Risks of Strychnine Use to:

Federally Threatened California Red-legged Frog
(*Rana aurora draytonii*)

California Tiger Salamander
(*Ambystoma californiense*)

CENTRAL CALIFORNIA DISTINCT POPULATION SEGMENT **Federally Threatened** AND SONOMA AND SANTA BARBARA COUNTY DISTINCT POPULATION SEGMENTS **Federally Endangered**

Federally Endangered San Joaquin Kit Fox
(*Vulpes macrotis mutica*)

Pesticide Effects Determinations

Environmental Fate and Effects Division
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1. 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), the California tiger salamander (*Ambystoma californiense*) (CTS), and the San Joaquin kit fox *(Vulpes macrotis mutica)* (SJKF) arising from FIFRA regulatory actions regarding use of strychnine on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitat for the CRLF, the CTS, and the SJKF. 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. Critical habitat has been designated for the CRLF.

The CTS was listed as a threatened species in 2004. The CTS occurs in the Santa Rosa area of Sonoma County, southern San Mateo County south to San Luis Obispo County, and the vicinity of northwestern Santa Barbara County. In the Central Valley and surrounding Sierra Nevada foothills and Coast Range, the species occurs from northern Yolo County (Dunnigan area) southward to northwestern Kern County and northern Tulare and Kings Counties. In the Federal Register notice (50-CFR 17) the USFWS (2004) listed the CTS as threatened rangewide. This listing was vacated by the U.S. District Court. The Sonoma and Santa Barbara Distinct Population Segments (DPSs) are currently listed as endangered while the Central California DPS is listed as threatened. Critical habitat has been designated for the CTS (USFWS, 2005).

The SJKF was listed as endangered by the USFWS on March 11, 1967. Its current range includes Alameda, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Monterey, San Benito, San Joaquin, San Luis Obispo, Santa Barbara, Santa Clara, Stanislaus, Tulare and Ventura counties in California. The SJKF inhabits a variety of habitats, including grasslands, scrublands, vernal pool areas, oak woodland, alkali meadows and playas, and an agricultural matrix of row crops, irrigated pastures, orchards, vineyards, and grazed annual grasslands. Critical habitat has not been designated for the SJKF.

Strychnine is a highly toxic, colorless crystalline alkaloid. Strychnine causes muscular convulsions and death through asphyxia and exhaustion. Its only labeled uses are restricted to the below-ground control of pocket gophers (*Thomomys* spp. and *Geomys* spp. in the US). The uses considered as part of the federal action are hand baiting and mechanical baiting of active burrows in California; these uses were evaluated in this assessment.

The acceptable environmental fate data are limited. Neither hydrolysis nor soil photolysis is a significant transformation pathway; no data are available for aqueous photodegradation. No acceptable metabolism data have been submitted to the Agency; qualitative information from the submitted studies suggest that aerobic degradation in soil can sometimes not occur, may be very slow, or can occur rapidly following a significant lag period under as yet undefined conditions. Due to the low vapor pressure and Henry's Law constant, strychnine is not expected to volatilize. Batch adsorption/desorption data demonstrate strychnine's strong binding to a number of soils. With the present use pattern of applying strychnine into specific below-ground burrows, leaching, spray drift, runoff, atmospheric transport, and volatilization are not potential transport mechanisms, and so are not quantitatively or qualitatively considered in the assessment. No monitoring data are available from either the U. S. Geological Survey's National Water Quality Assessment (NAWQA) program or the California Department of Pesticide Regulation.

The effects determination for each listed species assessed is based on a weight-of-evidence method that relies heavily on an evaluation of risks to each taxon relevant to assess both direct and indirect effects to the listed species and the potential for modification of their designated critical habitat (*i.e*., a taxon-level approach). Exposure of the listed species, their prey and their habitats to strychnine are assessed separately. Since strychnine is exclusively applied to below-ground burrows, runoff and spray drift are not expected to result in exposure to aquatic habitats, so no aquatic modeling was performed. Also, spray drift is not expected to result in exposure to aquatic or terrestrial habitats, so neither the AgDRIFT nor the AGDISP modeling were performed. The TerrPlant, T-REX, and T-HERPS models were not used to estimate strychnine exposures to terrestrial-phase animals and plants, because strychnine is neither applied as a foliar application nor as a traditional granular application. No degradates have been identified in any of the environmental fate data, so degradates were not considered in this assessment.

Usually risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. Strychnine is not used in a manner that lends itself to the calculation of an RQ. Therefore, risk is addressed qualitatively.

If a determination is made that the use of strychnine "may affect" the listed species being assessed and/or its designated critical habitat, additional information is considered to refine the potential for exposure and effects. 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) for each listed species assessed. For designated critical habitat, distinctions are made for actions that are expected to have "no effect" on a designated critical habitat from those actions that have a potential to result in "habitat modification."

Based on the best available information, the Agency makes a "May Affect, Likely to Adversely Affect" determination for the CRLF, the CTS, and the SJKF from the use of strychnine. Additionally, the Agency has determined that there is potential for modification of designated critical habitat for the CRLF and the CTS from use of the chemical.

Strychnine-treated bait is placed in underground burrows The CRLF and CTS are known to use burrows for shelter and so they may encounter the bait. Amphibians have permeable, non-scaly skin that is important for respiration; therefore, it can be presumed that the poison can be absorbed through amphibian skin. There is little expectation that strychnine can be inhaled because it is not expected to volatilize.

Pocket gophers plug the entrances to their burrows, which helps to protect them from carnivores. The SJKF is able to dig far enough to reach the gopher, but with more difficulty than would other predators. The gophers generally eat roots from within the burrow but may leave and forage near the entrance. During those time, the SJKF can dig into the burrow or prey on the gopher while it is outside the burrow. Since a SJKF would eat a gopher that had died in the burrow or was foraging on the surface, they could be exposed to strychnine. Schitoskey (1975) found that a kangaroo rat (*Dipodomys* sp.) killed with 12.8 mg of strychnine contained 10 times the LD_{50} for a desert kit fox (*Vulpes macrotis arsipus*) and killed the desert kit fox within 30 minutes.

A summary of the risk conclusions and effects determinations for each listed species assessed here and their designated critical habitat is presented in Tables 1.1 and 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 Effects of Strychnine on the CRLF, the CTS, and the SJKF.

Due to the nature of the application method, a meaningful estimation of exposure cannot be determined; thus RQs cannot be estimated.

Species	Effects Determination	Basis for Determination
California red-legged frog (*Rana aurora draytonii*) and **California tiger salamander** (*Ambystoma californiense*)	LAA	**Potential for Direct Effects** ***Aquatic-phase (Eggs, Larvae, and Adults using fish as a surrogate)***: Due to the current use pattern, no aquatic exposure is expected. Even if strychnine were used on ditchbanks or earthen dams it would be expected to reach aquatic environments at maximum estimated concentrations in the parts per trillion range, which is roughly 0.02 of the LOC for the most sensitive aquatic species tested. ***Terrestrial-phase (Juveniles and Adults using birds as a surrogate)***: Strychnine is highly toxic to birds on a subacute dietary basis (no acute oral data available). Dermal exposure to the bait is possible when the CRLF/CTS uses gopher burrows. Although dermal absorption in mammals may be very low; amphibians have thin, permeable skin. Therefore, it is assumed that it may be absorbed dermally and would also be highly toxic to terrestrial-phase amphibians. There is a potential for secondary poisoning through consumption of soil-dwelling/burrowing invertebrates that have either consumed the strychnine bait or are transporting/tracking it.

Table 1.1 Effects Determination Summary for Effects of Strychnine on the CRLF, the CTS, and the SJKF.		
Due to the nature of the application method, a meaningful estimation of exposure cannot be determined; thus RQs cannot be estimated.		
Species	**Effects Determination**	**Basis for Determination**
		Although exposures via dermal absorption and via consumption of invertebrates cannot be estimated, the potential exists for dermal exposure and consumption of invertebrates that have been in contact with the bait. Therefore, due to the high toxicity of strychnine, risk cannot be discounted.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity Due to the current use pattern, no aquatic exposure is expected. Even if strychnine were used on ditchbanks or earthen dams it would be expected to reach aquatic environments at maximum estimated concentrations are in the parts per trillion range, which is roughly 0.02 of the LOC for the most sensitive aquatic species tested.
		Terrestrial prey items There is a possible reduction in the amphibian prey base if there are a significant number of amphibians that utilize the gopher burrows and come in dermal contact with the bait. ***Potential Modification of Habitat*** It has been reported that some amphibians will use gopher burrows for resting and avoiding hot weather. The removal of pocket gophers will cause some burrows to become abandoned and unavailable to the amphibians for resting and shelter. California tiger salamanders spend much of their lives in underground retreats, often in burrowing mammal (ground squirrel, pocket gopher, and other burrowing mammal) burrows.
San Joaquin kit fox *(Vulpes macrotis mutica)*	LAA	**Potential for Direct Effects**
		The LD_{50} of strychnine is 0.75 mg/kg for the desert kit fox (*Vulpes macrotis arsipus*). SJKFs might receive a harmful or fatal dose of strychnine by eating a poisoned pocket gopher it dug out of its burrow or found above ground. One dose of bait contains from 43.2 mg to 65.7 mg of strychnine. Consumption of a kangaroo rat (*Dipodomys* sp.) killed with 12.8 mg of strychnine killed a desert kit fox within 30 minutes. A gopher with 12.8 mg of strychnine in its cheek pouches would carry enough poison to kill the fox. There is also a potential to secondary poisoning through consumption of soil-dwelling/burrowing invertebrates that have either consumed the strychnine bait or have been transporting/tracking it. Although exposures via consumption of pocket gophers and/or invertebrates cannot be estimated, due to the high toxicity and the potential for consumption of pocket gophers and/or invertebrates that have been in contact with the bait, risk cannot be discounted.
		Potential for Indirect Effects To the extent SJKF depend on gophers as a prey animal, the SJKF could be affected by their reduction in numbers.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis		
Designated Critical Habitat for:	**Effects Determination**	**Basis for Determination**
Due to the nature of the application method, a meaningful estimation of exposure cannot be determined; thus RQs cannot be estimated.		
California red-legged frog (*Rana aurora draytonii*) and **California tiger salamander** (*Ambystoma californiense*)	Habitat Modification	There is potential risk from dermal exposure in the gopher burrows and from consumption of terrestrial invertebrates that have been in contact with the bait. Due to the potential risk from dermal exposure, there is a possible reduction in the amphibian prey base. Finally, there is a potential loss of habitat following removal of pocket gophers (*e.g.*, some burrows will become abandoned and unavailable to the amphibians for resting and shelter).

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 listed species and its resources (*i.e.*, food and habitat) are not expected to be uniform across the action area.

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, CTS and SJKF life stages within the action area and/or applicable designated critical habitat. 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 assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, 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 species and potential modification to critical habitat.

2. Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. 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), the federally endangered SJKF (*Vulpes macrotis mutica*), and the federally threatened/endangered CTS (*Ambystoma californiense*)arising from FIFRA regulatory actions regarding use of strychnine to control burrow-dwelling rodents (specifically of the genus *Thomomys*) that are native to California. In addition, this assessment evaluates whether use on these sites is expected to result in modification of designated critical habitat for the CRLF and the Central California Distinct Population Segment (DPS) of the CTS.

Because the pesticide/pest relationship for strychnine is so different from conventional agricultural pesticides, the risk assessment is modified from EFED's standard risk assessment approach. A detailed description of the pest and the pesticide as used in California follows.

Use Profile

Strychnine is a Restricted Use rodenticide for the control of pocket gophers (the genus of concern in California is *Thomomys* – five species, with the valley pocket gopher *(T. bottae)* being most widespread). Strychnine is formulated as a bait composed of strychnine-treated grains (0.5% a.i. by weight on oats, milo, mixed grains or 1.8% by weight for a single CA SLN) and is lethal with a single feeding. Currently registered uses of Strychnine in California include both agricultural land and non-agricultural uses, which include public health treatments and structural treatments.

Habits of pocket gophers

Mounds of fresh soil are the best sign of gopher presence. Mounds are formed as the gopher digs its tunnel and pushes the loose dirt to the surface. Typical mounds are crescent- or horseshoe-shaped when viewed from above. The hole, which is off to one side of the mound, is usually plugged. Short, sloping lateral tunnels connect the main burrow system to the surface and are created during construction of the main tunnel for pushing dirt to the surface. The burrows are about 2-1/2 to 3-1/2 inches in diameter; feeding burrows (called main runways on labels) are usually 6 to 12 inches below ground, whereas the nest and food storage chamber may be as deep as 6 feet. Gophers seal the openings to the burrow system with earthen plugs.

Pocket gophers are herbivorous, feeding on a wide variety of vegetation, but generally preferring herbaceous plants, shrubs, and trees. Gophers use their sense of smell to locate food. Most commonly they feed on roots and fleshy portions of plants they encounter while digging. However, sometimes they feed above ground, venturing only a body length or so from their tunnel opening. Burrow openings used in this manner are called "feed holes." These are identified by the absence of a dirt mound and a circular band of clipped vegetation around the hole.

Application methods

Manual

Because lateral tunnels may not be revisited by the gopher, baiting in them is not as successful as in the main burrow. Access to the main runways can be made by excavating the earthen plug from the lateral tunnels until the main runway is reached and then applying the bait with a long spoon. A metal probe (Figure 2.1) can also be used to find the main burrows by probing about 8 to 12 inches from the plug side of the mound; it is usually located 6 to 12 inches deep[1]. When the probe penetrates the gopher's burrow, there will be a sudden, noticeable drop of about 2 inches.

[1] Illustration and descriptive text derived from Salmon, T. P., and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes.* Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385.

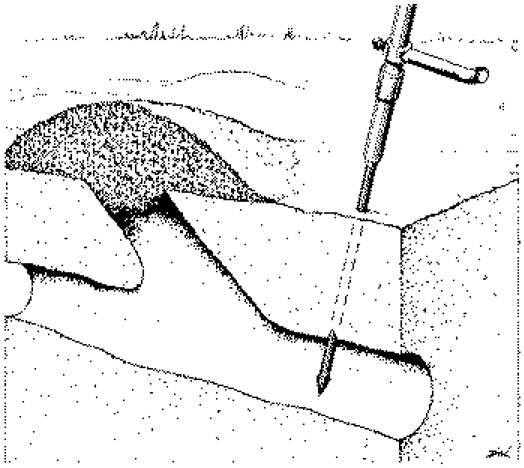


Figure 2.1. A gopher probe.

After locating the main gopher burrow, the opening is enlarged by rotating the probe or inserting a larger rod or stick. Following label directions, the bait is carefully placed in the opening using a spoon or other suitable implement that is used only for that purpose. (A funnel is useful for preventing spillage; any spilled bait is removed from the soil surface by burying it or gathering it up.) After placing the bait in the main burrow (approximately 1 teaspoon per hole), the lateral tunnel or probe hole is closed with sod, rocks, or some other material to exclude light and prevent dirt from falling on the bait. Several bait placements within a burrow system are made. Application rates for manual application range from 0.125 to 1 pounds bait per acre

Field-scale Equipment

Large-scale application to fields that have extensive pocket gopher populations at high densities can be made by tractor-operated mechanical burrow builder equipment[2]. Burrow builders (Figure 2.2) create tunnels through the soil by a "torpedo tube" and drop a measured amount of toxic grain bait into the newly-formed tunnels.

[2] Figure and descriptive text derived from Using Burrow Builders for Pocket Gopher Control. D.R. Virchow, S.E. Hygnstrom, and B.E. Anderson. NebGuide G03-1510. Published by University of Nebraska–Lincoln Extension. Institute of Agriculture and Natural Resources. ©2003

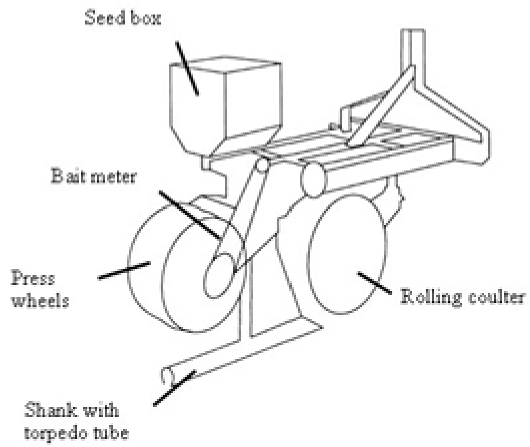


Figure 2.2. Basic parts of the burrow builder: 1) rolling coulter, 2) shank with torpedo tube, 3) bait box, 4) bait meter, 5) press wheel(s).

The machines are drawn by a tractor across the field where the tunnels intercept or come near the burrows of pocket gophers. The rolling coulter blade cuts surface trash and shallow roots ahead of the shank, and the bait is metered into the tunnel created by the torpedo tube. The press wheel closes the narrow slit at the top of the tunnel formed by the upper portion of the shank, taking care not to collapse the tunnel or to allow light to enter the tunnel. (Pocket gophers avoid light entering their burrows by blocking entrances with soil.) Pocket gophers subsequently, through their natural digging activities, intercept and enter the tunnels, and eat the toxic bait. Application rates for burrow builders range from 1 to 3 pounds bait per acre.

Ecological Risk Assessment

This ecological risk assessment has been prepared consistent with the settlement agreement in *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. This assessment also addresses the CTS and the SJKF for which strichnine was alleged to be of concern in a separate suit (*Center for Biological Diversity (CBD) vs. EPA et al.* (Case No. 07-2794JCS)).

In this assessment, direct and indirect effects to the CRLF, the SJKF, and the CTS and potential modification to designated critical habitat for the CRLF and the Central California DPS of the CTS are evaluated. The effects determinations for each listed species assessed is based on a weight-of-evidence method that relies heavily on an evaluation of risks to each taxon relevant to assess both direct and indirect effects to the listed species and the potential for modification of their designated critical habitat (*i.e.*, a taxon-level approach).

Screening level methods include use of standard exposure models, if appropriate, such as PRZM-EXAMS, T-REX, TerrPlant, AgDRIFT, and AGDISP, all of which are described at length in the Overview Document. 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).). However, since strychnine is applied to a burrow that is six to 12 inches below the surface of the ground, these exposure models were not used.

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 strychnine is based on an action area. The action area is the area directly or indirectly affected by the federal action. It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of strychnine 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, the SJKF, and the CTS and their designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached separately for each of the assessed species in the lawsuits regarding the potential use of strychnine in accordance with current labels:

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

The CRLF and the Central California DPS of the CTS have designated critical habitats associated with them. 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. Short descriptions of the PCEs for the CRLF and the CTS are presented in Table 2.5.

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

If a determination is made that use of strychnine "may affect" a listed species or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to each species and other taxonomic groups upon which these species depend (*e.g,* prey items). Additional information, including spatial analysis (to determine the geographical proximity of the assessed species' habitat and strychnine use sites) and further evaluation of the potential impact of strychnine 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 assessed listed species and/or result in "no effect" or potential modification to 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 strychnine is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for strychnine 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 strychnine that may alter the PCEs of the assessed species' critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the assessed species' designated critical habitat have been identified by the Services and are discussed further in Section 2.6.

2.2 Scope

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 strychnine in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment.

Although current registrations of strychnine allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of strychnine in portions of the action area that are reasonably assumed to be biologically relevant to the CRLF, the CTS, and the SJKF and their designated critical habitat. Further discussion of the action area for the CRLF, the CTS, and the SJKF and their critical habitat is provided in Section 2.7.

No degradates were identified for strychnine in the environmental fate studies submitted. Toxicity from degradates would not be of concern in any case, since strychnine is an acute poison.

The Agency does not routinely include in its risk assessments, an evaluation of mixtures of active ingredients, either those mixtures of multiple active ingredients in product formulations or those in the applicator's tank. In the case of the product formulations with multiple active ingredients each active ingredient is subject to an individual risk assessment for regulatory decision regarding the active ingredient on a particular use site.

If effects data are available for a formulated product containing more than one active ingredient, they may be used qualitatively or quantitatively in accordance with the Agency's Overview Document and the Services' Evaluation Memorandum (U.S., EPA 2004; USFWS/NMFS 2004).

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

2.3 Previous Assessments

"The above ground uses of strychnine were 'temporarily canceled' by EPA ([OPP-3900I7E; PH-FRL 2451-2] Federa1 Register VOL 48, No. 203 / Wednesday, October 19, 1983). Above ground uses of strychnine are canceled by a court order (April 11, 1988, U.S. District Court for the District of Minnesota in the case of *Defenders of Wildlife* v. *Administrator*, *EPA* . Civil No. 4-86-687) that enjoins EPA from continuing the registrations of Strychnine for above ground use. We believe that the danger from the below ground uses of Strychnine is minimal when used as directed. When the precautions recommended are taken, it does not constitute a threat to nontarget and endangered species."

In the disciplinary review of the 1996 Reregistration Eligibility Decision (RED) (USEPA, 1996a) EFED found that "The studies have demonstrated that the use of Strychnine above ground poses a threat to nontarget animals and may cause jeopardy to members of endangered, or threatened species...We believe that the danger from the below ground uses of Strychnine is minimal when used as directed. When the precautions as recommended are taken, it does not constitute a threat to nontarget or endangered species."

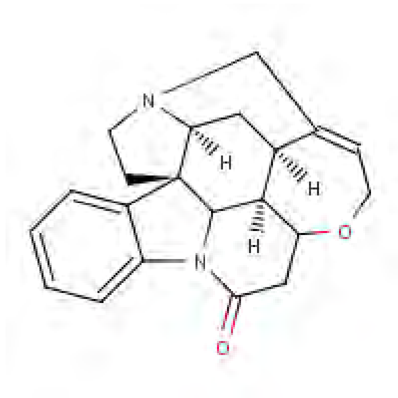
In a reevaluation of the use of strychnine in Canada, the Pest Management Regulatory Agency (2005) proposed that "the use of strychnine to control Northern pocket gophers, skunks, pigeons, wolves, coyotes and black bears does not represent an unacceptable risk to human health or the environment provided that the proposed mitigation measures are adopted." These uses include above ground poisoning.

2.4 Stressor Source and Distribution

Physical and Chemical Properties

Chemical name:	(4br,7as,8ar,13S,13ar,13bs)-5,6,7a,8,8a,11,13a,13b-octahydro-13H-13,14-ethano-7,9-methanooxepino(3,4-a)pyrrolo(2,3-d)carbazol-15-one
CAS No.:	57-24-9

Chemical structure:



Molecular formula:	$C_{21}H_{22}N_2O_2$.
Molecular weight:	334.40 g/mol
Physical state:	White crystalline powder.
Melting point:	273°C.
Solubility (20°C):	11.5 mg/L water
Dissociation constant (pKa):	8.26
Vapor pressure (20°C):	2.9×10^{-9} mm Hg
Henry's Law Constant:	6.0×10^{-14} atm m^3/mol
Octanol/Water Partition Coefficient:	0.9 at pH 5 4.0 at pH 7 114.0 at pH 9

2.4.1 Environmental Fate Properties

The acceptable environmental fate data are limited. Neither hydrolysis nor soil photolysis is a significant transformation pathway; no data are available for aqueous photodegradation. No acceptable metabolism data have been submitted to the Agency; qualitative information from the submitted studies suggest that aerobic degradation in soil can sometimes not occur, may be very slow, or can occur rapidly following a significant lag period under as yet undefined conditions. Batch adsorption/desorption data demonstrate strychnine's strong binding to a number of soils. With the present use pattern of applying strychnine into specific below-ground burrows, strychnine is not likely to reach ground or surface water.

Table 2.1 lists the environmental fate properties of strychnine.

Table 2.1. Summary of Strychnine Environmental Fate Properties

Study	Value (units)	Major Degradates *Minor Degradates*	MRID #	Study Status
Hydrolysis	Stable	None	41122301	Acceptable
Direct Aqueous	No data	--		No study submitted

Table 2.1. Summary of Strychnine Environmental Fate Properties				
Study	**Value (units)**	**Major Degradates** *Minor Degradates*	**MRID #**	**Study Status**
Photolysis				
Soil Photolysis	Stable	None detected	42973401	Acceptable
Aerobic Soil Metabolism	No acceptable data	--		Submitted studies invalid[1]
Anaerobic Soil Metabolism	No data	--		No study submitted
Anaerobic Aquatic Metabolism	No data	--		No study submitted
Aerobic Aquatic Metabolism	No data	--		No study submitted
$K_{d\text{-}ads}$ / $K_{d\text{-}des}$ (mL/g)	39-168		42366501	Acceptable
Terrestrial Field Dissipation	No data	--		No study submitted
Aquatic Field Dissipation	No data	--		No study submitted

[1]Aerobic soil metabolism studies did not determine material balances and did not identify degradates (MRIDs 42234201 and 43407601).

The strychnine molecule (parent) does not hydrolyze at pH 5, 7, or 9 (MRID 41122301). Strychnine is apparently stable to soil photolysis, since only a minimal amount of strychnine is transformed within the experimental period (30 days of irradiation with xenon light); no products of the transformation could be detected (MRID 42973401). The data indicate that strychnine is immobile; the parent is adsorbed to organic matter and clay. Using batch equilibrium techniques, strychnine had Freundlich K_{ads} in loamy sand, sandy loam, loam, and sandy clay loam soils of 39.79, 94.65, 118.87, and 168.97 mL/g, respectively; adsorption increased with increasing cation exchange capacity (CEC). Desorption (K_{des}) values were 55.0, 89.4, 114.6, and 146.1 mL/g for the loamy sand, the sandy loam, the loam, and the sandy clay loam soils, respectively (MRID 42366501).

2.4.2 Environmental Transport Mechanisms

Because strychnine is used only as a burrow-buried grain bait, surface water runoff and spray drift are not expected to be routes of exposure. Strychnine is not expected to volatilize, due to its low vapor pressure and Henry's Law Constant. In addition, soil-bound residues of strychnine are not expected to migrate to nearby or more distant ecosystems under subsurface application scenarios.

2.4.3 Mechanism of Action

Strychnine is a powerful convulsant. Glycine, an important inhibitory transmitter to motorneurons and interneurons in the spinal cord, is affected by strychnine. Strychnine acts as a selective competitive antagonist to block the inhibitory effects of glycine at all glycine receptors. The convulsant action of strychnine results from interference with postsynaptic inhibition normally mediated by glycine, causing excessive excitation that manifests itself as convulsions.

2.4.4 Use Characterization

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

Table 2.2 presents the current registered products, use sites, and application methods considered in this assessment. Strychnine use in California is currently limited to only below-ground application to control pocket gophers (*Thomomys* spp.).

Table 2.2 Strychnine Products allowed for use in California[1].

EPA Reg. No.	Product Name	% ai by wt	Use site	Application method
322-1	Fort Dodge Gopher Bait	0.5	Rangeland, pastures, cropland and non-ag areas	Burrow builder Probe-assisted manual applications, or manually operated bait-dispensing probes
641-1	Gopher-GO	0.5	Yard and garden areas around homes	Probe-assisted manual applications, or manually operated bait-dispensing probes
641-2	Gopher-GO AG Bait	0.5	Rangeland, pastures, cropland and non-ag areas	Burrow builder Probe-assisted manual applications, or manually operated bait-dispensing probes
814-4	Ro-Dex for Pocket Gophers	0.5	Outdoor residential areas including lawns	Long handled spoon only
909-2	Cooke Quick Action Gopher Mix	0.5	Outdoor residential areas including lawns	Long handled spoon only
4271-10	Pocket Gopher Bait containing strychnine 1-10 formulation on oats	0.5	Orchards, alfalfa fields, hay fields, pastures, rangelands, and noncrop areas.	Burrow builder Long handled spoon
4271-17	Pocket Gopher Bait containing strychnine 1-10 formulation on milo	0.5	Orchards, alfalfa fields, hay fields, pastures, rangelands, and noncrop areas.	Burrow builder Long handled spoon
5042-32	RCO Omega Gopher Grain Bait	0.5	Terrestrial food crops, and terrestrial nonfood and forestry areas	Long handled spoon Probe-assisted manual applications
5042-34	RCO Avalon Mixed Grain Gopher Bait	0.5	Rangelands, pastures, croplands, forests, and non-agricultural areas	Tractor-operated mechanical burrow builder Probe-assisted hand-held bait dispensers, or standard manual hand baiting techniques
10031-2	Petersen's Pocket Gopher Killer II for	0.5	Cropland, rangelands, and noncrop areas.	Mechanical burrow builder

Table 2.2 Strychnine Products allowed for use in California[1].				
EPA Reg. No.	Product Name	% ai by wt	Use site	Application method
	pocket gopher control only			Probe-assisted manual applications
10031-3	Petersen's Pocket Gopher Killer III for pocket gopher control only	0.5	Cropland, rangelands, and noncrop areas.	Mechanical burrow builder Probe assisted manual applications
10031-6	Petersen's Pocket Gopher Bait	0.5	Cropland, rangelands, and noncrop areas.	Mechanical burrow builder Probe-assisted manual applications Long handled spoon
35380-1	Elston Gopher Getter Bait	0.5	Rangelands, pastures, croplands, and non-agricultural areas	Mechanical burrow builders Probe-assisted manual applications
35380-3	G. G. Jr. Gopher Getter Bait	0.5	Rangeland, pastures, cropland and non-ag areas	Mechanical hand probe
36029-1	Wilco Gopher Getter Type-1 Bait	0.5	Yard and garden areas around homes	Applied manually
36029-7	Wilco Gopher Getter AG Bait	0.5	Rangeland, pastures, cropland and non-ag areas	Tractor-operated mechanical burrow builders, probe-assisted manual applications, or manually operated bait-dispensing probes
36029-16	Wilco Pocket Gopher Milo Bait for Hand Baiting	0.5	Rangeland, pastures, cropland and non-ag areas	Probe-assisted manual applications, or by use of manually operated bait-dispensing probes
53883-23	Martin's Gopher Bait 50	0.5	Rangelands, pastures, croplands and non-crop areas	Long handled spoon
53883-24	Martin's Gopher Bait 50	0.5	Rangelands, pastures, croplands and non-crop areas	Burrow builder Long handled spoon
56228-11	0.5% Strychnine Milo Pocket Gopher Bait for use in burrow builders	0.5	Rangelands, pastures, croplands, forests, and non-agricultural areas	Burrow builder only
56228-12	0.5% Strychnine Pocket Gopher Oat Bait for use in burrow builders	0.5	Rangelands, pastures, croplands, forests, and non-agricultural areas	Burrow builder only
56228-19	0.5% Strychnine Milo for Hand-Baiting Pocket Gophers	0.5	Rangelands, pastures, croplands, forests, and non-agricultural areas	Probe assisted manual applications Long handled spoon
56228-20	0.5% Strychnine on Oats for Hand-Baiting Pocket Gophers	0.5	Rangelands, pastures, croplands, forests, and non-agricultural areas	Probe assisted manual applications Long handled spoon
CA 79014500	Wilco Gopher Getter Restricted Use Bait 1.80% Bait	1.8	Rangeland, pastures, cropland, and nonagricultural areas	Tractor-operated mechanical burrow builders, probe-assisted manual applications, or manually operated bait-dispensing probes

1. Based on data supplied by BEAD (County-level Usage for Strychnidin; Strychnine; Triclopyr, butoxyethyl ester; Triclopyr, triethylamine salt; Diflubenzuron; Trifluralin; Thiobencarb; Chlorpyrifos; Vinclozalin; Iprodione in California in Support of a Red Legged Frog Endangered Species Assessment. J. Carter, BEAD/OPP. June 8, 2009).

No national map is available showing the estimated poundage of strychnine uses across the United States.

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information using state-level usage data obtained from USDA-NASS[3], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database[4]. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for strychnine by county in this California-specific assessment were generated using CDPR PUR data. Eight years (1999-2006) of usage data were included in this analysis. Data from CDPR PUR were obtained for every agricultural pesticide application made on every use site at the section level (approximately one square mile) of the public land survey system.[5] BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all eight years. The units of area treated are also provided where available.

The following analysis of the CDPR PUR data is a summarization of reported values, for the purpose of providing a characterization of the extent and nature of strychnine use in California. Based on the label information presented in Table 2.2, the only use sites for which strychnine-containing products are allowed for use in California are: outdoor residential areas (including lawns/yard and garden areas around homes) and rangelands, pastures, croplands, forests, and non-agricultural areas. Since the site names for which data are reported do not correspond exactly to the use sites allowed on the labels, reported data were grouped into Non-agricultural and Agricultural use sites based on the site names reported in the CALPUR data. The non-agricultural and agricultural use data were further grouped into broad categories to better show the sectors with the greatest usage.

Over the 8 years of data, a total of 12199.46 lbs of strychnine as active ingredient were applied to 745797.34 acres in 57 California counties. The most pounds of strychnine (3711.33, or 30.4%) were applied to the grouping Public Health sites (which also includes vertebrate control, structural pest control, fumigation other, and commodity fumigation). The predominant reported usage within that grouping was for vertebrate

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

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

[5] Most pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, and along roadside and railroad rights of way, and postharvest treatments of agricultural commodities. The primary exceptions to the reporting requirement are home-and-garden use and most industrial and institutional uses (http://www.cdpr.ca.gov/docs/pur/purmain.htm).

control; however, it is not possible to determine an average application rate in pounds per acre based on the data as reported.
There were no obvious trends in usage over the eight-year reporting timeframe.

A summary of Strychnine usage for all CDPR PUR use sites is provided below in **Table 2.3.**

Table 2.3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2006 for Currently Registered Strychnine Uses[1]

Site Name	Total Pounds Applied	Average Annual Pounds Applied [2]	Average Application Rate (lbs a.i./A)[2]	Maximum Application Rate (lbs a.i./A)
NON-AGRICULTURAL USES				
Public health (also includes vertebrate control, structural pest control, fumigation other, commodity fumigation)	3711.33	24.93	N/A[3]	0.066
Household/domestic dwellings/outdoor premises (Includes poultry, recreation area, landscape maintenance, animal premises)	2631.93	34.99	N/A[3]	1.5
Nonagricultural uncultivated areas/soils (Also includes water area, rights of way, ditchbank)	942.39	31.68	N/A[3]	0.18
Nursery plants (includes outdoor transplants, plants in containers, flowers; greenhouse; transplants, plants in containers, flowers; turf /sod)	9.53	0.11	0.006	0.208
Forest trees (Includes forest timberland, Christmas trees)	79.63	1.75	0.002	0.029
AGRICULTURAL USES				
Grapes, wine	1871.35	44.82	0.091	0.288
Agricultural uncultivated areas	125.16	11.53	0.044	0.738
Citrus (also includes oranges, tangerine, tangelo, lime, lemon, kumquat, grapefruit)	302.52	10.77	0.030	0.158
Vegetable crops (includes yam, watermelon, tomato, sweet potato, strawberry, squash, small fruits, pumpkin, potato, pepper, peas, lettuce, jojoba bean, herbs, cucumber, corn, celery, cantaloupe, broccoli, bean (all), asparagus)	12.19	0.05	0.015	0.18
Alfalfa	430.07	2.70	0.015	0.318
Nut orchards (includes walnut, pistachio, pecan, chestnut, almond)	1132.86	11.19	0.014	0.288
Orchards (includes orchard floor, nectarine, mango, olives, stone fruit, raspberry, prune, pomegranate, plum, persimmon, pear, peach, kiwi, fig, date, cherry, cherimoya, boysenberry, blueberry, avocado, apricot, apple, grapes)	901.77	4.10	0.009	0.450
Pastureland	8.59	0.07	0.009	0.120
Rangeland	1.54	0.02	0.008	0.060
Forage/fodder/hay (also includes oat forage/fodder, wheat forage/fodder, peas forage/fodder, corn forage/fodder)	6.72	0.10	0.008	0.029

Table 2.3 Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2006 for Currently Registered Strychnine Uses[1]				
Site Name	**Total Pounds Applied**	**Average Annual Pounds Applied [2]**	**Average Application Rate (lbs a.i./A)[2]**	**Maximum Application Rate (lbs a.i./A)**
Agricultural crops/soils (includes oats, wheat, research commodity, county ag comm., cotton, clover, barley, sugarbeet, soil fumigant preplant)	22.00	0.83	0.006	0.045

1. Based on data supplied by BEAD (County-level Usage for Strychnidin; Strychnine; Triclopyr, butoxyethyl ester; Triclopyr, triethylamine salt; Diflubenzuron; Trifluralin; Thiobencarb; Chlorpyrifos; Vinclozalin; Iprodione in California in Support of a Red Legged Frog Endangered Species Assessment. J. Carter, BEAD/OPP. June 8, 2009).
2. The average annual pounds applied was calculated as the weighted average of the average application rate for one county or average annual pounds applied for one county. The values reflect the average annual pounds applied to those sites across all counties and the average application rate for those sites across all counties.
3. Because of the nature of the application method or the sites treated insufficient info was provided from PUR data to calculate this value.

2.5 Assessed Species

Table 2.4 provides a summary of the current distribution, habitat requirements, and life history parameters for the listed species being assessed. More detailed life-history and distribution information can be found in **Attachments I, II, III, and IV**. See **Figure 2.3** for a map of the current range and critical habitat of the CRLF. See **Figure 2.4** for a map of the range and critical habitat of the CTS. See **Figure 2.5** for a map of the current range of the SJKF.

Table 2.4. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
California red-legged frog (*Rana aurora draytonii*)	Adult (85-138 cm in length), Females – 9-238 g, Males – 13-163 g; Juveniles (40-84 cm in length)	Northern CA coast, northern Transverse Ranges, foothills of Sierra Nevada, and in southern CA south of Santa Barbara	Freshwater perennial or near-perennial aquatic habitat with dense vegetation; artificial impoundments; riparian and upland areas	Yes	Breeding: Nov. to Apr. Tadpoles: Dec. to Mar. Young juveniles: Mar. to Sept.	Aquatic-phase[2]: algae, freshwater aquatic invertebrates Terrestrial-phase: aquatic and terrestrial invertebrates, small mammals, fish and frogs
San Joaquin kit fox (*Vulpes macrotis mutica*)	Adult ~2 kg	Alameda, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Monterey, San Benito, San Joaquin, San Luis Obispo, Santa Barbara, Santa Clara, Stanislaus, Tulare and Ventura counties	A variety of habitats, including grasslands, scrublands (*e.g.*, chenopod scrub and sub-shrub scrub), vernal pool areas, oak woodland, alkali meadows and playas, and an agricultural matrix of row crops, irrigated pastures, orchards, vineyards, and grazed annual grasslands. Kit foxes dig their own dens, modify and use those already constructed by other animals (ground squirrels, badgers, and coyotes), or use human-made structures .(culverts, abandoned pipelines, or banks in sumps or roadbeds). They move to new dens within their home range often (likely to avoid predation by coyotes)	No	Mating and conception: late December - March. Gestation period: 48 to 52 days. Litters born: February - late March Pups emerge from their dens at about 1-month of age and may begin to disperse after 4 – 5 months usually in Aug. or Sept.	Small animals including blacktailed hares, desert cottontails, mice, kangaroo rats, squirrels, birds, lizards, insects and grass. It satisfies its moisture requirements from prey and does not depend on freshwater sources.
California tiger salamander (*Ambystoma californiense*)	50 g	There are two distinct population segments; one in Santa Barbara County and the other in Sonoma County.	Freshwater pools or ponds (natural or man-made, vernal pools, ranch stock ponds, other fishless ponds); Grassland or oak savannah communities, in low foothill regions; Small mammal burrows	Yes	Emerge from burrows and breed: fall and winter rains Eggs: laid in pond Dec. – Feb., hatch: after 10 to 14 days Larval stage: 3-6 months, until the ponds dry out, metamorphose late spring or early summer, migrate to small mammal burrows	Aquatic Phase: algae, snails, zooplankton, small crustaceans, and aquatic larvae and invertebrates, smaller tadpoles of Pacific tree frogs, CRLF, toads; Terrestrial Phase: terrestrial invertebrates, insects, frogs, and worms

[1] For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see Attachments I, II, and III.

[2] For the purposes of this assessment, tadpoles and submerged adult frogs are considered “aquatic” because exposure pathways in the water are considerably different than those that occur on land.

Recovery Units

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

Core Areas

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

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

Figure 2.3. Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

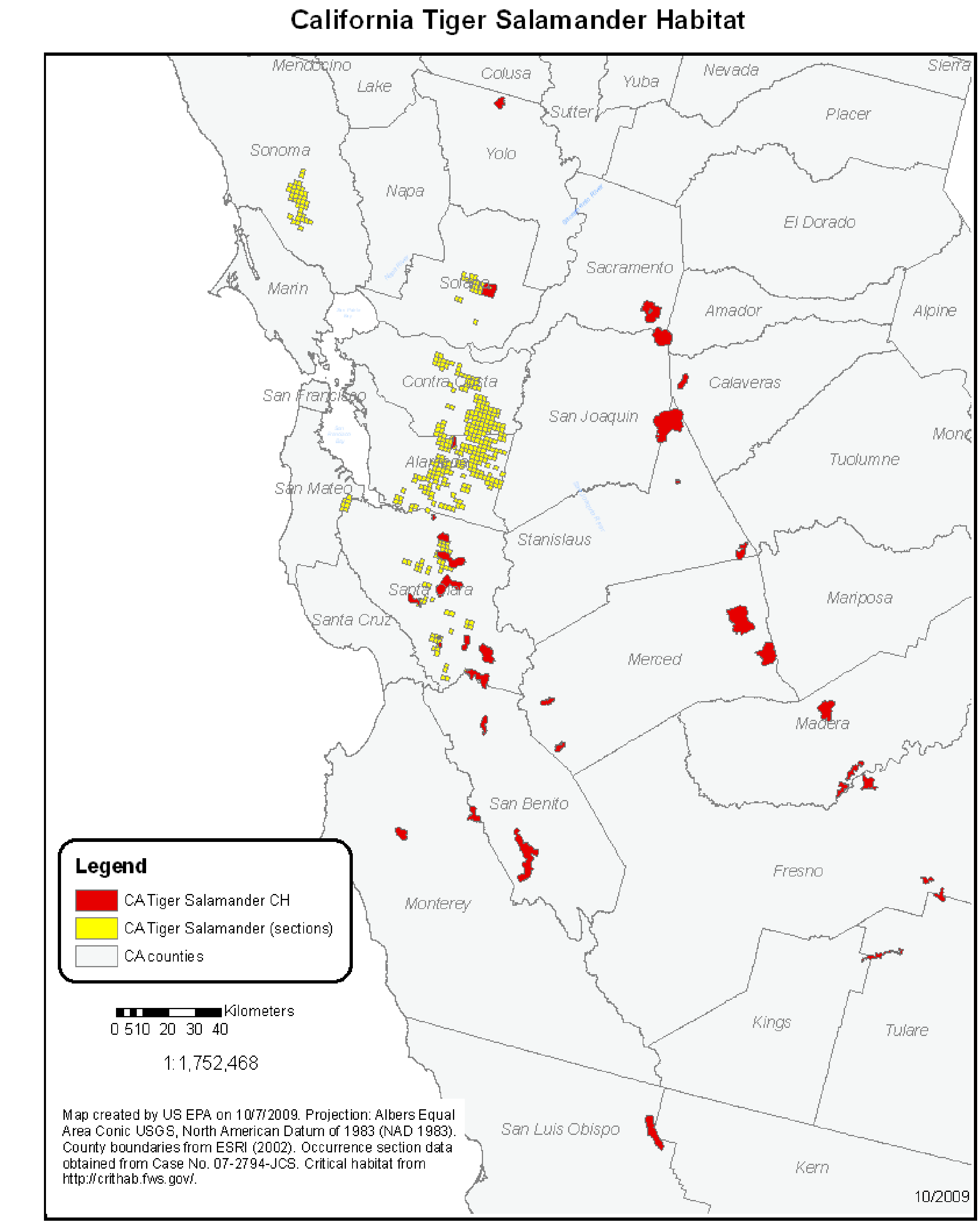

Figure 2.4. Range and Critical Habitat for CTS

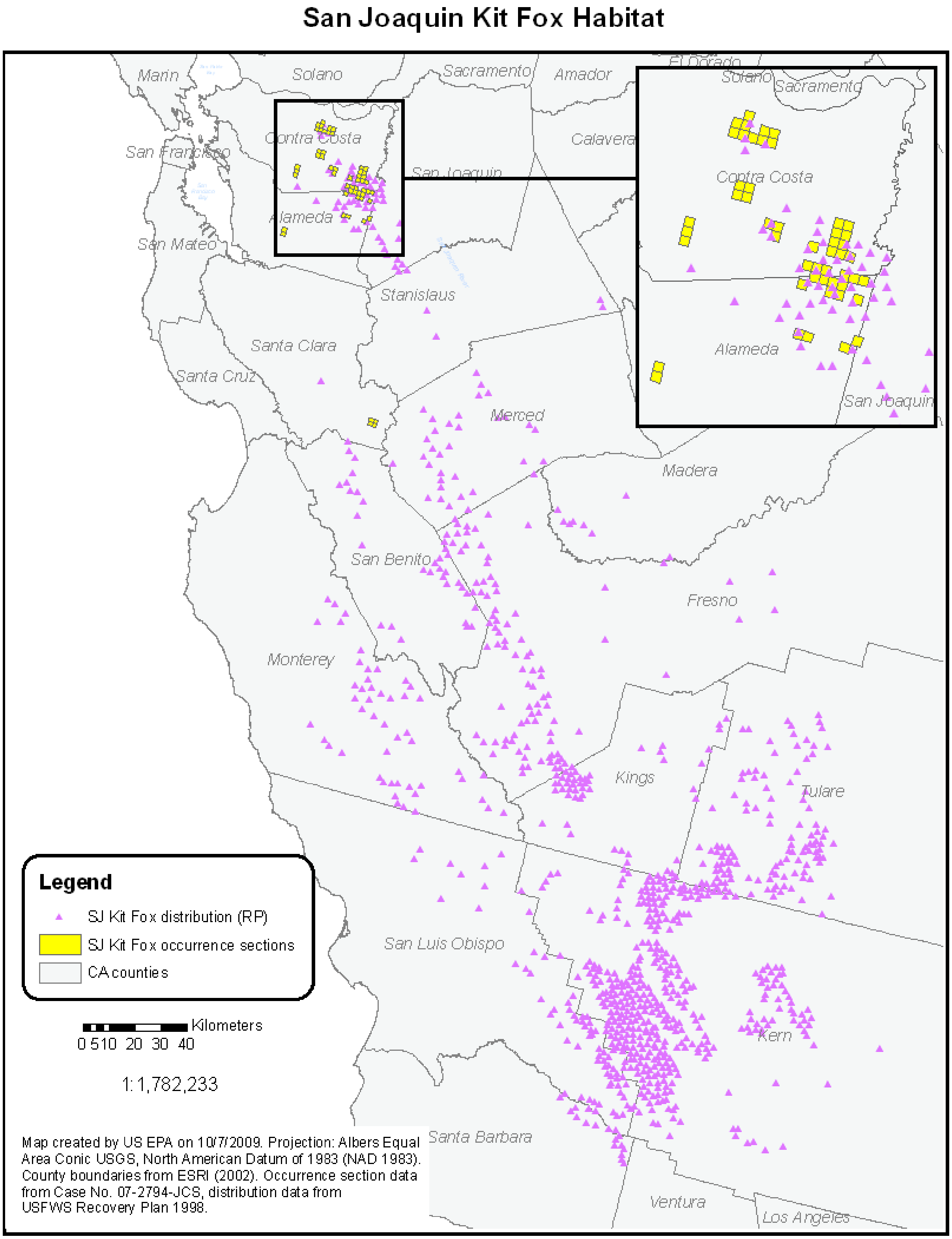

Figure 2.5. Current Distribution of the SJKF

2.6 Designated Critical Habitat

Critical habitat has been designated for the CRLF and the CTS. ‘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.’ Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be ‘essential to the conservation of the species.’ Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. **Table 2.5** describes the PCEs for the critical habitats designated for the CRLF and the CTS.

Table 2.5. Designated Critical Habitat PCEs for the CRLF and the CTS[1].

Species	PCEs	Reference
CRLF	Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond.	50 CFR 414.12(b), 2006
	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.	
	Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	
	Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	
	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	
CTS	Standing bodies of fresh water, including natural and man-made (*e.g.*, stock) ponds, vernal pools, and dune ponds, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (*i.e.*, 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle[2]	FR Vol. 69 No. 226 CTS, 68584, 2004
	Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation	
	Upland areas between breeding locations (PCE 1) and areas with small mammal burrows (PCE 2) that allow for dispersal among such sites	

[1] These PCEs are in addition to more general requirements for habitat areas that provide essential life cycle needs of the species such as, 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.

[2] PCEs that are abiotic, including, 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.

More detail on the designated critical habitat applicable to this assessment can be found in **Attachment I** (for the CRLF) and **Attachment III** (for the CTS). 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 strychnine that may alter the PCEs of the designated critical habitat for the CRLF and the CTS form the basis of the critical habitat impact analysis.

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 strychnine is expected to directly impact living organisms within the action area, critical habitat analysis for strychnine 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 strychnine is likely to encompass considerable portions of the United States based on the large array of agricultural and/or non-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, the SJKF, and the CTS and their designated critical habitat within the state of California. Although the watershed for the San Francisco Bay extends northward into the very southwestern portion of Lake County, Oregon, and westward into the western edge of Washoe County, Nevada, the non-California portions of the watershed are small. In addition, because of the nature of the application methods for strychnine (burial in rodent burrows) and its low mobility in soil, strychnine is expected to contribute a negligible amount from use in these areas, and so they are not considered as part of the action area applicable to this assessment.

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 strychnine. An analysis of labeled uses and review of available product labels was completed (Table 2.2). There is only one special local needs (SLN) use registered in California (CA) (Table 2.6):

Table 2.6 Special Local Needs (SLN) Registration for use in California.

EPA Reg. No.	Product Name	% ai by wt	Use site	Application method
CA79014500	Wilco Gopher Getter Restricted Use Bait 1.80% Bait	1.8	Rangeland, pastures, cropland, and nonagricultural areas	Tractor-operated mechanical burrow builders, probe-assisted manual applications, or manually operated bait-dispensing probes

For strychnine, the site names in **Table 2.7** are considered as part of the federal action evaluated in this assessment:

Table 2.7. Uses of Strychnine Considered as Part of the Federal Action Evaluated in this Assessment			
Site Name	**Maximum rate per application (lb bait / acre)**	**Maximum Number of Applications (per year)**	**Minimum Application Interval (days)**
Agricultural Uses[1]			
Agricultural crops/soils (unspecified)	1 lb bait treats 1 to 8 acres (hand treatment) 1 to 3 lb bait treats 1 acre (burrow builder)	Not specified	Not specified
Agricultural uncultivated areas			
Alfalfa			
Grass forage/fodder/hay			
Orchards (unspecified)			
Pastures			
Rangeland			
Non-Agricultural Uses[2]			
Forest trees (all or unspecified)	1 lb bait treats 1 to 8 acres (hand treatment) 1 to 3 lb bait treats 1 acre (burrow builder)	Not specified	Not specified
Nonagricultural uncultivated areas/soils			
Residential lawns	1 lb bait treats 1 to 8 acres (hand treatment)		
Household/domestic dwellings outdoor premises			

1 Table A2. Food/Feed Use Patterns Summary for Strychnine (Case 3133). Current as of 11/13/2008. LUIS Report generated 3/26/2009.

2 Table A3. Non-Food/Non-Feed Use Patterns Summary for Strychnine (Case 3133). Current as of 11/13/2008. LUIS Report generated 3/26/2009.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of strychnine 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. Based on the many and varied uses sites, and the widespread use of strychnine based on the CalPUR data, the initial area of concern is the entire state of California. The potential boundaries of the action area are usually determined by estimating the extent of offsite transport via spray drift and runoff; however, since strychnine is a bait used as burrow treatment, spray drift and runoff of strychnine residues will not occur.

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. Deriving the geographical extent of this portion of the action area is based on consideration of the types of effects that strychnine may be expected to have on the environment, the exposure levels to strychnine that are associated with those effects, and the best available information concerning the use of strychnine and its fate and transport within the state of California. Specific measures of ecological effect for the assessed species that define the action area include any direct and indirect toxic effect to the assessed species 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.

An evaluation of usage information was conducted to determine the area where use of strychnine may impact the assessed species. This analysis is used to characterize where predicted exposures are most likely to occur, but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed. These data suggest that strychnine has historically been used on a wide variety of agricultural and non-agricultural uses.

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."[6] Selection of the assessment endpoints is based on valued entities (*e.g.,* CRLF, the SJKF, and the CTS, organisms important in the life cycle of the assessed species, 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 strychnine (*e.g.*, runoff, spray drift, *etc*.), and the routes by which ecological receptors are exposed to strychnine *(e.g.*, direct contact, *etc.).*

2.8.1 Assessment Endpoints

Assessment endpoints for the CRLF, the SJKF, and the CTS include direct toxic effects on the survival, reproduction, and growth of individuals, 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 assessed species. 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.

[6] U.S. EPA (1992). Framework of 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 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect risks for each of the assessed species associated with exposure to strychnine is provided in Section 2.5 and **Table 2.6**.

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 do not include aquatic-phase amphibians, freshwater fish, freshwater invertebrates, or aquatic plants, because strychnine is not applied near water and is not expected to wash into water. It also did not include terrestrial plants, because strychnine is not applied to or near plants. The assessment did include birds (surrogate for terrestrial-phase amphibians), mammals, and terrestrial invertebrates. Acute (short-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on strychnine. No chronic (long-term) studies were found.

Table 2.8 identifies the taxa used to assess the potential for direct and indirect effects from the uses of strychnine for each listed species assessed here. The specific assessment endpoints used to assess the potential for direct and indirect effects to each listed species are provided in **Table 2.9**.

Table 2.8. Taxa Used in the Analyses of Direct and Indirect Effects for the Assessed Listed Species.

Listed Species	**Birds**	**Mammals**	**Terrestrial Invertebrates**
California Red Legged Frog	Direct Indirect (prey)	Indirect (prey)	Indirect (prey)
San Joaquin kit fox	Indirect (prey)	Direct Indirect (prey)	Indirect (prey)
California tiger salamander	Direct	N/A	Indirect (prey)

N/A = Not applicable

<table>
<tr><th colspan="4">Table 2.9. Taxa and Assessment Endpoints Used to Evaluate the Potential for the Use of Strychnine to Result in Direct and Indirect Effects to the Assessed Listed Species.</th></tr>
<tr><th>Taxa Used to Assess Direct and/or Indirect Effects to Assessed Species</th><th>Assessed Listed Species</th><th>Assessment Endpoints</th><th>Measures of Ecological Effects</th></tr>
<tr><td rowspan="2">1. Birds</td><td>Direct Effect
-Terrestrial-phase CRLF and CTS</td><td>Survival, growth, and reproduction of individuals via direct effects</td><td rowspan="2">1a. Most sensitive bird[a] or terrestrial-phase amphibian acute LC_{50} or LD_{50} (guideline or ECOTOX)
1b. Most sensitive bird[a] or terrestrial-phase amphibian chronic NOAEC (guideline or ECOTOX)</td></tr>
<tr><td>Indirect Effect (prey)
-SJKF</td><td>Survival, growth, and reproduction of individuals via indirect effects on terrestrial prey (birds)</td></tr>
<tr><td rowspan="2">2. Mammals</td><td>Direct Effect
-SJKF</td><td>Survival, growth, and reproduction of individuals via direct effects</td><td rowspan="2">2a. Most sensitive mammal acute LC_{50} or LD_{50} (guideline or ECOTOX)
2b. Most sensitive laboratory rat chronic NOAEC (guideline or ECOTOX)</td></tr>
<tr><td>Indirect Effect (prey/habitat from burrows)
-Terrestrial-phase CRLF and CTS
-SJKF</td><td>Survival, growth, and reproduction of individuals via indirect effects on terrestrial prey (mammals)</td></tr>
<tr><td>3. Terrestrial Invertebrates</td><td>Indirect Effect (prey)
-Terrestrial-phase CRLF
-SJKF</td><td>Survival, growth, and reproduction of individuals via indirect effects on terrestrial prey (terrestrial invertebrates)</td><td>3a. Most sensitive terrestrial invertebrate acute EC_{50} or LC_{50} (guideline or ECOTOX)
3b. Most sensitive terrestrial invertebrate chronic NOAEC (guideline or ECOTOX)</td></tr>
</table>

[a] 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 strychnine that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species 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 assessed species. 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 strychnine effects data are available.

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. Measures of ecological effect used to assess the potential for adverse modification to the critical habitat of the CRLF and the CTS are described in **Table 2.10**.

Table 2.10. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat for the CRLF and the CTS.			
Taxon Used to Assess Modification of PCE	**Assessed Listed Species Associated with the PCE**	**Assessment Endpoints**	**Measures of Ecological Effects**
1. Birds	Direct Effect -Terrestrial-phase CRLF and CTS	Survival, growth, and reproduction of individuals via direct effects	1a. Most sensitive bird[a] or terrestrial-phase amphibian acute LC_{50} or LD_{50} (guideline or ECOTOX) 1b. Most sensitive bird[a] or terrestrial-phase amphibian chronic NOAEC (guideline or ECOTOX)
2. Mammals	Indirect Effect (prey/habitat from burrows) -Terrestrial-phase CRLF and CTS	Modification of critical habitat via change in terrestrial prey (mammals)	2a. Most sensitive mammals acute LC_{50} or LD_{50} (guideline or ECOTOX) 2b. Most sensitive laboratory rat chronic NOAEC (guideline or ECOTOX)
3. Terrestrial Invertebrates	Indirect Effect (prey) -Terrestrial-phase CRLF and CTS	Modification of critical habitat via change in terrestrial prey (terrestrial invertebrates)	3a. Most sensitive terrestrial invertebrate acute EC_{50} or LC_{50} (guideline or ECOTOX) 3b. Most sensitive terrestrial invertebrate chronic NOAEC (guideline or ECOTOX)

[a] Birds are used as surrogates for terrestrial phase amphibians.

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 strychnine to the environment.

Because strychnine is used in California only as a bait that is placed in the underground burrows of pocket gophers, surface water runoff and spray drift are not expected to be routes of exposure. Strychnine is not expected to volatilize, due to its low vapor pressure and low Henry's law Constant. In addition, soil-bound residues of strychnine are not expected to migrate to nearby or more distant ecosystems via long-range atmospheric transport.

Effects on designated critical habitat in the CRLF and/or the CTS species' current ranges such as effects on primary productivity and/or cover provided by aquatic plants, and the composition of the aquatic and terrestrial plant communities, are not expected due to the insignificant potential for exposure of aquatic and terrestrial plants to strychnine.

Effects on designated critical habitat in the CRLF and/or the CTS species' current ranges such as a reduction or change in aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation) are not expected due to the insignificant potential for strychnine to reach aquatic systems.

The following risk hypotheses are presumed for each assessed species in this assessment.

The labeled use of strychnine within the action area may:

- directly affect the CRLF, the SJKF, or the CTS by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect the CRLF, the SJKF or the CTS or modify the designated critical habitat of the CRLF or CTS, by reducing or changing the composition of their food supply;

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies strychnine release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual model for the terrestrial phases of the CRLF, the SJKF, and the CTS is shown in **Figure 2.6**. Although the conceptual models for direct/indirect effects and modification of designated critical habitat PCEs are shown on the same diagram, the potential for direct/indirect effects and modification of PCEs will be evaluated separately in this assessment. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to the CRLF, the SJKF, and the CTS and modification to designated critical habitat is expected to be negligible.

Because there is an insignificant potential for aquatic exposure, a conceptual model for aquatic phases of the CRLF and the CTS is not presented.

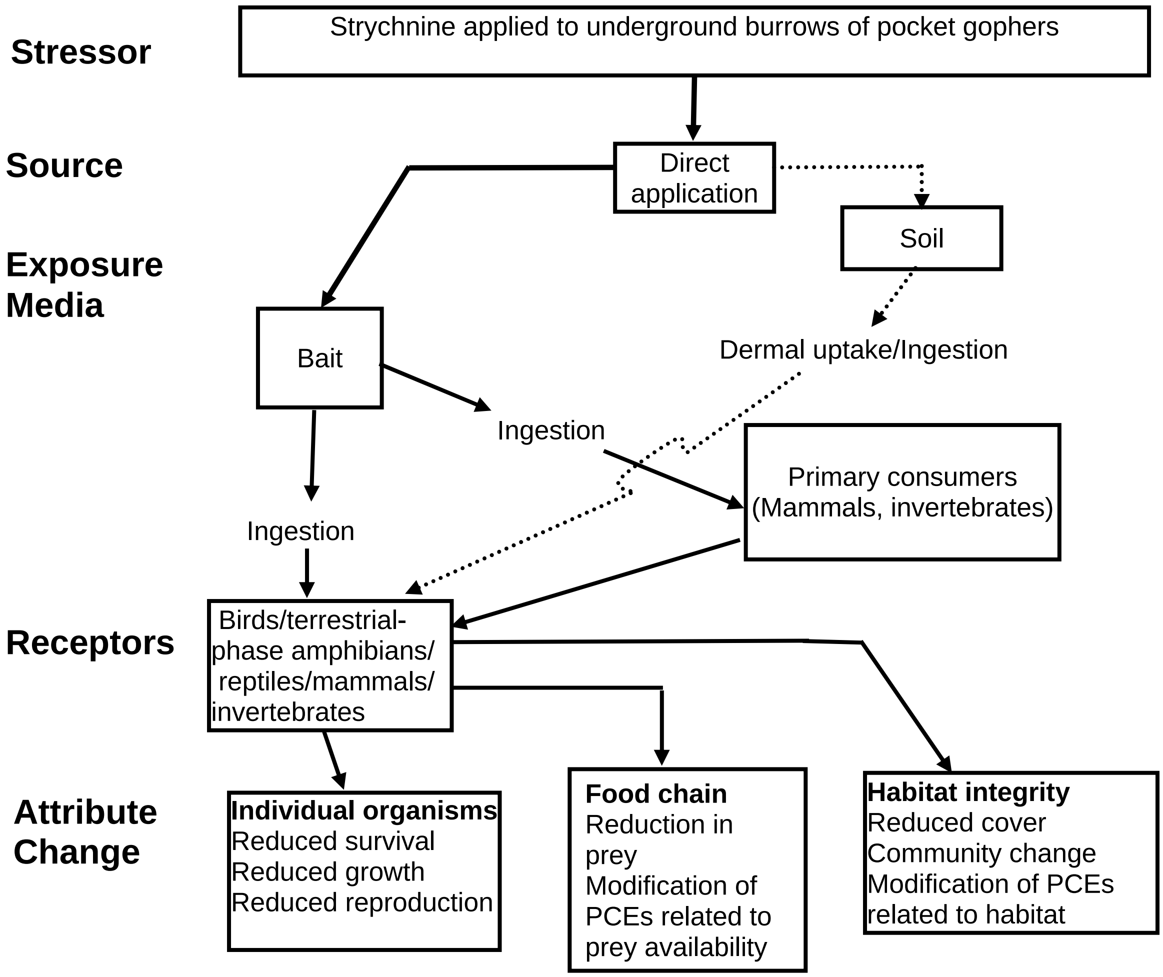

Figure 2.6. Conceptual Model for Terrestrial Phase of the CRLF, CTS, and SJKF.

2.10 Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the CRLF, the SJKF, and the CTS, prey items, and habitat is estimated based on a taxon-level approach. In the following sections, the use, environmental fate, and ecological effects of strychnine are characterized and integrated to assess the risks. Although this is usually accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach, the nature of the use profile requires a qualitative assessment of risk. This does not allow for an estimate of likelihood and/or magnitude of an adverse effect.

2.10.1 Measures to Evaluate the Risk Hypothesis and Conceptual Model

2.10.1.1 Measures of Exposure

The application methods for strychnine-containing products (burial in rodent burrows) indicate that runoff and spray drift will not be potential transport mechanisms of strychnine to the aquatic and terrestrial habitats of the CRLF, the SJKF, and the CTS. In addition, the low vapor pressure of strychnine in combination with no interaction with the above ground air indicate that atmospheric transport is unlikely. Therefore, measures of exposure based on aquatic models that predict estimated environmental concentrations (EECs) of strychnine are not applicable to strychnine, and so aquatic modeling was not performed. Exposure of terrestrial and wetland plants to strychnine is not expected, so TerrPlant modeling was not performed.

Direct dietary exposures of the CRLF, CTS and SJKF to strychnine bait were not calculated. Although they may be able to come into contact with the bait while either digging into the burrow or going into the burrow entrance while the gopher is on the surface, it is believed that the bait, which is formulated as a grain to attract rodents, would not attract amphibians or the fox. Direct dermal exposure to the CRLF and CTS was not calculated because there are no data available to predict skin absorption in amphibians. Direct dermal exposure for the SJKF was also not calculated because there are no dermal absorption data for mammals and because existing acute dermal data on mammals indicate that dermal absorption in mammals may be very low.

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, the CTS, and the SJKF. Data were obtained from registrant submitted studies. In addition, 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 and terrestrial-phase CTS makes the assumption that toxicity of strychnine to birds is similar to or less than the toxicity to terrestrial-phase amphibians and reptiles (this also applies to potential prey items).

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 assessed species and their 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 strychnine, and the likelihood of direct and indirect effects to the CRLF, the CTS, and the SJKF in terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. Exposure is not expected in aquatic habitats.

Usually risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. In the case of strychnine, the data are insufficient to calculate RQs. Strychnine is not used in such a manner that allows for a meaningful estimation of exposure. It is placed in burrows as a bait and buried so that only the target animal or animals that can enter the burrow, can reach it. There is no spray drift or runoff. The risk characterization will be based on a qualitative assessment of the effects of strychnine when used as a burrow treatment.

2.10.2 Data Gaps

In order to quantitatively evaluate the effect of strychnine-poisoned gophers on SJKFs, studies on secondary poisoning of predatory mammals that are fed rodents that have been killed with strychnine would need to be evaluated. No such studies were located nor are any scheduled to be conducted as data requirements under FIFRA to support registration.

3. Exposure Assessment

Strychnine is formulated as a bait composed of strychnine-treated grains (0.5 or 1.8 % a.i. by weight on oats, milo, mixed grains) for the control of pocket gophers (*Thomomys* spp. in California). The poisoned bait can be applied by hand to individual main runways of gopher burrows, or by tractor-operated mechanical burrow builder equipment.

3.1 Label Application Rates and Intervals

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

All strychnine product labels specify that the product is for underground use only. All agricultural labels for strychnine are identified as Restricted Use Pesticides, meaning that only certified applicators or persons under their supervision may apply them. Certified applicators have special training in using the pesticide, the presumption being that they will know and obey all of the handling instruction for the use of pesticides. In addition, there are extensive instructions on the labels regarding safety regulations.

Currently registered agricultural and non-agricultural uses of strychnine within California include orchards, alfalfa fields, hay fields, pastures, rangelands, cropland and noncrop areas and forestry areas. Non-agricultural uses include yard and garden areas around homes, and outdoor residential areas including lawns. The use rates being assessed are summarized in **Table 3.1**.

Table 3.1 Strychnine Use Rates Assessed for California[1]

Application Method	Max. Appl. Rate (lb a.i./acre)	Max. Number of Applications per Year
Long handled spoon; Probe-assisted manual applications; manually operated bait-dispensing probes (all uses)	0.00225 to 0.018	As needed
Burrow builder (where conditions allow)	0.018 to 0.054	As needed

1 Based on SLN CA 79014500

3.2 Aquatic Exposure Assessment

3.2.1 Modeling Approach

Because the nature of the application methods (direct subterranean application of strychnine-treated baits to main runway of rodent burrows followed by covering of treatment holes, or construction of artificial subterranean tunnels that intersect gopher-formed burrows using a burrow builder), the potential for aquatic exposure to strychnine by spray drift does not exist under currently labeled use conditions. Also, pocket gopher burrow depths of 6 to 12 inches lie below the extraction zone for surface water runoff as would be modeled in PRZM/EXAMS (4-cm depth).

Ditchbanks and earthen dams have been mentioned as likely sites for gopher control, since gopher tunnels may weaken these structures, causing water loss by seepage and piping through a bank or the complete loss or washout of a canal bank (Case and Jasch (in Hygnstrom, et al., 1994). In addition, ditchbank use of strychnine was reported four times in Ventura county in two years during the 1999-2006 reporting interval: a total of 0.0805 lb ai were applied to a total of 22 acres in 2004; a total of 0.0875 lb ai were applied to 25 acres in 2006 (CDPR PUR data). Since the ditchbank use may result in strychnine residues reaching adjacent water bodies in the event that bait is washed out of treated gopher burrows by water movement through a ditchbank, GENEEC was used to estimate possible aquatic exposure from this use of strychnine-containing products. Assumptions used were: three pounds per acre of strychnine bait (the maximum rate allowed for a product containing 1.8% strychnine w:w) was applied twice at the surface at a 7-day interval. Application at the surface is obviously a misuse of the product, but this exercise provides an upper limit of strychnine exposure. Based on those assumptions, a peak strychnine EEC in water in the ditches or behind the dams is 925 ppt (trillion). (Modeling results are presented in **Appendix A**.) The lowest aquatic endpoint is 0.76 ppm (fish LC_{50}), so the resulting RQ would be 0.00122, or roughly 41 times lower than the LOC for aquatic endangered species (0.05).

Aquatic exposure, even under these extreme model parameters, is such that it would result in a no effect determination. Therefore, no further aquatic analysis is performed for this assessment.

3.2.2 Existing Monitoring Data

As an additional line of evidence surface water, ground water and atmospheric monitoring data were sought. However, no monitoring data for strychnine were found. The sources queried for such data are discussed below.

3.2.2.1 USGS NAWQA Surface Water Data

The USGS NAWQA program (http://water.usgs.gov/nawqa) was queried for strychnine surface water data. Strychnine is not one of the analytes for the program, so no data were found.

3.2.2.2 USGS NAWQA Groundwater Data

The USGS NAWQA program (http://water.usgs.gov/nawqa) was queried for strychnine ground water data. Strychnine is not one of the analytes for the program, so no data were found.

3.2.2.3 California Department of Pesticide Regulation (CPR) Data

The California Department of Pesticide Regulation (CDPR) Surface Water Database (URL:http://www.cdpr.ca.gov/docs/emon/surfwtr/surfcont.htm) was queried for strychnine monitoring data. The monitoring data available through this web site were updated as of June 2008; no strychnine data were reported.

No ground water monitoring data were reported for California by the CDPR for strychnine (http://www.cdpr.ca.gov/docs/emon/grndwtr/list_mon.htm) nor is it listed to be added to the Ground Water Protection List (3CCR section 6800[b]; http://www.cdpr.ca.gov/docs/legbills/calcode/040101.htm#a6800).

3.2.2.4 Atmospheric Monitoring Data

No toxic air contaminant monitoring data were reported for California by the CDPR for strychnine (http://www.cdpr.ca.gov/docs/emon/pubs/tac/tacstdys.htm). In addition, no toxic air contaminant monitoring data have been reported for strychnine in general (Pesticides in the Atmosphere, M.S. Majewski and P.D. Capel. 1995. Volume One of the series Pesticides in the Hydrologic System. R.J Gilliom, Series Editor).

3.2.2.5 Other Sources of Monitoring Data

No ground water contaminant monitoring data have been reported for strychnine (Pesticides in Ground Water, J.E. Barbash and E.A. Resek. 1996. Volume Two of the series Pesticides in the Hydrologic System. R.J Gilliom, Series Editor). No surface water contaminant monitoring data have been reported for strychnine (Pesticides in Surface Waters, S.J. Larson, P.D. Capel, and M.S. Majewski. 1997. Volume Three of the series Pesticides in the Hydrologic System. R.J Gilliom, Series Editor)

3.2.3 Spray Drift Buffer and Downstream Dilution Analysis for Action Area

Because the nature of the application method (direct subterranean application of strychnine-treated baits to main runway of rodent burrows, followed by covering of treatment hole), the potential for exposure from spray drift does not exist under currently labeled use conditions for strychnine rodent baits, and as a result, spray drift modeling was not performed for this assessment. In addition, the potential for stream exposure does not exist under currently labeled use conditions for strychnine rodent baits, so the downstream dilution analysis was not performed for this assessment.

3.3 Terrestrial Animal Exposure Assessment

Direct exposure

Usually risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. Strychnine is not used in such a manner that allows for a meaningful estimation of exposure and therefore, RQs are not calculated. It is placed in burrows as a bait and buried. There is no spray drift or runoff.

In order to be exposed to strychnine, the SJKF, CRLF, and the CTS can dig down to the burrow or go into a burrow’s entrance while the gopher is on the surface. This would

give them access to the poison bait. Since the bait is composed of grain to attract rodents, it is believed that it would not attract amphibians or a fox. Therefore, direct dietary exposure to strychnine bait is a possibility, but it is believed to be minor and cannot be evaluated. As stated previously, direct dermal exposure to the CRLF and CTS resting in the burrows was not calculated because there are no data available to predict skin absorption in amphibians. In addition, direct dermal exposure for the SJKF was not calculated because there are no dermal absorption data for mammals and because existing acute dermal data on mammals indicate that dermal absorption in mammals is probably very low.
.
An assessment of terrestrial dietary exposure was not conducted because food items (plant foliage and seeds, flying and above ground insects) would not be exposed to strychnine baits.

Secondary and nontarget poisoning

As a qualitative assessment of terrestrial exposure from scavenging of poisoned carcasses, a rough estimate of the maximum amount of strychnine contained in a typical recommended dose of bait (one teaspoon) was calculated using the following assumptions:

1 gram (g) of bait contains 0.018 g strychnine (label info for CA 79014500; 1.8% w:w).

The bulk density of oat grains[7] (typical carrier for bait) is 0.48 g/cubic centimeter (cc). The bulk density of sorghum seed (also called milo; typical carrier for bait) is 0.73 g/cc.

One teaspoon is approximately 5 cc.

One teaspoon of oat grains is 0.48 g/cc x 5 cc = 2.4 g; one teaspoon of milo is 3.65 g.

One teaspoon of oat bait contains 2.4 g x 0.018 g strychnine/g bait; one teaspoon of milo bait contains 3.65 g x 0.018 g strychnine/g bait.

Therefore, one dose of bait contains from 43.2 mg to 65.7 mg of strychnine. Since a single dose is considered lethal (Salmon and Gorenzel, 2002), this amount of strychnine could persist in the tissues, the gut, or the external cheek pouches of a pocket gopher carcass and could be scavenged by the SJKF.

3.4 Terrestrial Plant Exposure Assessment

Since there is no above-ground exposure to strychnine, effects to plants are not expected. There is no evidence that roots of plants encountering bait in burrows take up the strychnine and transport it to the above-ground portions of the plant.

[7] Source of information on bulk density of grain: http://www.a-a-c-a.org/information/bulkdensity.pdf

4. Effects Assessment

This assessment evaluates the potential of strychnine to affect, directly or indirectly, the CRLF, SJKF and the CTS or to modify their designated critical habitat. As previously discussed in Section 2.7, assessment endpoints for the effects determination for each assessed species include direct toxic effects on the survival, reproduction, and growth, 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 each assessed species. Direct effects to the aquatic-phase CRLF and CTS are not assessed because aquatic exposure is not expected. Direct effects to the terrestrial-phase CRLF and CTS are based on avian toxicity data, given that birds are generally used as a surrogate for terrestrial-phase amphibians.

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 birds (used as a surrogate for terrestrial-phase amphibians), mammals and terrestrial invertebrates. 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 strychnine.

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). Data presented in this assessment were obtained from Registration Eligibility Documents, Data Evaluation Reports (registrant submitted data), Risk Evaluations, USFWS documents and ECOTOX information obtained on 02/28/2009. 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.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, 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 strychnine. The ECOTOX database was queried, and with the exception of an acute toxicity study with mammals, none of the open literature data provided more sensitive endpoints than those generated from the submitted guideline studies.

Citations of all open literature that were not considered as part of this assessment because they were either rejected by the ECOTOX screen or were accepted by ECOTOX but not used (*e.g.*, the endpoint was less sensitive) are included in **Appendix C. Appendix C** also includes a rationale for rejection of those studies either that did not pass the ECOTOX screen or were not utilized in this assessment for other reasons.

A detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sublethal endpoints is presented in **Appendix B**. **Appendix D** provides a summary of the human health effects data for strychnine.

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 strychnine. A summary of the available terrestrial ecotoxicity information, use of the probit dose response relationship, and the incident information for strychnine are provided in Sections 4.1 through 4.4, respectively.

Strychnine does not have any known toxic degradates and strychnine is not co-formulated with other toxicants.

4.1 Toxicity of Strychnine to Aquatic Organisms

Based on the use patterns in California, aquatic exposure to strychnine is not expected. Therefore, assessment of risk to aquatic organisms will not be conducted. However, the aquatic toxicity profile is provided below in **Table 4.1.**

Table 4.1 Aquatic Toxicity Profile for Strychnine

Assessment Endpoint	Acute/ Chronic	Surrogate Species	Toxicity Value LC50 (95% C.I.) ppm	Author, Date MRID	Acceptability
Freshwater fish and aquatic-phase amphibians					
Survival	Acute	Rainbow· trout *(Oncorhynchus mykiss)*	2.3 (1.7-3.2)	Bowman, 1989 41126501	Acceptable
	Acute	Bluegill sunfish *(Lepomis*	0.76 (0.61-0.96)	Bowman, 1989 41126502	Acceptable

		macrochirus)			
Reproduction and growth	Chronic	Waived			
Freshwater invertebrate					
Survival	Acute	Waterflea (*Daphnia magna)*	10 (8-12)	Forbis, 1989 41126503	Acceptable

4.2 Toxicity of Strychnine to Terrestrial Organisms

Table 4.2 summarizes the most sensitive terrestrial toxicity endpoints, based on an evaluation of both the submitted studies and the open literature. A brief summary of submitted data considered relevant to this ecological risk assessment for the CRLF, the CTS, and the SJKF is presented below. Based on the use patterns in California, exposure to terrestrial plants is not expected. Therefore, assessment of risk to terrestrial plants will not be conducted and the toxicity to terrestrial plants is not summarized in this document.

Table 4.2 Terrestrial Toxicity Profile for Strychnine

Assessment Endpoint	Acute/ Chronic	Surrogate Species	Toxicity Value	Effects	Author, Date MRID / ECOTOX	Acceptability
Avian						
Survival	Acute oral	Waived				
Survival	Subacute dietary	Bobwhite quail (*Colinus virginianus*)	LC_{50}: 3536 ppm NOAEC: 1250 ppm	Internal bleeding, pale liver, gaseous intestines, loss of reflexes, immobility, death	Pederson, 1989 41322602	Acceptable
		Mallard duck (*Anus platyrhynchos*)	LC_{50}: 212 ppm NOAEC: 78 ppm	Lethargy, loss of reflexes, muscle spasms, death	Pederson, 1998 41322601	Acceptable
Repro-duction	Chronic	Bob white quail (*Colinus virginianus*)	NOAEC: 1114/1200 ppm (highest measured/ nominal levels	None	Pederson, 1993 42716801	Acceptable
		Mallard duck (*Anus platyrhynchos*)	NOAEC not reported/ LOAEC: 33 ppm	No. of eggs chick wt, testes wt, adult wt	Pederson, 1993 42716802	Acceptable
Mammalian						
Survival	Acute oral	Desert kit fox *Vulpes macrotis arsipus*	LD_{50}: 0.75 mg/kg bw	Mortality	Schitoskey, 1975 E35428	Supplemental

Dietary	Subacute dietary	Red fox (*Vulpes fulva*)	LC_{50}: 70 (52-96) ppm	Mortality	4029650 Record/ 1987	Supplemental

Acute toxicity to terrestrial animals is categorized using the classification system shown in **Table 4.3** (U.S. EPA, 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4.3 Categories of Acute Toxicity for Avian and Mammalian Studies		
Toxicity Category	**Oral LD_{50}**	**Dietary LC_{50}**
Very highly toxic	< 10 mg/kg	< 50 ppm
Highly toxic	10 - 50 mg/kg	50 - 500 ppm
Moderately toxic	51 – 500 mg/kg	501 - 1000 ppm
Slightly toxic	501 - 2000 mg/kg	1001 - 5000 ppm
Practically non-toxic	> 2000 mg/kg	> 5000 ppm

4.2.1 Toxicity to Birds and Terrestrial-Phase Amphibians

As specified in the Overview Document, the Agency uses birds as a surrogate for terrestrial-phase amphibians when toxicity data for each specific taxon are not available (U.S. EPA, 2004).

In addition to the avian toxicity studies summarized in Table 4.1, a subacute dietary study was conducted on the black-billed magpie (*Pica pica*) and the American kestrel (*Falco sparverius*) (MRID 40815201). Strychnine was highly toxic in both species with LC_{50}'s of 99 and 234 ppm, respectively.

A field evaluation of strychnine (0.5, 1.15, and 1.8 % baits) to control the Valley pocket gopher *(Thomomys bottae)* was performed (MRID 42488601). Strychnine residues were found in the muscle tissue of the gophers; the mean was approximately 0.5 ppm and ranged as high as 5.4 ppm. It was also found in the gastrointestinal tract with a mean of approximately 5 ppm and as high as 35.8 ppm. There also was evidence of secondary poisonings, in that three dead vertebrates were found. Strychnine residues in a horned lark (*Eremophila alpestris*) were 0.3491 and 1.6133 ppm for the muscle tissue and gastrointestinal tract, respectively; for a brewer's blackbird (*Euphagus cyanocephalus*), residues were 0.5606 and 23.3283 ppm for the muscle tissue and gastrointestinal tract, respectively. A striped skunk (*Mephitis mephitis*) was also found, but it was not analyzed for strychnine.

A summary of the acute and chronic bird data used in this assessment was provided in Table 4.1.

4.2.2 Toxicity to Mammals

A summary of acute and chronic mammalian data, including data published in the open literature, is provided below in Sections 4.2.2.1 through 4.2.1.2.

4.2.2.1 Mammals: Acute Oral and Dietary Exposure Studies

Table 4.4 Acute Toxicity of Strychnine in Selected Mammalian Species				
Species	**Study Type**	**Endpoint**	**MRID, ECOTOX Reference or Citation Date**	**Study Classification**
Laboratory rat (*Rattus norvegicus)*	Acute oral	LD_{50} = 2.2 mg/kg	40908901	Supplemental
Striped skunk *(Mephitis mephitis)*	Acute mg per egg bait	LD_{100} = 3 mg/egg/skunk	4029650 Record 1987	Supplemental
Desert kit fox (*Vulpes macrotis arsipus*)	Acute oral	LD_{50} = 0.75 mg/kg	E35428 Schitoskey, 1975	Supplemental
European ferret *(Mustela putorius)*	Dietary 5-day	LC_{50} = 198 ppm	40296502 Record 1987	Supplemental
Red fox *(Vulpes fulva)*	Dietary 5-day	LC_{50} = 70 ppm (52-96)	40296503 Record 1987	Supplemental

These results show that strychnine is very highly toxic to small mammals on both an acute oral and dietary basis. Clinical signs of toxicity, including death, occurred within one hour. This is considered to be typical of strychnine. There was one open literature study that indicated a more sensitive acute oral endpoint for mammals than those observed in the submitted studies. This study (ECOTOX ref. no. E35428) reported an LD_{50} for another species of kit fox (*Vulpes macrotis arsipus*). The study is classified as supplemental because it had no control group and only used eight animals. The LD_{50} was 0.75 mg/kg.

4.2.2.2 Mammals: Chronic Exposure (Growth, Reproduction) Studies

No chronic data for mammals are available.

4.2.3 Toxicity to Terrestrial Invertebrates

No toxicity data are available for terrestrial invertebrates.

4.2.4 Toxicity to Terrestrial Plants

The use patterns state that the strychnine formulation is to be buried in rodent burrows. Since foliar deposition is not expected either from spray drift or direct deposition, no risk to terrestrial plants is expected. Therefore, no plant toxicity data are presented in this document.

4.2.5 Terrestrial Field Studies

A field efficacy study conducted with strychnine baits (0.5, 1.15, and 1.8 % w:w) to control the Valley pocket gopher *(Thomomys bottae)* was assessed (MRID# 42488601; USEPA, 1994). Strychnine residues were found in the muscle tissue of the gophers; the mean was approximately 0.5 ppm and ranged as high as 5.4 ppm. It was also found in the gastrointestinal tract with a mean of approximately 5 ppm and as high as 35.8 ppm. Three dead vertebrates were found: a horned lark (*Eremophila alpestris*), a brewer's blackbird (*Euphagus cyanocephalus*) and a striped skunk (*Mephitis mephitis*). Strychnine residues in the horned lark were 0.3491 and 1.6133 ppm for the muscle tissue and gastrointestinal tract, respectively and, for the brewer's blackbird they were 0.5606 and 23.3283 ppm for the muscle tissue and gastrointestinal tract, respectively. The skunk was not analyzed for strychnine residues. This study confirmed the possibility of secondary exposure (i.e., dead gophers were preyed upon by red-tailed hawks) and that direct exposure occurs to birds).

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

The chance of an individual event (*i.e*., mortality or immobilization) occurring is certain, because a single exposure to strychnine (one dose) is lethal. Therefore a probit dose response analysis was not conducted.

4.4 Incident Database Review

A review of the EIIS database for ecological incidents involving strychnine was completed in August 2009. A complete list of the incidents involving strychnine including associated uncertainties is included as **Appendix E**. Between 1981 and 1993 (before above-ground application was banned), 30 incidents were reported.

There have been 16 incidents since strychnine above-ground uses were banned (1994 to the present). One was classified as an accidental misuse and three were classified as intentional misuses. No incidents were attributed to the currently labeled uses for strychnine. In eleven poisonings, the certainty that strychnine was the responsible chemical was classified as "Highly Probable"; in five poisonings the certainty was "Probable". Nine of the incidents occurred in California.

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to the CRLF, the CTS, and the SJKF or for modification to their designated critical habitat from the use of strychnine in California. 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 assessed species or their designated critical habitat (*i.e*., "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect").

5.1 Risk Estimation

A quantitative estimation of risk is usually estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated. RQs are derived as quantitative estimates of potential high-end risk. In the case of strychnine use in California, RQs cannot be estimated. Strychnine is not used in a manner that allows for a meaningful estimation of exposure. It is placed in burrows as a bait and buried and there is no spray drift or runoff.

Acute and chronic risks to aquatic organisms and acute risks to terrestrial plants from strychnine are not expected. Acute and chronic risks to terrestrial animals are estimated qualitatively based on observations in submitted studies and the open literature.

5.1.1 Exposures in the Aquatic Habitat

Because the nature of the application method (direct subterranean application to main runway of rodent burrows, followed by covering of the treatment hole), surface waters are not expected to be exposed to runoff of strychnine residues. Therefore, the potential for aquatic exposure does not exist under currently labeled use conditions for strychnine rodent baits, and as a result, quantitative risk estimation for aquatic organisms was not conducted for this assessment. Due to lack of exposure, strychnine has no potential to directly affect the aquatic-phase CRLF and CTS. Additionally, there is no potential for indirect effects to those listed species that rely on freshwater fish, and/or aquatic-phase amphibians, freshwater invertebrates and aquatic plants during at least some portion of their life-cycle (*i.e*., CRLF and CTS).

5.1.2 Exposures in the Terrestrial Habitat

As stated in the aquatic exposure section, due to the nature of the application method, there is no direct foliar application. In addition, with the exception of the target species, no direct exposure to the bait itself is expected. There is no evidence of transport of strychnine through terrestrial plant roots to the leaves; thus, no exposure to terrestrial plants is expected. Therefore, the current models for estimating terrestrial exposure, T-REX (v. 1.4.1) and TERRPLANT (v. 1.2.2) cannot be used for a quantitative estimation of risk. Nevertheless, there is potential for direct dermal exposure (CRLF and CTS) while utilizing gopher burrows and secondary exposure through consumption of poisoned gophers (SJKF) and invertebrates (CRLF, CTS and SJKF) which have consumed the bait. Further discussion is found in the risk description (Section 5.2). Due to the possibility of secondary exposure and dermal absorption, strychnine has the potential to directly affect the terrestrial-phase CRLF and CTF and the SJFK. Strychnine has the potential to indirectly affect the terrestrial-phase CRLF and CTS through the reduction in gopher burrows (habitat) and the SJFK through the reduction in the small mammal prey base (gophers).

5.1.3 Primary Constituent Elements of Designated Critical Habitat

For strychnine use, the assessment endpoints for designated critical habitat PCEs involve the same endpoints as those being assessed relative to the potential for direct and indirect effects to the listed species assessed here. Therefore, the effects determinations for direct and indirect effects are used as the basis of the effects determination for potential modification to designated critical habitat.

5.2 Risk Description

The risk description synthesizes 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 assessed species and the potential for modification of their designated critical habitat.

A summary of the risk estimation results are provided in **Table 5.1** for direct and indirect effects to the listed species assessed here and in **Table 5.2** for the PCEs of their designated critical habitat.

Table 5.1. Risk Estimation Summary for Strychnine[1]

Taxa	Description of Results of Risk Estimation	Assessed Species Potentially Affected
Freshwater Fish and Aquatic-phase Amphibians	No aquatic exposure is expected.	Direct Effects: None
	No aquatic exposure is expected.	Indirect Effects: None
Freshwater Invertebrates	No aquatic exposure is expected.	Direct Effects: None
	No aquatic exposure is expected.	Indirect Effects: None
Vascular and Non-Vascular Aquatic Plants	No aquatic exposure is expected.	Direct Effects: None
	No aquatic exposure is expected.	Indirect Effects: None
Birds, Reptiles, and Terrestrial-Phase	Possible absorption of strychnine through the skin upon contact within the burrows.	Direct Effects: Terrestrial-phase CRLF and CTS

Table 5.1. Risk Estimation Summary for Strychnine[1]		
Taxa	**Description of Results of Risk Estimation**	**Assessed Species Potentially Affected**
Amphibians	Possible reduction in amphibian prey base due to absorption through skin upon contact with the bait within the burrows	Indirect Effects: Terrestrial-phase CRLF and CTS
Mammals	Secondary poisoning through consumption of poisoned gophers	Direct Effects: SJKF
	Possible reduction in prey base and gopher burrows (habitat)	Indirect Effects: Terrestrial-phase CRLF and CTS and SJKF
Terrestrial Invertebrates	Secondary poisoning through consumption of invertebrates that have consumed bait	Direct Effects: Terrestrial-phase CRLF and CTS and SJKF
	None	Indirect Effects: None
Terrestrial Plants – Monocots and Dicots	No exposure to terrestrial plants expected	Direct and Indirect Effects: None

[1] Direct and indirect effects RQs could not be calculated.

Table 5.2. Risk Estimation Summary for Strychnine – Effects to Designated Critical Habitat (PCEs)		
Taxa	**Description of Results of Risk Estimation**	**Species Associated with a Designated Critical Habitat that May Be Modified by**
Freshwater Fish, Aquatic-phase Amphibians, Invertebrates and Aquatic Vascular and Non-Vascular Plants	No aquatic exposure is expected.	None
Birds, Reptiles, and Terrestrial-Phase Amphibians	Possible reduction in amphibian prey based due to absorption through skin upon contact with the bait within the burrows	Terrestrial-phase CRLF and CTS
Mammals	Possible reduction in prey base and gopher burrows (habitat)	Terrestrial-phase CRLF and CTS and SJFK
Terrestrial Invertebrates	None	None

Table 5.2. Risk Estimation Summary for Strychnine – Effects to Designated Critical Habitat (PCEs)		
Taxa	**Description of Results of Risk Estimation**	**Species Associated with a Designated Critical Habitat that May Be Modified by**
Terrestrial Plants - Monocots and Dicots	No exposure to terrestrial plants expected	None

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 assessed species. 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 assessed species and its designated critical habitat.

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the assessed species or modify 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 assessed species and their designated critical habitat is provided in **Sections 5.2.1 through 5.2.2**. The effects determination section for each listed species assessed will follow a similar pattern. Each will start with a discussion of the potential for direct effects, followed by a discussion of the potential for indirect effects. For those listed species that have designated critical habitat, the section will end with a discussion on the potential for modification to the critical habitat from the use of strychnine.

5.2.1 The CRLF and CTS

5.2.1.1 Direct Effects

No aquatic exposure is expected. Therefore, there is no potential for direct effects to the aquatic-phase CRLF or CTS. For the terrestrial-phase CRLF and CTS, direct dietary exposure through consumption of the bait (if accessed from inside the burrow) is assumed to be negligible due to observed dietary habits in the field (see Table 2.4).

Dermal exposure to the bait is possible while the CRLF and particularly the CTS are resting in the gopher burrows. The Reregistration Eligibility Decision (RED) for strychnine (USEPA, 1996) indicates that based on the acute oral and acute dermal toxicity of strychnine in mammals, dermal absorption in mammals may be very low. However, amphibians have thin, permeable skin. There are currently no data nor models available to the Agency to predict the dermal absorption and/or dermal toxicity of strychnine with amphibians. Therefore, there is an uncertainty associated with the potential risk to amphibians following dermal exposure to strychnine. The subacute dietary LC_{50} to mallard ducks is 212 ppm. This classifies strychnine as highly toxic via the dietary route to birds, the surrogate for terrestrial-phase amphibians. There are no available avian acute oral toxicity data. Due to the fact that strychnine is highly toxic via the diet in birds, it is assumed that if dermally absorbed, it would also be highly toxic to terrestrial-phase amphibians.

There is a potential for secondary poisoning through consumption of soil-dwelling/burrowing invertebrates that have either consumed the strychnine bait or have been transporting/tracking it. The terrestrial-phase CRLF and CTS both consume terrestrial invertebrates. Again, there are neither data nor models to predict exposure to the bait from consumption of terrestrial invertebrates and associated strychnine either in or on the invertebrate. In the Final Rule for the status of the CTS, USFWS (2004) stated:

> "there may be potential for secondary exposure from this application method if estivating salamanders consume burrow-dwelling invertebrates that have ingested the treated grains. While no definitive risk assessment can be made for these possible exposures, we believe this application method would result in an increased risk for take of the CTS and should therefore be avoided whenever possible."

They were writing about anti-coagulants and the CTS, but the same reasoning would be applicable to strychnine and CRLF.

Based on the weight-of-evidence, there is a potential for direct effects to the terrestrial-phase of the CRLF and CTS, supported by the possibility of dermal absorption following contact within the gopher burrows and secondary poisoning through consumption of soil-dwelling/burrowing invertebrates that have been in contact with the bait. Although exposure cannot be estimated, due to the high toxicity, the potential for dermal exposure and consumption of invertebrates that have been in contact with the bait, risk cannot be discounted.

5.2.1.2 Indirect Effects.

Potential Loss of Prey

Terrestrial-phase CRLFs and CTS' feed on invertebrates, small fish, frogs, and small mammals (Jennings, et al 1997; Hayes and Tennant (1985)). There may be a possible reduction in the amphibian prey base if there are a significant number of amphibians that utilize the gopher burrows and come in dermal contact with the bait.

Potential Modification of Habitat

Elimination of Burrow Systems

It has been reported that some amphibians will use the gophers' burrows for resting and avoiding hot weather. The removal of pocket gophers will cause some burrows to become abandoned and unavailable to the amphibians for resting and shelter.

> "California tiger salamanders spend much of their lives in underground retreats, often in burrowing mammal (ground squirrel, pocket gopher, and other burrowing mammal) burrows. Therefore, widespread burrowing mammal control may pose threats to the salamander". (U.S. Fish and Wildlife Service. 2004).
>
> "This underground phase has often been referred to as estivation (the summertime equivalent of hibernation), but true estivation has never been observed, and fiber optic cameras in burrows have allowed researchers to witness salamanders actively foraging. . . . [T]he burrow complexes of various ground dwelling mammals are vitally important in the life cycle of the CTS. These burrows serve as shelters and estivation sites for the terrestrial adult and juvenile salamanders. In addition, the presence of these burrows near suitable water bodies may be critical for any water body to become a successful, long-term breeding site for the CTS." (USFWS, 2004).

Active ground-burrowing rodent populations probably are required to sustain CTS because inactive burrow systems become progressively unsuitable over time. Loredo *et al.* (1996) found that California ground squirrel burrow systems collapsed within 18 months following abandonment by, or loss of, the mammals. This probably applies to pocket gopher burrows as well.

The USFWS (2004) wrote

> "The baiting of pocket gopher burrows with strychnine would not cause modifications of the burrow system directly, but, in-so-far as the poisoning campaign is successful, it would leave the burrows vacant. Although there is no data on the subject, it is believed that a vacant burrow would collapse

because of the natural action of the weather and gravity. This would result in a significant loss of suitable sheltering and aestivation habitats."

5.2.1.3 Modification of Designated Critical Habitat

Based on the weight-of-evidence, there is a potential for the modification of CRLF and CTS designated critical habitat based on the potential for both direct and indirect effects discussed in the above sections 5.2.1.1 and 5.2.1.2. Due to the fact that the Action Area is the entire State of California, the areas of effect overlap with the assessed species' designated critical habitat. Modification to critical habitat is expected.

5.2.2 SJKF

5.2.2.1 Direct Effects

Based on the observed dietary habits in the field (see Table 2.4) and that there is no exposure to terrestrial plants, direct dietary exposure to strychnine is not expected.

The SJKF may be dermally exposed to strychnine in burrows. Again, the RED for strychnine (USEPA, 1996) indicates that based on the acute oral and acute dermal toxicity of strychnine in mammals, dermal absorption in mammals may be very low. Therefore, it seems unlikely it would be absorbed through the skin.

SJKFs might receive a harmful or fatal dose of strychnine by eating a poisoned pocket gopher dug out of its burrow or found above ground. Gophers can forage from below ground by pulling the roots of plants into their burrows, but they do leave their burrows to forage (Jones and Baxter, 2004). SJKFs have been reported to eat a wide variety of rodents and lagomorphs. Jones and Baxter (2004) report that many mammals, birds and reptiles prey on the gophers including the SJKF, but specific data are not given. A SJKF would eat a gopher that had died or was foraging on the surface. A rough estimate of the maximum amount of strychnine contained in a typical recommended dose of bait (one teaspoon) was calculated (see Section 3.3). One dose of bait contains from 43.2 mg to 65.7 mg of strychnine. Since a single dose is considered lethal (Salmon and Gorenzel, 2002), this amount of strychnine could persist in the tissues, the gut, or the external cheek pouches of a pocket gopher carcass and could be scavenged by the SJKF. The following studies support the assumption that when a single dose of bait is consumed by a pocket gopher, it could be lethal to the SJKF.

Schitoskey (1975) found that a kangaroo rat (*Dipodomys* sp.) killed with 12.8 mg of strychnine contained 10 times the LD_{50} for a fox and killed the desert kit fox within 30 minutes. A gopher with 12.8 mg of strychnine in its cheek pouches would carry enough poison to kill the fox.

A field evaluation of strychnine (0.5, 1.15, and 1.8 % baits) to control the Valley pocket gopher (*Thomomys bottae*) has been reviewed (MRID# 42488601). Strychnine residues were found in the muscle tissue; the mean was approximately 0.5 ppm and ranged as high as 5.4 ppm. It was also found in the gastro-intestinal tract with a mean of approximately 5 ppm and as high as 35.8 ppm. Secondary poisoning with strychnine rodenticide baits may depend on whether or not the stomach or intestines of the poisoned rodent are consumed by the kit fox.

Hegdal, Gatz, and Fite (1981) wrote that, "Hegdal and Gatz (1976) evaluated the secondary effects of underground strychnine baiting for pocket gophers. They found no indication of secondary poisoning among radio-equipped badgers, striped skunks, red foxes (*Vulpes vulpes*), or coyotes. Pocket gophers are the predominant prey item found in badger's scats (Sargeant and Warner, 1972; Lampe, 1976). Lampe (1976), Hegdal and Gatz, and Sargeant and Warner (1972) found that badgers spend considerable effort digging in pocket gopher burrows, apparently in search of food. Although pocket gopher remains are rare in skunk stomachs or fecal passages (R. Mead, per. Comm. *in* Hegdal and Gatz) and Sargeant and Warner (1972) indentified one skunk in California that died after consuming a pocket gopher that had been killed by a strychnine bait applied with a burrow-builder."

Evans, et al (1970) reported that cage- and field-strychnine poisoned jackrabbits were lethal to coyotes, but only when the stomach contents were eaten.

Wood (1965) reported possible secondary poisoning in two grey foxes and two coyotes found dead on a study area treated with strychnine bait for rodent control. "O.E. Stephl and E.C. Cates (unpublished data 1928) reported that no coyotes or badgers were found dead during a prairie dog control operation in Montana although they were observed feeding on the carcasses of dead prairie dogs. O.E. Stephl (unpublished data, 1925) reported 'a few' dead skunks in a strychnine baited area."

There is also a potential for secondary poisoning through consumption of soil-dwelling/burrowing invertebrates that have either consumed the strychnine bait or have been transporting/tracking it. Again, there are neither data nor models to predict exposure to the bait from consumption of terrestrial invertebrates and associated strychnine either in or on the invertebrate.

Based on the weight-of-evidence, there is a potential for direct effects to the SJKF through secondary poisoning by consumption of poisoned gophers and through consumption of soil-dwelling/burrowing invertebrates that have been in contact with the bait.

5.2.2.2 Indirect Effects.

Potential Loss of Prey

In the northern portion of their range, SJKF most commonly prey on California ground squirrels, cottontails (*Sylvilagus auduboni*), black-tail jackrabbits (*Lepus californicus*), pocket mice (*Perognathus* spp.), and kangaroo rats (*Dipodomys* spp.). Secondary prey taken opportunistically may include ground-nesting birds, reptiles, and insects.

McGrew (1979) quoted sources saying that the primary item in the kit fox diet is usually the most abundant nocturnal rodent or lagomorph in the vicinity of the den. Kangaroo rats *(Dipodomys* spp.*)* accounted for its distribution in California. Kangaroo rat remains occurred in over 80% of 52 *V. m. mutica* scats from Kern County, California, while rabbit remains *(Lepus, Sylvilagus)* occurred in 52%. In another study black-tailed jackrabbits *(Lepus califomicus)* made up over 94% of the food eaten by a family (two adults and five pups) of *V. m. nevadensis*.

Cypher, et al (2007) said kangaroo rats and ground squirrels are among the SJKF's prey. The USFWS (1998) said, "Diet varies geographically, seasonally and annually, based on abundance of prey. In the southern part of the range, one-third of the kit fox's diet consists of kangaroo rats (*Dipodomys* spp.), pocket mice (*Perognathus* spp.), white-footed mice (*Peromyscus* spp.) and other nocturnal rodents. In the northern portion of the range (San Joaquin, Alameda and Contra Costa counties), kit foxes most often prey on California ground squirrels (*Spermophilus beecheyi*). Kit foxes also prey on black-tailed hares (*Lepus californicus*), San Joaquin antelope squirrels (*Ammospermophilus nelsoni*), desert cottontails (*Sylvilagus audubonii*), ground-nesting birds and insects."

Therefore, there is a potential for reduction in the pocket gopher population, the target species, which is one of many potential prey item for the SJKF.

Potential Modification of Habitat

There is no potential modification of habitat for the SJFK.

5.2.2.3 Modification of Designated Critical Habitat

The SJKF does not have a designated critical habitat.

5.2.3 Spatial Extent of Potential Effects

5.2.3.1 Spray Drift

Because the nature of the application method (direct subterranean application of strychnine-treated baits to main runway of rodent burrows, followed by covering of treatment hole), terrestrial and aquatic habitats of concern are not expected to be exposed to strychnine residues from spray drift. As a result, spray drift modeling was not conducted for this assessment.

5.2.3.2 Downstream Dilution Analysis

Because the nature of the application method (direct subterranean application to main runway of rodent burrows, followed by covering of treatment holes), surface waters are not expected to be exposed to runoff of strychnine residues. Therefore, the potential for stream exposure does not exist under currently labeled use conditions for strychnine rodent baits, and as a result, the downstream dilution analysis was not conducted for this assessment.

5.2.3.3 Overlap between CRLF, CTS, and SJKF habitat and Spatial Extent of Potential Effects

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

6. Uncertainties

6.1 Exposure Assessment Uncertainties

6.1.1 Maximum Use Scenario

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

6.1.2 Aquatic Exposure Modeling of Strychnine

Because the nature of the application method (direct subterranean application to main runway of rodent burrows, followed by covering of treatment holes), strychnine-treated baits are not expected to be exposed to rainfall that would result in runoff of strychnine residues to surface water bodies. In addition, the strychnine on the treated baits in the burrow will not be exposed to sufficient percolating water to leach from the bait into groundwater, in particular since the material is strongly sorbed to soil.

Therefore, the potential for aquatic exposure is insignificant under currently labeled use conditions for strychnine rodent baits, and as a result, aquatic exposure modeling was not performed for this assessment.

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.

Strychnine is not expected to have effects that differ by age class.

6.2.2 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 area or adjacent areas where poisoned pocket gophers may be found. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the treatment area. In this case, strychnine is placed in a hole in the ground. It does not have drift or runoff. Therefore, the above assumptions have been modified to fit this particular assessment.

7. 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 Strychnine to the CRLF, CTS, and SJKF and their designated critical habitats.

Based on the best available information, the Agency makes a Likely to Adversely Affect determination for the CRLF, CTS and SJKF from the use of strychnine.

Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the CRLF and the CTS from the use of the chemical. Given the LAA determination for the CRLF and CTS, and potential modification of designated critical habitat for the CRLF and CTS, a description of the baseline status and cumulative effects for the CRLF is provided in **Attachment II** and the baseline status and cumulative effects for the CTS and SJKF is provided in **Attachment IV**.

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

Table 7.1 Effects Determination Summary for Effects of Strychnine on the CRLF, the CTS, and the SJKF.
Due to the nature of the application method, a meaningful estimation of exposure cannot be determined; thus RQs cannot be estimated.

Species	Effects Determination	Basis for Determination
California red-legged frog (*Rana aurora draytonii*) and **California tiger salamander** (*Ambystoma californiense*)	LAA	**Potential for Direct Effects** ***Aquatic-phase (Eggs, Larvae, and Adults using fish as a surrogate)***: Due to the current use pattern, no aquatic exposure is expected. Even if strychnine were used on ditchbanks or earthen dams, it would be expected to reach aquatic environments at maximum estimated concentrations in the parts per trillion range, which is roughly 0.02 of the LOC for the most sensitive aquatic species tested. ***Terrestrial-phase (Juveniles and Adults using birds as a surrogate)***: Strychnine is highly toxic to birds on a subacute dietary basis (no acute oral data available). Dermal exposure to the bait is possible when the CRLF/CTS uses gopher burrows. Although dermal absorption in mammals may be very low; amphibians have thin, permeable skin. Therefore, it is assumed that it may be dermally absorbed and would also be highly toxic to terrestrial-phase amphibians. There is a potential to secondary poisoning through consumption of soil-dwelling/burrowing invertebrates that have either consumed the strychnine bait or are transporting/tracking it. Although exposures via dermal absorption and via consumption of invertebrates cannot be estimated, the potential exists for dermal exposure and consumption of invertebrates that have been in contact with the bait. Therefore, due to the high toxicity of strychnine, risk cannot be discounted. **Potential for Indirect Effects** ***Aquatic prey items, aquatic habitat, cover and/or primary productivity*** Due to the current use pattern, no aquatic exposure is expected. If strychnine were to reach an aquatic environment after being used on ditchbanks or earthen dams, maximum estimated concentrations are in the parts per trillion range, which is roughly 0.02 of the LOC for the most sensitive aquatic species tested. ***Terrestrial prey items*** There is a possible reduction in the amphibian prey base if there are a significant number of amphibians that utilize the gopher burrows and come in dermal contact with the bait. ***Potential Modification of Habitat*** It has been reported that some amphibians will use the gopher burrows for resting and avoiding hot weather. The removal of pocket gophers will cause some burrows to become abandoned and unavailable to the amphibians for resting and shelter. California tiger salamanders spend much of their lives in underground retreats, often in burrowing mammal (ground squirrel, pocket gopher, and other burrowing mammal) burrows.
San Joaquin kit fox *(Vulpes macrotis mutica)*	LAA	**Potential for Direct Effects** The LD_{50} of strychnine is 0.75 mg/kg for the desert kit fox (*Vulpes macrotis arsipus*). SJKFs might receive a harmful or fatal dose of strychnine by eating a poisoned pocket gopher it dug out of its burrow or found above ground. One dose of bait contains from 43.2 mg to 65.7 mg of strychnine. Consumption of a kangaroo rat (*Dipodomys* sp.) killed with 12.8 mg of strychnine killed a desert kit fox within 30 minutes. A gopher with 12.8 mg of strychnine in its cheek pouches would carry enough poison to kill the fox. There is also a potential to secondary poisoning through consumption of soil-

Table 7.1 Effects Determination Summary for Effects of Strychnine on the CRLF, the CTS, and the SJKF.		
Due to the nature of the application method, a meaningful estimation of exposure cannot be determined; thus RQs cannot be estimated.		
Species	**Effects Determination**	**Basis for Determination**
		dwelling/burrowing invertebrates that have either consumed the strychnine bait or have been transporting/tracking it. Although exposures via consumption of pocket gophers and/or invertebrates cannot be estimated, due to the high toxicity and the potential for consumption of pocket gophers and/or invertebrates that have been in contact with the bait, risk cannot be discounted.
		Potential for Indirect Effects To the extent SJKF depends on gophers as a prey animal, the SJKF could be affected by their reduction in numbers.

Table 7.2 Effects Determination Summary for the Critical Habitat Impact Analysis		
Designated Critical Habitat for:	**Effects Determination**	**Basis for Determination**
Due to the nature of the application method, a meaningful estimation of exposure cannot be determined; thus RQs cannot be estimated.		
California red-legged frog (*Rana aurora draytonii*) and **California tiger salamander** (*Ambystoma californiense*)	Habitat Modification	There is potential risk from dermal exposure in the gopher burrows and from consumption of terrestrial invertebrates that have been in contact with the bait. Due to the potential risk from dermal exposure, there is a possible reduction in the amphibian prey base. Finally, there is a potential loss of habitat following removal of pocket gophers (*e.g.*, some burrows will become abandoned and unavailable to the amphibians for resting and shelter.

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 listed species and its resources (*i.e*., food and habitat) are not expected to be uniform across the action area. 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, the SJKF, and the CTS life stages within the action area and/or applicable designated critical habitat. 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 assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, 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 species and potential modification to critical habitat.

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