for frogs serving as potential prey of CRLF adults. T-REX simulates a 1-year time period. For this assessment, spray applications of norflurazon are considered, as discussed in below.

Terrestrial EECs for foliar formulations of norflurazon were derived for the uses summarized in **Table 3.4**. Given that no data on interception and subsequent dissipation from foliar surfaces is available for norflurazon, a default foliar dissipation half-life of 35 days is used based on the work of Willis and McDowell (1987). Since norflurazon is a pre-emergent herbicide, the default foliar dissipation half-life of 35 day is likely conservative since the presence of foliar surfaces is likely limited. However, the majority of uses have a single application per year, so the use of this half-life is relevant only to the alfalfa use where there are two applications per year. Use-specific input values, including number of applications, application rate and application interval are provided in **Table 3.4**. The nursery stock use is included under the higher 3.93 lb ai/A rate. An example output from T-REX is available in **Appendix E**.

Table 3.4 Input Parameters for Foliar Applications Used to Derive Terrestrial EECs for Norflurazon with T-REX

Use (Application method)	Application rate (lbs ai/A)	Number of Applications
All uses (except alfalfa)	3.93	1
Alfalfa	0.983[a]	2

[a]Two applications, seven day interval

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

For modeling purposes, exposures of the CRLF to norflurazon through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey are assessed using the small mammal (15 g) which consumes short grass. Upper-bound Kenega nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential prey (**Table 3.5**). Dietary-based EECs for small and large insects reported by T-REX as well as the resulting adjusted EECs are available in **Table 3.6**. An example output from T-REX v1.4.1 is available in **Appendix C**.

Table 3.5 Upper-bound Kenega Nomogram EECs for Dietary- and Dose-based Exposures of the CRLF and its Prey to Norflurazon

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
All uses (except alfalfa)	531	604	943	899
Alfalfa*	248	283	441	421

*assuming 7-day reapplication interval

Table 3.6 EECs (ppm) for Indirect Effects to the Terrestrial-Phase CRLF via Effects to Terrestrial Invertebrate Prey Items

Use	Small Insect (ppm)	Large Insect (ppm)
All uses (except alfalfa)	604	67
Alfalfa*	283	31

*assuming 7-day reapplication interval

3.2.2 Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.2.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method (**Table 3.7**). A runoff value of 0.02 is utilized based on the solubility of norflurazon. For aerial and ground application methods, drift is assumed to be 5% and 1%, respectively. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 3.7**. An example output from TerrPlant v.1.2.2 is available in **Appendix D.**

Table 3.7 TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Norflurazon via Runoff and Drift

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift EEC (lbs ai/A)	Dry area EEC (lbs ai/A)	Semi-aquatic area EEC (lbs ai/A)
All uses (except alfalfa)	3.93	Foliar - ground	1	0.039	0.118	0.825
Alfalfa	0.983	Foliar-air	5	0.049	0.069	0.246

4.0 Effects Assessment

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

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

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

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

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

Citations of all open literature not considered as part of this assessment because they were rejected by the ECOTOX screen is included in **Appendix E**. **Appendix E** also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this endangered species risk assessment. A detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sublethal endpoints is presented in **Appendix F**. There were no more sensitive endpoints available in the ECOTOX database other than the registrant-submitted studies used for this assessment. **Appendix G** includes the Health Effects Division summary of mammalian effects data for norflurazon.

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

No degradate toxicity data have been identified by HED, and there are no ecotoxicological studies on the toxicity of norflurazon degradates. Therefore, desethylnorflurazon is assumed to have equivalent toxicity to the parent. Available formulated product studies report similar toxicity to the TGAI.

4.1 Evaluation of Aquatic Ecotoxicity Studies

Table 4.1 summarizes the most sensitive aquatic toxicity endpoints for the CRLF, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted data considered relevant to this ecological risk assessment for the CRLF is presented below.

Table 4.1 Freshwater Aquatic Toxicity Profile for Norflurazon.

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Citation MRID # (Author & Date)	Comment
Acute Direct Toxicity to Aquatic-Phase CRLF	Rainbow trout	LC_{50}=8.1 mg ai/L	00246434	Acceptable
Chronic Direct Toxicity to Aquatic-Phase CRLF	Rainbow trout	NOAEC=0.77 mg ai/L	00248829	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Acute Toxicity to Freshwater Invertebrates (i.e. prey items)	*Daphnia magna*	LC_{50}>15 mg ai/L	0035709	Acceptable (no mortality)
Indirect Toxicity to Aquatic-Phase CRLF via Chronic Toxicity to Freshwater Invertebrates (i.e. prey items)	*Daphnia magna*	NOAEC=1.0 mg ai/L	0118049	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Non-vascular Aquatic Plants	Green algae	EC_{50}=9.7 µg ai/L	420804-06	Acceptable
Indirect Toxicity to Aquatic-Phase CRLF via Toxicity to Vascular Aquatic Plants	Duckweed	EC_{50}=58.2 µg ai/L	420804-07	Acceptable

Toxicity to aquatic fish and invertebrates is categorized using the system shown in **Table 4.2** (U.S. EPA, 2004). Toxicity categories for aquatic plants have not been defined.

Table 4.2 Categories of Acute Toxicity for Aquatic Animals

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

4.1.1 Toxicity to Freshwater Fish

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

Agency guideline aquatic animal studies are supposed to test up to 100 mg/L, which the available studies did not; however, the solubility limit of the compound is 28 mg/L. Presumably, solubility was an issue in the aquatic studies.

A summary of acute and chronic freshwater fish data, including data from the open literature, is provided below.

4.1.1.1 Freshwater Fish: Acute Exposure (Mortality) Studies

Two submitted guideline studies provide insight into the potential acute effects of norflurazon on freshwater fish, and by extension, on the aquatic-phase CRLF as well. One study, with bluegill sunfish, *Lepomis macrochirus*, resulted in an LC_{50} of 16.3 mg ai/L with no adverse effects observed at 10 mg ai/L. A second study, with rainbow trout, resulted in an LC_{50} of 8.1 mg ai/L with no adverse effects observed at 4 mg ai/L. For a protective assessment, the LC_{50} of 8.1 mg ai/L will be used for RQ calculation. Norflurazon is categorized as moderately toxic to freshwater fish on an acute exposure basis.

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

Two guideline early life stage (ELS) studies are available for evaluation of potential chronic effects of norflurazon on the aquatic-phase CRLF. Both studies are with the rainbow trout and result in similar NOAECs, based on reduced growth. One study resulted in a NOAEC of 1.1 mg ai/L, with a LOAEC of 2.1 mg ai/L. The other study resulted in a NOAEC of 0.77 mg ai/L and the LOAEC is 1.5 mg ai/L. The most sensitive endpoint used in the chronic assessment for CRLF is the NOAEC of 0.77 mg ai/L.

4.1.2 Toxicity to Freshwater Invertebrates

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

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

4.1.2.1 Freshwater Invertebrates: Acute Exposure (Mortality) Studies

The guideline study with *Daphnia magna* resulted in a nondefinitive LC_{50} of >15 mg ai/L, with no observed adverse effects to the animals in the study at the highest concentration tested. Norflurazon is categorized as slightly toxic to freshwater invertebrates on an acute exposure basis.

4.1.2.2 Freshwater Invertebrates: Chronic Exposure (Reproduction) Studies

The guideline study evaluating potential chronic effects to aquatic invertebrates, with *Daphnia magna*, resulted in a NOAEC of 1.0 mg ai/L. The LOAEC in the study is 2.6 mg ai/L, based on reduced number of offspring produced compared to the control.

4.1.3 Toxicity to Aquatic Plants

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

Laboratory studies were used to determine whether norflurazon may cause direct effects to aquatic plants. A summary of the laboratory data and freshwater field studies for aquatic plants is provided in Sections 4.1.3.1.

4.1.3.1 Aquatic Plants: Laboratory Data

A 5-day study with *Lemna gibba* resulted in an EC_{50} of 58.2 µg ai/L, the endpoint used for estimating effects to aquatic vascular plants, a component of CRLF habitat. A 5-day study with the green algae, *Pseudokirchneriella subcapitata* (formerly *Selenastrum capricornutum*), resulted in an EC_{50} of 9.7 µg ai/L, the endpoint used for assessing potential effects to aquatic nonvascular plants, a component of the aquatic-phase CRLF diet.

4.2 Toxicity of Norflurazon to Terrestrial Organisms

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

Table 4.3 Terrestrial Toxicity Profile for Norflurazon

Endpoint	Species	Toxicity Value Used in Risk Assessment	MRID#	Comment
Acute Direct Toxicity to Terrestrial-Phase CRLF	Mallard duck	LD_{50} >2,510 mg ai/kg-bw	00048362	No mortalities or clinical observation of effect
Acute Direct Toxicity to Terrestrial-Phase CRLF	Bobwhite quail	LC_{50} >10,000 mg ai/kg-diet	0037051	No mortalities or clinical observation of effect
Chronic Direct	Bobwhite quail	NOAEC=40 mg ai/kg-diet	426153-01	No adult mortality; based on reduced # of 14-d old survivors

Endpoint	Species	Toxicity Value Used in Risk Assessment	MRID#	Comment
Toxicity to Terrestrial-Phase CRLF				
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to mammalian prey items)	Laboratory rat	LD_{50}=9,300 mg ai/kg-bw	00111612	
Indirect Toxicity to Terrestrial-Phase CRLF (via chronic toxicity to mammalian prey items)	Laboratory rat	NOAEC=150 mg ai/kg-diet	00082019	Decreased pup weights
Indirect Toxicity to Terrestrial-Phase CRLF (via acute toxicity to terrestrial invertebrate prey items)	Honey bee	LD_{50}>235 µg/bee	00146168	No mortalities
Indirect Toxicity to Terrestrial- and Aquatic-Phase CRLF (via toxicity to terrestrial plants)	Seedling Emergence Monocots	EC_{25}=0.034 lbs ai/A	433125-01	Onion fresh weight
	Seedling Emergence Dicots	EC_{25}=0.002 lbs ai/A	433125-01	Mustard fresh weight
	Vegetative Vigor Monocots	EC_{25}=0.13 lbs ai/A	420804-05	Onion fresh weight
	Vegetative Vigor Dicots	EC_{25}=0.08 lbs ai/A	420804-05	Cucumber fresh weight

Acute toxicity to terrestrial animals is categorized using the classification system shown in **Table 4.4** (U.S. EPA, 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4.4 Categories of Acute Oral and Subacute Dietary Toxicity for Avian and Mammalian Studies

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

4.2.1 Toxicity to Birds

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

4.2.1.1 Birds: Acute Exposure (Mortality) Studies

An avian acute oral toxicity study with mallard duck is available for norflurazon. The study was conducted with five doses, with five males and five females at each level. No mortalities were observed at the highest concentration tested (2150 mg ai/kg body weight (bw)). The LD_{50} for avian acute effects is >2150 mg ai/kg-bw. Norflurazon is categorized as practically nontoxic to avian species on an acute oral exposure basis.

Two avian subacute dietary studies are available for norflurazon, one with bobwhite quail and the other with mallard duck. No mortalities were reported in either study at the highest concentration tested (10,000 mg ai/kg diet). Some loss of feathers was reported for bobwhite quail at the highest dose. The LC_{50} for subacute dietary exposure to avian species is >10,000 mg ai/kg-diet. Norflurazon is categorized as practically nontoxic on a subacute dietary exposure basis.

4.2.1.2 Birds: Chronic Exposure (Growth, Reproduction) Studies

Effects to avian species from chronic exposure are assessed with one-generation reproduction studies. Two studies, one with bobwhite quail and one with mallard duck are used to evaluate the chronic toxicity of norflurazon to avian species. No effects on adult in either study were reported. The mallard study determined an NOAEC of 40 mg ai/kg-diet, based on decreased hatchling weights relative to the control (15%). The quail study determined an NOAEC of 40 mg ai/kg-diet, based on decreased hatchling survival at the second highest dose (200 mg ai/kg-diet) relative to the control; however, this effect may not be treatment related. The LOAEC for both studies is 200 mg ai/kg-diet.

4.2.2 Toxicity to Mammals

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

A NOAEL was not determined in the rat developmental toxicity study (MRID 00063621). The LOAEL for the study is 100 mg ai/kg-bw/day, the lowest dose tested, base on maternal weight loss. There were no developmental effects observed in the offspring. For more information, see the HED Human Health Risk Assessment in **Appendix G**.

4.2.2.1 Mammals: Acute Exposure (Mortality) Studies

Effects to mammals are assessed with the acute oral toxicity study with the laboratory rat. The LD_{50} from this study (MRID 00111612) is 9,300 mg ai/kg-bw; therefore norflurazon is categorized as practically nontoxic to mammalian species on an acute exposure basis.

4.2.2.2 Mammals: Chronic Exposure (Growth, Reproduction) Studies

The two-generation study with the laboratory rat is used to assess potential for effects to mammals from chronic exposure. The study for norflurazon determined a NOAEC for both parental and offspring of 150 mg ai/kg-diet. The parental LOAEC is 750 mg ai/kg-bw, based on increased liver and kidney weights in both generations. The offspring LOAEC is also 750 mg ai/kg-bw, based on decreased pup weights.

4.2.3 Toxicity to Terrestrial Invertebrates

Terrestrial invertebrate toxicity data are used to assess potential indirect effects of norflurazon to the terrestrial-phase CRLF. Effects to terrestrial invertebrates resulting from exposure to norflurazon could also indirectly affect the CRLF via reduction in available food. The honeybee acute oral and contact studies indicate norflurazon is practically nontoxic to adult honeybees on an acute exposure basis, with an LD_{50} in both studies >235 µg ai/bee. The acute contact toxicity of formulated norflurazon (80% ai) reports an LC_{50}s >90 µg ai/bee, the highest concentration test. No effects were observed in any study.

4.2.4 Toxicity to Terrestrial Plants

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

Plant toxicity data from both registrant-submitted studies and studies in the open literature were reviewed for this assessment. Registrant-submitted studies are conducted under conditions and with species defined in EPA toxicity test guidelines. Sub-lethal endpoints such as plant growth, dry weight, and biomass are evaluated for both monocots and dicots, and effects are evaluated at both seedling emergence and vegetative life stages.

The results of the Tier II seedling emergence and vegetative vigor toxicity tests on non-target plant biomass are summarized below in **Table 4.5** and **4.6.** Sensitivity varied widely across species, indicating tat some species of plants are more sensitive to norflurazon. Grasses exhibited low sensitivity to norflurazon in both studies. As expected with a pre-emergent herbicide, the most sensitive endpoint is in the seedling emergence study (mustard; 0.002 lbs ai/A), and effects were seen in more species in that study. However, effects were seen in the vegetative vigor study in sensitive species (*e.g.* cucumber).

Table 4.5 Non-target Terrestrial Plant Seedling Emergence Toxicity (Tier II) Data

Crop	Type of Study Species	EC_{25} (lb ai/A)	NOAEC (lb ai/A)	Most sensitive parameter
Monocots	Onion	**0.034***	0.016	Fresh weight
	Corn	2.0	0.40	Fresh weight
	Oat	0.45	0.08	Fresh weight
	Sorghum	0.40	0.08	Fresh weight
Dicots	Buckwheat	2.0	0.40	Fresh weight
	Cucumber	0.40	0.08	Fresh weight
	Mustard	**0.002***	0.00064	Fresh weight
	Radish	0.08	0.0032	Fresh weight
	Soybean	>2.00	>2.00	Fresh weight
	tomato	0.03	0.016	Fresh weight

*Bold indicates inputs to TerrPlant.

Table 4.6 Non-target Terrestrial Plant Vegetative Vigor Toxicity (Tier II) Data

Crop	Type of Study Species	EC_{25} (lb ai/A)	NOAEC (lb ai/A)	Most sensitive parameter
Monocots	**Onion**	**0.40**	0.08	**Fresh weight**
	Corn	0.55	0.08	Fresh weight
	Oat	1.8	0.40	Fresh weight
	Sorghum	2.0	0.08	Fresh weight
Dicots	Buckwheat	>2.0	0.40	Fresh weight
	Cucumber	0.08	0.0032	**Fresh weight**
	Mustard	0.39	0.08	Fresh weight
	Radish	>2.0	0.40	Fresh weight
	Soybean	2.00	0.40	Fresh weight
	Tomato	0.27	0.08	Fresh weight

*Bold indicates endpoint inputs to TerrPlant.

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

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

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

For norflurazon, there are no acute effect LOC exceedances; therefore IEC results presented in Table 5.1 are only are for the effects chance at the LOC and the LC_{50}, assuming the default slope.

4.4 Incident Database Review

A review of the EIIS database for ecological incidents involving norflurazon was completed on November 25, 2008. The results of this review for terrestrial, plant, and aquatic incidents are discussed below.

4.4.1 Plant Incidents

Seven terrestrial incidents are reported for norflurazon, all for adverse effects to plant species, with the certainty determination for most as “possible”. Of these, three were the result of misuse and one was the result of a registered use (on plums in Tulare County, CA).

4.4.2 Aquatic Incidents

Three aquatic incidents are reported. Two are for uses in Louisiana on cotton which were classified as unlikely to be due to norflurazon. In these two incidents, mortality of ‘thousands’ of fish occurred in a nearby lake. Both of these incidents (I004021-005 and I004021-004) are for the same date and the same county in LA, and therefore may be two reports for the same incident. The other aquatic incident occurred in Delaware and was of undetermined legality (of use) and undetermined target application. It is classified as ‘possible’ and involves the mortality of an unknown number of an unspecified species of fish in 1992 (I000180-001).

5.0 Risk Characterization

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

5.1 Risk Estimation

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

Risk to the aquatic-phase CRLF is estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs based on the label-recommended norflurazon usage scenarios summarized in **Table 2.3** and the appropriate aquatic toxicity endpoint from **Table 4.1**. Risks to the terrestrial-phase CRLF and its prey (*e.g.* terrestrial insects, small mammals and terrestrial-phase frogs) are estimated based on exposures resulting from applications of norflurazon (**Section 3)** and the appropriate toxicity endpoint from **Table 4.3**. Exposures are also derived for terrestrial plants, as discussed in Section 3.2 and summarized in **Table 3.7**, based on the highest application rates of norflurazon use within the action area.

5.1.1 Exposures in the Aquatic Habitat

5.1.1.1 Direct Effects to Aquatic-Phase CRLF

Direct acute effects to the aquatic-phase CRLF are based on peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. In order to assess direct chronic risks to the CRLF, 60-day EECs and the lowest chronic toxicity value for freshwater fish are used. Aquatic EECs were generated using the Tier II PRZM/EXAMS model, as described in **Section 3.1.1**. RQs calculated with the highest acute (peak) and chronic (60-day) EECs (from the rights-of-way use) do not exceed either the acute or chronic LOC (**Table 5.1**); norflurazon will have no effect directly on the aquatic-phase CRLF.

Table 5.1 Summary of Direct Effect RQs for the Aquatic-phase CRLF

Direct Effects to CRLF[a]	Surrogate Species	Toxicity Value (µg/L)	EEC (µg/L)[b]	RQ	Probability of Individual Effect at ES LOC	Probability of Individual Effect at RQ
Acute Direct Toxicity	Rainbow trout	LC_{50} = 8100	Peak: 79	0.009[d]	1 in 4.18E+11	1 in 5.9 E+19
Chronic Direct Toxicity		NOAEC = 770	60-day: 78	0.10[e]	Not calculated for chronic endpoints	

[a] RQs associated with acute and chronic direct toxicity to the CRLF are also used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items.
[b] The highest EEC based on foliar use of norflurazon on orchard crops at 3.93 lb ai/A.
[c] A probit slope value for acute toxicity is not available; therefore, the effect probability was based the default slope assumption.
[d] RQ < acute risk to endangered species LOC of 0.05.
[e] RQ < chronic risk LOC of 1.0.

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

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

Indirect effects of norflurazon to the aquatic-phase CRLF (tadpoles) via reduction in non-vascular aquatic plants as a food source are based on 1-in-10 year peak EECs and the lowest toxicity value (EC_{50}) for aquatic non-vascular plants. All uses except fruit trees and citrus exceed the LOC for nonvascular aquatic plants (**Table 5.2**). The maximum EEC, for rights of way, results in an 8-fold exceedance of the LOC (RQ=7.9). Avocado and almonds result in the highest EECs among the agricultural uses, with an approximately 3.5-fold exceedance of the LOC. Based on these results, norflurazon is likely to indirectly affect the CRLF via reduction in nonvascular plants for all uses except fruit trees and citrus.

Table 5.2 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Non-Vascular Aquatic Plants (EC_{50}=9.7 µg/L) (diet of CRLF in tadpole life stage and habitat of aquatic-phase CRLF).

Scenario	Application Rate	Date of First Application	Crops Represented	Peak EEC	RQ
California fruit trees (non-citrus)	3.93	March 15	Apples, apricots, cherries, nectarines, peaches, pears, plums and prunes	7.4	0.76
Alfalfa	0.983x2	January 1	Alfalfa	27.3	2.8*
Avocado	3.93	March 15	Avocado	36.4	3.8*
Almond	3.93	August 15	Almonds, filberts (hazelnuts) and walnuts (black and English)	34.7	3.6*
Citrus	3.93	March 15	Citrus	5.0	0.52
Grapes	3.93	March 15	Grapes, blueberries, caneberries, hops	14.4	1.5*
Nursery	2.358	March 15	Nursery Stock	41.8	4.3*
Rights of Way	3.93	March 15	Industrial areas, refuse/solid waste sites (outdoors), non agricultural ROW/fencerows/hedgerows, non agricultural uncultivated areas/soils	79	8.1*

*Exceeds risk to non-vascular plant LOC (RQ≥1.0)

b) <u>Aquatic Invertebrates</u>

Indirect acute effects to the aquatic-phase CRLF via effects to invertebrate prey in aquatic habitats are based on peak EECs and the lowest acute toxicity value for freshwater invertebrates. For chronic risks, 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive RQs. The highest acute and chronic aquatic invertebrate RQ values do not exceed the LOC (**Table 5.3**). Because the acute aquatic invertebrate endpoint (EC_{50}) is greater than 15 mg ai/L, the highest dose tested, the acute RQ is a less than value. Based on these RQs, norflurazon is not likely to indirectly affect the CRLF via reduction in freshwater invertebrate prey items (no effect).

Table 5.3 Summary of Acute and Chronic RQs Used to Estimate Indirect Effects to the CRLF via Direct Effects on Aquatic Invertebrates as Dietary Food Items (prey of CRLF juveniles and adults in aquatic habitats) Based on Acute LC_{50} and Chronic NOAEC Toxicity Endpoints for *Daphnia magna* of >15,000 µg/L and 1,000 µg/L, respectively.

Uses	Application rate (lb ai/A)	Peak EEC (µg/L)	21-day EEC (µg/L)	Indirect Effects Acute RQ*	Indirect Effects Chronic RQ*
Highest aquatic exposure (ROWs)	3.93	79	78	<0.005	0.08

c) <u>Fish and Frogs</u>

Fish and frogs also represent potential prey items of adult aquatic-phase CRLFs. RQs associated with acute and chronic direct toxicity to the CRLF (**Table 5.1**) are used to assess potential indirect effects to the CRLF based on a reduction in freshwater fish and frogs as food items. Because the RQs for direct acute effects to the CRLF, which are based on the more conservative listed species LOC, do not result in exceedances, norflurazon is not likely to acutely indirect affect the CRLF via reduction in freshwater fish and frogs as food items (no effect).

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

Indirect effects to the CRLF via direct toxicity to aquatic plants are estimated using the most sensitive non-vascular and vascular plant toxicity endpoints. Because there are no obligate relationships between the CRLF and any aquatic plant species, the most sensitive EC_{50} values, rather than NOAEC values, were used to derive RQs. The EECs for the rights-of-way use resulted in an exceedance for aquatic vascular plants based on the sensitivity of *Lemna gibba* (RQ=1.4). No other use resulted in an exceedance for aquatic vascular plants. Based on this result, norflurazon may indirectly affect the CRLF via effects to vascular plants in proximity to rights of way and industrial areas.

Potential effects to nonvascular aquatic plants were presented in Section 5.1.1.2a. RQs exceed the LOC for all use patterns except citrus and fruit trees.

Table 5.4 Summary of RQs Used to Estimate Indirect Effects to the CRLF via Effects to Vascular Aquatic Plants (habitat of aquatic-phase CRLF) Based on *L. gibba* EC_{50} of 58.2 µg/L.

Scenario	Application Rate	Date of First Application	Crops Represented	Peak EEC	RQ
California fruit trees	3.93	March 15	Apples, apricots, cherries, nectarines, peaches, pears, plums and prunes	7.4	0.13
Alfalfa	0.983x2	January 1	Alfalfa	27.3	0.47
Avocado	3.93	March 15	Avocado	36.4	0.62
Almond	3.93	August 15	Almonds, filberts (hazelnuts) and walnuts (black and English)	34.7	0.60
Citrus	3.93	March 15	Citrus	5.0	0.09
Grapes	3.93	March 15	Grapes, blueberries, caneberries, hops	14.4	0.25
Nursery	2.358	March 15	Nursery Stock	41.8	0.72
Rights-of-Way	3.93	March 15	Industrial areas, refuse/solid waste sites (outdoors), non agricultural ROW/fencerows/hedgerows, non agricultural uncultivated areas/soils	79	1.4*

*Exceeds vascular aquatic plant LOC.(RQ≥1.0)

5.1.2 Exposures in the Terrestrial Habitat

5.1.2.1 Direct Effects to Terrestrial-phase CRLF

As previously discussed in Section 3.2, potential direct effects to terrestrial-phase CRLFs are based on foliar applications of norflurazon.

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

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

The avian acute and subacute endpoints are not definitive (*i.e.* greater than values), therefore definitive RQs cannot be calculated. There was no mortality in any of the studies, and the potential for direct acute or subacute effects to the CRLF are presumed low. However, using these endpoints to calculate RQs can provide insight into the potential for direct effects to the CRLF. Using the subacute dietary endpoint, LC_{50} >10,000 mg ai/kg-diet, results in a dietary RQ value of <0.05, which is below the acute risk LOC of 0.1 for listed avian species. The dose-based endpoint, LD_{50} >2510 mg ai/kg-bw, results in an RQ <0.46, below the acute risk LOC but potentially greater than the acute risk to listed species LOC.

Although the avian acute RQ is not definitive, and the potential for direct acute risk to birds is low, the T-HERPS model was used to refine the dietary-based risk estimate based on the lower food demand of amphibians. The use of this model, using the LD_{50}> 2,510 mg ai/kg-bw as if it were an endpoint, results in RQs <0.01. Based on these results, norflurazon is not likely to directly affect the terrestrial-phase of the CRLF.

Direct effects to the CRLF from chronic exposure are estimated using the results from the avian reproduction studies (NOAEC = 40 mg ai/kg-diet). The resulting dietary-based RQ = 13, based on the upper-bound EECs. The T-REX model indicates EECs may remain at or above 40 ppm for up to 76 days following application. Based on these results, direct effects through chronic exposure may affect the terrestrial-phase CRLF.

Table 5.5 Summary of Chronic RQs* Used to Estimate Direct Effects to the Terrestrial-phase CRLF.

Use (Application Rate)	Dietary-based Chronic RQ[1]
Non agriculture and Agricultural uses (except alfalfa)	**13***
Alfalfa	**6***
* = chronic risk LOC exceeded (chronic RQ $\geq$ 1) [1] Based on avian NOAEC = 40 mg ai/kg-diet.	

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

a) Terrestrial Invertebrates

Chemicals with an acute toxicity value of >11 µg ai/bee are classified as practically nontoxic to bees. Norflurazon was tested up to 235 µg ai/ bee in both acute contact and acute ingestion studies (LD_{50} >235 µg ai/bee). Given that no mortality or sublethal effects were observed in either study, the potential of norflurazon to affect terrestrial invertebrates is considered low, and given the nondefinitive endpoint, RQs are not calculated. Norflurazon is not likely to indirectly affect CRLF through effects on the terrestrial invertebrate prey items.

b) Mammals

Risks associated with ingestion of small mammals by large terrestrial-phase CRLFs are derived for dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming short grass. Acute and chronic effects are estimated using the most sensitive mammalian toxicity data. EECs are divided by the toxicity value to estimate acute and chronic dose-based RQs as well as chronic dietary-based RQs (**Table 5.6**). The acute dose-based RQ, calculated with the LD_{50} = 9,300 mg ai/kg-bw, is 0.04, well below the acute risk LOC for mammals; therefore acute effects to mammals are not likely to affect the CRLF mammalian prey items.

RQs for mammalian effects from chronic exposure to norflurazon are possible, due to exceedance of the LOC by both the dose-based and the dietary-based RQs (**Table 5.7**). Because of the roughly 26- to 55-fold exceedances of the LOC, norflurazon may indirectly affect the CRLF via reduction in small mammal prey items via chronic effects on offspring growth.

Table 5.6 Summary of Acute and Chronic RQs* Used to Estimate Indirect Effects to the Terrestrial-phase CRLF via Direct Effects on Small Mammals as Dietary Food Items Based on an Acute Oral LD_{50} of 9300 mg/kg-bw and Chronic NOAEC of 150 mg/kg-diet.

Use (Application Rate)	**Chronic RQ**		**Acute RQ**
	Dose-based Chronic RQ[1]	**Dietary-based Chronic RQ[2]**	**Dose-based Acute RQ[3]**
All uses (except alfalfa) (3.93 lb ai/A)	**55***	**6.3***	0.04
Alfalfa (0.983 x 2)	**26***	**2.9***	0.02
* = chronic risk LOC exceeded (chronic RQ ≥ 1)			

c) Frogs

An additional prey item of the adult terrestrial-phase CRLF is other species of frogs. In order to assess risks to these organisms, dietary-based and dose-based exposures modeled in T-REX and T-HERPS for a small bird (20g) consuming small invertebrates are used. As noted previously (Section 5.1.2.1), norflurazon is practically nontoxic to birds on both an acute oral and subacute dietary exposure basis and based on birds serving as surrogates for terrestrial-phase amphibians, indirect risk to terrestrial CRLF from acute effects to frogs serving as prey is assumed to be low. However, chronic effects (RQ range: 6-13) to the CRLF terrestrial-phase amphibian prey items are possible (Table 5.5).

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

Potential indirect effects to the CRLF resulting from direct effects on riparian and upland vegetation are assessed using the EC_{25}s from terrestrial plant seedling emergence and vegetative vigor studies to calculate RQs (**Table 5.7** and **Table 5.8**). Based on LOC exceedances for all use patterns at the maximum single application rate, norflurazon may indirectly affect the CRLF via reduction in terrestrial plants as habitat. Example output from TerrPlant v.1.2.2 is provided in **Appendix F.**

Table 5.7 RQs for Monocots Inhabiting Dry and Semi-Aquatic Areas Exposed to Norflurazon via Runoff and Drift.

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ	Dry area RQ	Semi-aquatic area RQ
All uses (except alfalfa)	3.93	Ground	1	**1.2***	**3.5***	**24***
Alfalfa	0.983	Aerial	5	**1.4***	**2.0***	**7.2***
Alfalfa	0.983	Ground	1	0.3	0.9	**6.1***
* = Terrestrial plant risk LOC exceeded (RQ $\geq$ 1); exceedances are bolded and shaded.						

Table 5.8 RQs for Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Norflurazon via Runoff and Drift

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift RQ	Dry area RQ	Semi-aquatic area RQ
All uses (except alfalfa)	3.93	Ground	1	**20***	**58***	**413***
Alfalfa	0.983	Aerial	5	**25***	**34***	**123***
Alfalfa	0.983	Ground	1	**4.9***	**15***	**103***
* = Terrestrial plant risk LOC exceeded (RQ $\geq$ 1); exceedances are bolded and shaded.						

5.1.3 Primary Constituent Elements of Designated Critical Habitat

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

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

- Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.

- Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.
- Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae).

Based on the risk estimation for potential effects to aquatic and terrestrial plants provided in Sections 5.1.1.2, 5.1.1.3, and 5.1.2.3, norflurazon is likely to affect aquatic-phase PCEs of designated habitat related to effects on aquatic and/or terrestrial plants. Although the RQ for aquatic vascular plants (**Table 5.4**) only indicates potential for indirect effects to the CRLF for the rights-of-way use, effects to water quality may occur through effects on aquatic nonvascular plants (**Table 5.2**) for all uses except fruit trees and citrus, as indicated by the roughly 8-fold exceedance of the LOC for rights-of-way and exceedances for other use patterns. Alterations can be expected in the species composition of and/or relative abundance in terrestrial plant communities, especially in riparian areas. The RQs for terrestrial plants for the highest application rate range from 1.2 for sensitive monocots based on drift exposure alone to 413 for sensitive dicots for areas receiving higher runoff (semi-aquatic areas).

The remaining aquatic-phase PCE is “alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.” To assess the impact of norflurazon on this PCE (*i.e.*, alteration of food sources), acute and chronic freshwater fish and invertebrate toxicity endpoints, as well endpoints for aquatic non-vascular plants, are used as measures of effects. RQs for these endpoints were calculated in Sections 5.1.1.1 and 5.1.1.2. Although indirect effects to the CRLF due to norflurazon are not likely based on the acute and chronic RQs for fish and aquatic invertebrates, reductions in the availability of algae as a food source for the aquatic-phase CRLF can be expected, based on the roughly 8-fold exceedance of the LOC for nonvascular aquatic plants. Therefore, norflurazon may affect aquatic-phase PCEs of designated habitat related to effects of alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.

5.1.3.2 Terrestrial-Phase (Upland Habitat and Dispersal Habitat)

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

- Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance
- Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of

each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal

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

The third terrestrial-phase PCE is “reduction and/or modification of food sources for terrestrial phase juveniles and adults.” To assess the impact of norflurazon on this PCE, acute and chronic toxicity endpoints for birds, mammals, and terrestrial invertebrates are used as measures of effects. RQs for these endpoints were calculated in Section 5.1.2.2. Based on the chronic LOC exceedance for birds (terrestrial-phase frogs) and mammals that serve as prey for CRLFs, norflurazon may affect the third terrestrial-phase PCE.

The fourth terrestrial-phase PCE is based on chemical alteration of characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Because of the potential effects to terrestrial plants as habitat for the CRLF and its food sources and because the chronic risk LOC for direct effects to the CRLF is exceeded, norflurazon may affect the fourth terrestrial-phase PCE.

5.1.4 Spatial Extent of Potential Effects

An LAA determination applies to those areas where it is expected that the pesticide’s use will directly or indirectly affect the CRLF or its designated critical habitat. To determine this area, the footprint of norflurazon’s use pattern is identified, using land cover data that correspond to norflurazon’s use pattern. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift. The identified effects and/or modification to critical habitat are anticipated to occur only for those currently occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the CRLF that overlap with the initial area of concern plus 1867’ spray drift distance from its boundary, based on Tier 3 modeling. It is assumed that non-flowing waterbodies (or potential CRLF habitat) are included within this area.

In addition to the spray drift buffer, the results of the downstream dilution extent analysis result in a distance of 58 kilometers which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern. If any of these streams reaches flow into CRLF habitat, there is potential to affect either the CRLF or modify its habitat. These lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of norflurazon sufficient to result in LAA determination and modification of critical habitat.

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

5.1.4.1 Spray Drift

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

For norflurazon use relative to the terrestrial-phase CRLF, the results of the screening-level risk assessment indicate that spray drift using the most sensitive endpoints for terrestrial plants extends as far as 1,867'. Based on this assessment, effects from spray drift are not expected beyond this distance.

In order to characterize the spatial extent of the effects determination that is relevant to the CRLF (*i.e.* NLAA versus LAA), the analysis was conducted using the most sensitive non-endangered plant EC_{25} of 0.002 lbs ai/A, for dicot seedling emergence. The NOAEC is used when there is an obligate relationship between the species being assessed and endangered plants (or other taxa). However, there is no obligate relationship between the CRLF and any endangered plant; therefore the LAA/NLAA determination is based on the area defined by the non-listed species LOC (*i.e.*, EEC/EC_{25}).

The estimated buffer distance identifies those locations where terrestrial landscapes can be impacted by spray drift deposition alone (no runoff considered) at concentrations above the LOC for terrestrial plants. The LOC was compared to the highest RQ for aerial applications to alfalfa at 0.983 lbs ai/A. The maximum effect distance for the alfalfa aerial use of norflurazon on dicot seedling emergence is 1,867 ft. For ground applications at the 3.93 lbs ai/A, the maximum distance LOC is exceeded is 990 ft. Given that the greatest buffer distance is 1,867 ft for terrestrial plants, this value was used to define the spatial extent of the effects determination (i.e., this buffer distance is added to the initial area of concern).

5.1.4.2 Downstream Dilution Analysis

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

Using a EC_{50} value of 9.7 µg/L for non-vascular aquatic plants (the most sensitive species) and a peak EEC for the avocado use 36 µg/L yields an RQ/LOC ratio of 3.6 (3.6/1). Although the rights-of-way use has a higher EEC, this use pattern is likely to be quite marginal based on the PUR data, which indicates rights-of way account for <2% of total pounds applied. Using the downstream dilution approach (described in more detail in **Appendix B**) results in a distance of 58 kilometers, which represents the maximum continuous distance of downstream dilution from the edge of the initial area of concern.

5.2 Risk Description

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

If the RQs presented in the Risk Estimation (Section 5.1) show no direct or indirect effects for the CRLF, and no modification to PCEs of the CRLF’s designated critical habitat, a “no effect” determination is made, based on norflurazon’s use within the action area. However, if direct or indirect effect LOCs are exceeded and effects may modify the PCEs of the CRLF’s critical habitat, the Agency concludes a preliminary “may affect” determination for the FIFRA regulatory action regarding norflurazon.

A preliminary effects determination of “may affect” is made for the CRLF and critical habitat from the uses of norflurazon. A summary of the results of risk estimation are provided in **Table 5.9** for direct and indirect effects to the CRLF and in **Table 5.10** for the PCEs of designated critical habitat for the CRLF.

Table 5.9 Risk Estimation Summary for Norflurazon - Direct and Indirect Effects to CRLF

Assessment Endpoint	LOC Exceedances (Y/N)	Description of Results of Risk Estimation
Aquatic-Phase CRLF (eggs, larvae, tadpoles, juveniles, and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	No	There are no LOC exceedances for fish, the surrogate for the aquatic-phase CRLF
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	Yes	Although there are no LOC exceedances for aquatic invertebrates, there are exceedances for aquatic non-vascular plants.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	Yes	There are exceedances of the LOC for both vascular and non-vascular plants.
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	Yes	Effects are possible to aquatic vascular plants. RQs for terrestrial plants vary, but effects on the seedling emergence of sensitive plant species are expected.
Terrestrial-Phase CRLF (Juveniles and adults)		
Direct Effects Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	Yes	Although no direct acute effects to the CRLF are expected, there is a possibility for effects from chronic exposure
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.*, terrestrial invertebrates, small terrestrial mammals and terrestrial phase amphibians)	Yes	Although acute effect to these prey items are not expected, effects from chronic exposure to mammalian and amphibian prey items may occur
Indirect Effects Survival, growth, and reproduction of CRLF individuals via effects on habitat (*i.e.*, riparian vegetation)	Yes	RQs for terrestrial plants vary, but effects on the seedling emergence of sensitive plant species are expected

Table 5.10 Risk Estimation Summary for Norflurazon – PCEs of Designated Critical Habitat for the CRLF

Assessment Endpoint	LOC Exceedances (Y/N)	Description of Results of Risk Estimation
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Yes	Effects to aquatic vascular plants are expected for ROW uses. RQs for terrestrial plants vary, but effects on the seedling emergence of sensitive plant species are expected
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Yes	Aquatic plants may be affected by norflurazon use. RQs for terrestrial plants vary, but effects on sensitive plant species are expected
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Yes	Due to potential effects on aquatic plants and terrestrial riparian plant species, alteration in chemical characteristics of aquatic habitat (*e.g.* dissolved oxygen) may occur.
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (e.g., algae)	Yes	Effects to aquatic plant species are expected
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	Yes	RQs for terrestrial plants vary, but effects on sensitive plant species are expected
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	Yes	RQs for terrestrial plants vary, but effects on sensitive plant species are expected; these effects may alter plant communities necessary for dispersal habitat
Reduction and/or modification of food sources for terrestrial-phase juveniles and adults	Yes	Chronic effects are expected on amphibians and mammal that serve as prey for CRLFs
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Yes	Changes in aquatic vegetation and riparian communities may alter the chemical characteristic of CRLF habitat

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

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

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

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

5.2.1 Direct Effects

5.2.1.1 Aquatic-Phase CRLF

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

No acute or chronic RQs presented in Section 5.1.1.1 and **Table 5.1** exceed the LOCs for direct effects to the aquatic-phase CRLF. No direct effects to the aquatic-phase CRLF are expected from the labeled uses of norflurazon. Although there are reported fish kill incidents for norflurazon, they are considered unlikely to be due to norflurazon (NE).

5.2.1.2 Terrestrial-Phase CRLF

Acute and chronic RQs presented in Section 5.1.2.1 provide the basis for risk estimation to the terrestrial-phase CRLF. Direct acute effects to the CRLF are not expected, based on the lack of LOC exceedances. No mortalities were observed in any of the acute oral or sub-acute dietary toxicity studies of birds that serve as surrogates for terrestrial-phase amphibians, although some loss of breast feathers was noted in the bobwhite quail sub-acute dietary toxicity study. However, direct chronic effects to the CRLF are possible, based on the exceedances of the chronic risk LOC. The NOAEC is based on decreased survival of 14-d chicks, and this effect could represent potential effects to the CRLF (LAA).

5.2.2 Indirect Effects (via Reductions in Prey Base)

5.2.2.1 Algae (non-vascular aquatic plants)

As discussed in Section 2.5.3, the diet of CRLF tadpoles is composed primarily of unicellular aquatic plants (*i.e.*, algae and diatoms) and detritus. Because the aquatic nonvascular plant RQs exceed the LOC for all uses except citrus and non-citrus fruit trees, norflurazon is considered likely to indirectly affect the aquatic-phase CRLF via effects on aquatic nonvascular plants (LAA).

5.2.2.2 Aquatic Invertebrates

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

Neither the acute nor chronic aquatic invertebrate RQs presented in Section 5.1.1.2 (**Table 5.3**) exceed the LOCs, based on results from the modeling. Therefore, norflurazon is not considered likely to indirectly affect the CRLF via effects on aquatic invertebrates (NE).

5.2.2.3 Fish and Aquatic-phase Frogs

Based on the results from Section 5.2.1.1, which report acute and chronic LOCs for fish and aquatic invertebrates are not exceeded, indirect effects to the CRLF are not expected via effects to fish and aquatic-phase frogs as food items (NE).

5.2.2.4 Terrestrial Invertebrates

When the terrestrial-phase CRLF reaches juvenile and adult stages, its diet is mainly composed of terrestrial invertebrates. In the absence of other relevant data, potential effects to terrestrial invertebrates are assessed using registrant-submitted acute toxicity studies for honey bees. For norflurazon, no mortality or sublethal effects were reported for the acute contact and acute oral honey bee studies at the highest dose tested (235 µg ai/bee). The Agency considers an LD_{50} $\geq$11 µg ai/bee to be practically nontoxic to bees. Therefore, indirect affects to the CRLF via decreased availability of terrestrial invertebrate prey items from the use of norflurazon are not expected (NE).

5.2.2.5 Mammals

Life history data for terrestrial-phase CRLFs indicate that large adult frogs consume terrestrial vertebrates, including mice. Acute RQs for mammals do not exceed the LOC, and therefore indirect effects to the terrestrial-phase CRLF from acute effects to mammalian prey are not expected. However, both the dietary-based and the dose-based chronic RQs (**Table 5.6**) exceed the LOC for all uses (3- 55-fold). Therefore indirect effects to the CRLF via reduction in small mammal prey items that are exposed to norflurazon are likely (LAA).

5.2.2.6 Terrestrial-phase Amphibians

Terrestrial-phase adult CRLFs also consume frogs. RQ values representing direct exposures of norflurazon to terrestrial-phase CRLFs are used to represent exposures of norflurazon to frogs in terrestrial habitats. Indirect effects to frogs as food items are based on results from the direct effects analysis for terrestrial-phase CRLF.

Results from Section 5.2.1.2 indicate that no acute effects on amphibian food items are expected. However, the frog prey base may be adversely affected from chronic exposure to norflurazon, based on the 6- to 13-fold exceedance of the chronic risk LOC (**Table 5.5**) (LAA).

5.2.3 Indirect Effects (via Habitat Effects)

5.2.3.1 Aquatic Plants (Vascular and Nonvascular)

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

Potential indirect effects to the CRLF based on impacts to habitat and/or primary production were assessed using RQs from freshwater aquatic vascular and non-vascular plant data. The RQ for nonvascular plants exceeds the LOC for all uses except citrus and fruit trees (previously described in Section 5.2.2.1 and summarized in **Table 5.2**). Therefore, there is a potential for indirect impact to CRLF habitat through adverse effects to nonvascular plants (HM).

The aquatic vascular plant RQ (RQ=1.4) exceeds the LOC for the rights-of -way/industrial sites use. No other use pattern results in an exceedance for aquatic vascular plants. The nonagricultural uses of norflurazon have a reported total annual average usage of 320 lbs. out of a total annual average usage of 11,360 lbs, for the State of California (CDPR-PUR; **Table 2.4**). These data indicate that nonagricultural uses average <2% of the total norflurazon use in California.
As a pre-emergent herbicide, norflurazon is likely to be applied in limited, highly managed rights of way and industrial areas, as opposed to more rural rights-of-way likely to be adjacent to CRLF habitat, where the use of post-emergent (established plant) herbicides are likely to be more effective.

The RQ of 1.4 for rights-of-way is based on the EEC of 75 ppb. If the model's input parameters, such as amount of impervious surface or application rate, are higher than those actually used, the EEC would be less than estimated by the model. If the EEC was 60 ppb or less, the RQ would not exceed the LOC.

Although widespread affects on the habitat of the CRLF via effects of norflurazon on aquatic vascular plants unlikely, norflurazon use is likely to effect to aquatic vascular plants in specific local situations (HM).

5.2.3.2 Terrestrial Plants

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

As expected for a pre-emergent herbicide, the most sensitive toxicity endpoints were for biomass reductions in the seedling emergence study. While the vegetative vigor study demonstrated effects from exposure to norflurazon, the effects (on biomass) occurred at higher exposures than in the seedling emergence study. Based on TerrPlant, endpoints from the vegetative vigor studies do not result in exceedances of the LOC, except for dicots from drift alone for the alfalfa use (RQ =3.1). This exceedance is due to the higher drift assumption for aerial use. The RQ results from the radish endpoint; none of the other nine species tested in the vegetative vigor study results in an exceedance for any use pattern. Given that norflurazon is a pre-emergent herbicide, it is expected that broad across-species sensitivity to established plants would be low. However, as exhibited by radish, sensitive dicots exposed to a sufficient amount norflurazon drift may be adversely affected.

Because loading is based on runoff plus spray drift, there is uncertainty regarding the exposure estimate. It is not known whether plants will be exposed to both the spray drift and runoff components at the same time. Exceedances for seedling emergence occur for both monocots and dicots, although only for the onion, mustard and tomato endpoints. However, given the RQs range from 3.5 to more than 413, effects to the emergence of sensitive plant are likely, especially those in vulnerable areas, such as wetlands.

Sensitivity to norflurazon varied widely across test species in the seedling emergence study, and highly sensitive species (as evidenced with mustard) may be affected at very low exposures. The highest RQs are for areas receiving the greatest amount of runoff (*e.g.* wetland areas) adjacent to application sites. As with dryer areas, these RQs are estimated using loading to adjacent areas, which is runoff (based on solubility) plus drift (*e.g.* 1% for ground applications). Therefore the exposure values will decrease with distance from the application site and will be limited by the distance the runoff maintains the modeled EECs and the distance norflurazon spray will drift.

Application method, aerial or ground, is an important factor in how far from the application site norflurazon may drift in sufficient amounts to affect sensitive plant species. As a pre-emergent herbicide, norflurazon is likely to be applied to bare ground or over the top of insensitive crop species. The distance spray drift can travel is affected by wind speed and direction and the height of application above the ground, droplet size and the potential for interception by established nontarget plants (such as windrows and established plants). Ground spray application at the lowest practical boom height greatly reduces the distance drift will travel. Because the alfalfa use pattern allows aerial spray, drift mitigation is likely limited to specifying a larger droplet size for application.

To refine the potential effect of spray drift on terrestrial plants, the AgDRIFT model is used. Using the results from AgDRIFT, highly sensitive plants such as mustard may have their emergence affected as far as 1,867’ from the application area for aerial application (alfalfa use). For ground applications at the 3.93 lbs ai/A rate, emergence effects may occur to sensitive plants such as mustard 990 ft from the application site. Possible emergence effects to plants less sensitive than mustard or from effects to vegetative vigor of any species are likely not to occur great than 150 ft from the application area.

Based on this assessment, the labeled use of norflurazon has the potential to indirectly affect the CRLF through disruption in plant communities and habitat modification (HM).

5.2.4 Modification to Designated Critical Habitat

5.2.4.1 Aquatic-Phase PCEs

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

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

Conclusions for potential indirect effects to the CRLF via direct effects to aquatic and terrestrial plants are used to determine whether modification to critical habitat may occur. While widespread habitat modification due to effects on aquatic vascular plants is not expected, local effects may occur. There is a potential for habitat modification via impacts to aquatic nonvascular plants (Sections 5.2.2.1) and terrestrial plants (5.2.3.2)

The remaining aquatic-phase PCE is “alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.” Other than impacts to algae as food items for tadpoles (discussed above), this PCE is assessed by considering direct and indirect effects to the aquatic-phase CRLF via acute and chronic freshwater fish and invertebrate toxicity endpoints as measures of effects. Based on the absence of LOC exceedances, there is not a potential for habitat modification via impacts to aquatic-phase CRLFs (Sections 5.2.1.1) and effects to freshwater invertebrates and fish as food items (Sections 5.2.2.2 and 5.2.2.3).

5.2.4.2 Terrestrial-Phase PCEs

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

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

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

As previously described, there is a potential for habitat modification via impacts to terrestrial plants (5.2.3.2).

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

The fourth terrestrial-phase PCE is based on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Based on potential effects of norflurazon on terrestrial plant communities, there is potential for habitat modification to terrestrial-phase CRLFs.

6.0 Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

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

6.1.2 Aquatic Exposure Modeling of Norflurazon

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

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

(Hayes and Jennings 1988). Therefore, the EXAMS pond is assumed to be representative of exposure to aquatic-phase CRLFs. In addition, the Services agree that the existing EXAMS pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004).

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

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

Additionally, there are soil adsorption data for the parent compound and limited adsorption data for the degradate desmethyl norflurazon which indicates that desmethyl norflurazon approaches the mobility of the parent compound. Regardless, because the parent data were used in lieu of definitive adsorption coefficient data for the degradate, this increases the uncertainty surrounding the EECs.

In order to account for uncertainties associated with modeling, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for norflurazon concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (*e.g.* application rates and timing, crops) associated with the agricultural areas are unknown, however, they are assumed to be representative of potential norflurazon use areas. Although the available monitoring data are not target to norflurazon application times and/or sites, the maximum concentration of norflurazon reported by NAWQA for California surface waters with agricultural watersheds is 0.62 µg/L. This value is approximately 127 times less than the maximum model-estimated environmental concentration. The maximum concentration of norflurazon reported by the California Department of Pesticide Regulation surface water database (0.98 µg/L) is roughly 81 times lower than the highest peak model-estimated environmental concentration. Therefore, EECs provide a conservative measure of exposure.

6.1.3 Potential Groundwater Contributions to Surface Water Chemical Concentrations

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

Groundwater monitoring data from NAWQA and the PGW study suggest that both norflurazon and desmethyl norflurazon may leach and persist in groundwater. Given these detections in ground water, it can be assumed (based upon persistence in sub- and anoxic conditions, and mobility) that much of the compounds entering the groundwater will be transported some distance and eventually discharged into surface water. Although concentrations in a receiving water body resulting from groundwater discharge cannot be explicitly quantified, it should be assumed that attenuation and retardation of the chemical will have occurred subsequent to recharge and prior to discharge. Nevertheless, groundwater could still be a significant consistent source of chronic background concentrations in surface water, and may also add to surface runoff during storm events (as a result of enhanced groundwater discharge typically characterized by the 'tailing limb' of a storm hydrograph).

6.1.4 Usage Uncertainties

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

6.1.5 Terrestrial Exposure Modeling of Norflurazon

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. The field measurement efforts used to develop the Fletcher estimates of exposure involve highly varied sampling techniques. It is entirely possible that much of these data reflect residues averaged over entire above ground plants in the case of grass and forage sampling.

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

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

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

6.1.6 Spray Drift Modeling

It is unlikely that the same organism would be exposed to the maximum amount of spray drift from every application made. In order for an organism to receive the maximum concentration of norflurazon from multiple applications, each application of norflurazon would have to occur under identical atmospheric conditions (*e.g.*, same wind speed and same wind direction) and (if it is an animal) the animal being exposed would have to be located in the same location (which receives the maximum amount of spray drift) after each application. Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT model (*i.e*., it models spray drift from aerial and ground applications in a flat area with little to no ground cover and a steady, constant wind speed and direction). Therefore, in most cases, the drift estimates from AgDRIFT may overestimate exposure, especially as the distance increases from the site of application, since the model does not account for potential obstructions (*e.g*., large hills, berms, buildings, trees, *etc*.). Furthermore, conservative assumptions are made regarding the droplet size distributions being modeled 'ASAE Very Fine' for agricultural uses), the application method (*i.e*., aerial), release heights and wind speeds. Alterations in any of these inputs would decrease the area of potential effect.

6.2 Effects Assessment Uncertainties

6.2.1 Age Class and Sensitivity of Effects Thresholds

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

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

6.2.2 Use of Surrogate Species Effects Data

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

Guideline studies generally evaluate toxicity to ten crop species. These tests are typically conducted on herbaceous crop species only, and extrapolation of effects to wild herbaceous species or woody plants contributes uncertainty to risk conclusions. The primary goal of these studies is to determine effects on biomass and shoot length; effects on seed production or other reproductive mechanisms are not evaluated.

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

6.2.3 Sublethal Effects

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

6.2.4 Location of Wildlife Species

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

7.0 Risk Conclusions

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

Based on the best available information, the Agency makes a Likely to Adversely Affect determination for the CRLF from the use of norflurazon. Additionally, the Agency has determined that there is the potential for modification of CRLF designated critical habitat from the use of norflurazon. The potential effects, both direct and indirect, presented in this document are for all norflurazon use patterns. Although the application rate for alfalfa is considerably lower than for other use patterns, it can be applied twice, at an undefined interval, and it too exceeds the LOC in all of the same categories, such as direct chronic effects to the CRLF, as the other uses at higher rates of application.

A summary of the risk conclusions and effects determinations for the CRLF and its critical habitat, given the uncertainties discussed in Section 6, is presented in **Table 7.1** and **Table 7.2**.

Table 7.1 Effects Determination Summary for Norflurazon Use and the CRLF

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Survival, growth, and/or reproduction of CRLF individuals	LAA	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults): No effects to freshwater fish (as a surrogate to the aquatic-phase frog) that result in acute and/or chronic risk LOC exceedances
		Terrestrial-phase (Juveniles and Adults): Chronic effects to birds (as a surrogate to the terrestrial-phase frog) result in exceedance of the chronic risk LOC
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity No effects to freshwater invertebrates, fish or frogs or are expected. Effects to non-vascular aquatic plants result in exceedance of the LOC, and for locations proximal to ROWs, effects to vascular aquatic plants may occur.
		Terrestrial prey items, riparian habitat Chronic effects to small terrestrial vertebrates including mammals and terrestrial-phase amphibians (using birds as a surrogate), and effects to terrestrial plants, result in LOC exceedances

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

Table 7.2 Effects Determination Summary for Norflurazon Use and CRLF Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination [1]	Basis for Determination
Modification of aquatic-phase PCE	HM[1]	Effects to riparian vegetation (terrestrial plants) and aquatic nonvascular plants result in LOC exceedances. Exposure to aquatic vascular plants proximal to use on ROWs may be sufficient to elicit deleterious effects. These effects may indirectly affect the CRLF via reduction in food supply, changes in available cover, physical parameters of the waterbody *(e.g.* increase temperature or turbidity)
Modification of terrestrial-phase PCE		Effects to riparian vegetation (terrestrial plants) result in LOC exceedances, based on the seedling emergence study. Effects may result in changes in community composition or relative abundance of riparian plant species, possibly altering terrestrial – phase CRLF habitat

[1] Habitat Modification or No effect (NE)

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

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

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