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Spinosad Bait Spray Applications

Nontarget Risk Assessment, October 2003

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I. Introduction

The fruit flies of the family Tephritidae include several species that are major pests of agriculture throughout the world and that represent a serious threat to U.S. agriculture. The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), in cooperation with other Federal and State organizations, has conducted a number of programs to eradicate some species of fruit flies when these insect pests have been introduced. There have also been several cooperative programs with other countries to eliminate fruit fly infestations that could pose pest risks from introduction to the United States. These programs generally have employed an integrated pest management approach to eradication. Historically, many programs have involved application of malathion bait spray to effectively lower fly populations in the infested area followed by release of sterile flies. This approach has generally been very effective. Aerial applications of the bait spray over populated areas to control infestations of fruit flies have been controversial. Concerns about adverse health effects from exposure to malathion bait spray have been raised by residents of treated neighborhoods. Concerns have also been raised about effects on water quality and nontarget organisms.

As part of APHIS' ongoing effort to seek effective alternatives that pose less risk to public health and the environment, trial tests are periodically conducted with chemicals that show promise for control and appear to pose lower risk to the human environment. Research on potential program insecticides ensures that the safest and most effective control strategies can be determined for future eradication efforts. Analysis of applications of bait spray using spinosad against fruit flies indicates that its use causes less adverse environmental impacts than other effective eradication pesticides. Spinosad is a mixture of macrocyclic lactones produced by the soil actinomycete fungus, *Saccharopolyspora spinosa*. The insecticidal action of spinosad occurs through dermal exposure or ingestion and is particularly effective against feeding stages of butterflies, moths, and flies. The low application rate (0.00025 pounds active ingredient (a.i.) per acre) minimizes nontarget exposure. The formulated bait includes sugars and attractants diluted in water.

This risk assessment analyzes the potential risk of adverse effects to human health, wildlife, and environmental quality from the application of the spinosad bait spray formulation. Risk assessment of one bait, Nulure®, was presented in the Medfly Cooperative Eradication Program Final Environmental Impact Statement—1993 (USDA, APHIS, 1993). Nulure® is considered safe to animals, birds, and fish (Miller Chemical & Fertilizer Corporation, undated). The present formulation used in programs is GF-120 NF Naturalyte Fruit Fly Bait®. The bait used in this formulation contains about 2.5% ammonium acetate and this concentration of ammonium acetate (in excess of 1%) has been shown to repel some nontarget species including bees (Rendon et al., 2000) . This risk assessment will focus on potential effects of the active spinosyn factors in spinosad, but will acknowledge the influence of the repellant nature of the bait on exposure and toxicity, where applicable to nontarget risk.

II. Hazard Analysis of Active Ingredients

Spinosad is a mixture of compounds (spinosyns) produced naturally by the actinomycete fungus, *Saccharopolyspora spinosa*. Applications of spinosad are registered for use on various crops, and spinosad has permanent tolerances for some fruits (including citrus), nuts, vegetables, cotton, and meat. The active ingredients in spinosad are spinosyn A and spinosyn D.

Qualitative data regarding the lures and attractants have been described in the Human Health Risk Assessment APHIS Fruit Fly Programs (SERA, 1992) and in the chemical background statement on attractants (Labat-Anderson, 1992). These reviews of the lures and attractants describe the known effects thoroughly. These chemicals pose low hazards and no further description of the low hazards from these compounds is provided except as it relates to attraction, repulsion, and exposure of certain species to the active ingredients in spinosad.

The U.S. Environmental Protection Agency (EPA) has established toxicity categories based upon the median lethal dose (LD_{50}) for humans and terrestrial organisms and on the median lethal concentration (LC_{50}) for aquatic organisms. The terminology associated with these categories, as defined in table 2–1, is used throughout this document.

Table 2–1. EPA Toxicity Categories

Category	Criteria
Terrestrial (mg toxicant/kg body weight)	
Severely toxic	$LD_{50} \leq 50$
Moderately toxic	$50 < LD_{50} \leq 500$
Slightly toxic	$500 < LD_{50} \leq 5{,}000$
Very slightly toxic	$5{,}000 < LD_{50} \leq 50{,}000$
Aquatic (mg toxicant/L water)	
Very highly toxic	$LC_{50} \leq 0.1$
Highly toxic	$0.1 < LC_{50} \leq 1.0$
Moderately toxic	$1.0 < LC_{50} \leq 10$
Slightly toxic	$10 < LC_{50} \leq 100$
Practically non-toxic	$LC_{50} > 100$

A. Human Health

Spinosad is a mixture of compounds (macrocyclic lactones referred to as spinosyns) produced naturally by the actinomycete fungus, *Saccharopolyspora spinosa*. Applications of spinosad are registered for use on various crops and has permanent tolerances for some fruits (including citrus), nuts, vegetables, cotton, and meat.

Acute toxicity of spinosad is low by all routes of exposure. Spinosad is of very slight acute oral toxicity to mammals. The acute oral median lethal dose (LD_{50}) to rats is greater than 5,000 milligrams (mg) of spinosad per kilogram (kg) body weight (Dow Agrosciences, 1998; EPA, 1998a). The acute dermal LD_{50} to rats is greater than 2,800 mg/kg. The acute inhalation median lethal concentration (LC_{50}) to rats is greater than 5.18 mg per liter (L). Primary eye irritation tests in rabbits showed slight conjunctival irritation. Primary dermal irritation studies in rabbits showed slight transient erythema and edema. Spinosad was not found to be a skin sensitizer.

Subchronic and chronic studies of spinosad also indicate low hazard. The systemic NOEL for spinosad from chronic feeding of dogs was determined to be 2.68 mg/kg/day (EPA, 1998a). The LOEL for this study (8.22 mg/kg/day) was based upon vacuolated cells in glands (parathyroid) and lymphatic tissues, arteritis, and increases in serum enzymes. No studies found any evidence of neurotoxicity or neurobehavioral effects. A neuropathology NOEL was determined to be 46 mg/kg/day for male rats and 57 mg/kg/day for female rats. No evidence of carcinogenicity was found in chronic studies of mice and rats. EPA has classified the carcinogenic potential of spinosad as Group E—no evidence of carcinogenicity (EPA, 1998b).

There has been no evidence of mutagenic effects from spinosad (EPA, 1998a). Tests have been negative for mouse forward mutations without metabolic activation to 25 µg/ml and with metabolic activation to 50 µg/ml. No increases in chromosomal aberrations in Chinese hamster ovary cells were observed without activation to 35 µg/ml or with activation to 500 µg/ml. No increase in frequency of micronuclei in bone marrow cells of mice were found for 2-day exposures of spinosad up to 2,000 µg/ml. No unscheduled DNA synthesis was observed in adult rat hepatocytes in vitro at concentrations of spinosad as high as 5 µg/ml.

Reproductive and developmental toxicity studies have found that these effects occur only at doses that exceed those which cause other toxic effects to the parent animal. The reproductive NOEL from a 2-generation study of rats was determined to be 10 mg/kg/day with a LOEL of 100 mg/kg/day based upon decreased litter size, decreased pup survival, decreased body weight, increased dystocia, increased vaginal post-partum bleeding, and increased dam mortality (EPA, 1998a).

The primary active ingredients in spinosad are spinosyn factor A and spinosyn factor D. All other substances in the formulated products of spinosad are of lower toxicity. Spinosyns are relatively inert and their metabolism in rats results in either parent compound or N- and O-demethylated glutathione conjugates as excretory products (EPA, 1998a). Studies have found that 95 percent of the spinosad residues in rats are eliminated within 24 hours.

The regulatory reference value or RRV selected for spinosad is 0.027 mg/kg/day for the general population and 0.27 mg/kg/day for occupational exposures (table 2–2). The RRV is intended to be a program-specific exposure reference used to assess the need to mitigate human health risks from program pesticide applications. Exposures determined to be less than the RRV in exposure scenarios pose no human health risks and require no special mitigations of application methods. The RRV values determined for spinosad are derived from a chronic feeding study in dogs. This study determined a NOEL to dogs of 2.68 mg/kg/day and a LOEL to dogs of 8.46 mg/kg/day based upon vacuolation in glandular cells (parathyroid) and lymphatic tissues, arteritis, and increases in serum enzymes (EPA, 1998a). The RRV values were determined by applying an uncertainty (safety) factor of 10 to the NOEL to account for inter-species variation for occupational exposures and by applying an uncertainty factor of 100 to the NOEL to account for inter-species and intra-species variation for general population exposures. There is no increased sensitivity of infants or children to spinosad over that of the general population, so it is unnecessary to apply an additional uncertainty factor of 10 for protection of this subgroup of the population. The lack of adverse acute and subchronic effect data for spinosad result in establishment of only a chronic RRV for this pesticide. The quantitative analysis aspect of this risk assessment is designed to err conservatively on the side of human health protection and therefore, this chronic RRV is applied to all (both acute and chronic) human exposure scenarios analyzed for program applications of spinosad. This approach may be revised in future assessments of spinosad if appropriate acute and subchronic data are available to develop RRV values for those exposures.

Table 2–2. Duration-Specific RRVs for Chemical Exposure

Chemical	Exposed Population	Acceptable Cumulative Daily Dermal and Oral Exposure (mg/kg/day)		
		Acute	Subchronic	Chronic
Spinosad	General	NA	NA	0.027
	Occupational	NA	NA	0.27

B. Nontarget Wildlife

Quantitative and qualitative risk assessments were performed for selected nontarget species exposed to spinosad as a result of APHIS fruit fly programs. This risk assessment does not address physical stressors associated with the programs or multiple exposures. There are no other compounds that are known to have the same toxic mechanism of action as spinosad, so synergism or potentiation of any adverse effects from exposure is not anticipated. The risk is evaluated to each species from spinosad based on estimated exposure within either the first 24 hours (terrestrial species) or the first 96 hours (aquatic species) after treatment (initial exposure). For purposes of this risk assessment, it was assumed that almost every species was exposed to the pesticide of concern, but the potential routes of exposure (dermal, oral, inhalation) were considered on a species basis. The repellant nature of the attractant, ammonium acetate, to some species was also considered in determination of non-target exposure to the formulation (Rendon et al., 2000). Pertinent data regarding the fate, transport, and persistence of spinosad are summarized in chapter 3.

APHIS used the Forest Service Cramer Barry Grim (FSCBG) model, the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model, and also developed surface water models to estimate environmental concentrations of pesticides in soil and water (see appendix B in the Medfly risk assessment (APHIS, 1992)). Results of environmental fate modeling are presented in chapter 3 of this assessment and in chapter 3 of the Medfly Nontarget Risk Assessment (APHIS, 1992).

APHIS developed exposure models for terrestrial and aquatic species and considered both routine and extreme exposure scenarios. The model methodology, selected species, and scenario assumptions are presented in chapter 3 of this assessment and in chapter 4 of the Medfly Nontarget Risk Assessment (APHIS, 1992). Further details are given in appendix D of the Medfly document.

The results of the exposure analyses for each species and pesticide in each ecoregion are discussed in chapter 3 of this assessment and in chapter 5 of the Medfly Nontarget Risk Assessment (APHIS, 1992). Model input data are presented in Medfly appendices E and F.

The quantitative risk assessments performed for nontarget organisms and the characterization of that risk are presented in chapter 4. Qualitative assessments were made for the use of lures and attractants. Risk assessment methods and calculations are discussed in detail in appendices G through J of the Medfly Nontarget Risk Assessment (APHIS, 1992). It is important to bear in mind that estimated risks are based upon populations of nontarget organisms that come into contact with the chemicals used in fruit fly programs. Therefore, the discussion centers on aerial bait spray applications because these applications of chemicals are anticipated to expose more nontarget species at a greater frequency than the other uses of chemicals in fruit fly programs.

Spinosad is of very slight acute oral toxicity to mammals. The acute oral median lethal dose of spinosad to rabbits and rats was determined to be greater than 5,000 mg/kg (Borth *et al.*, 1996; Dow Agrosciences, 1998; EPA, 1998a). The acute median lethal dose of spinosyn A to rats was found to range from 3,783 to greater than 5,000 mg/kg (Thompson *et al.*, 1995). The acute dietary median lethal concentration of spinosad was determined for an herbivore (vole, 6,120 ppm), a granivore (mouse, 23,100 ppm), and an insectivore (shrew, 3,400 ppm) (Borth *et al.*, 1996). The acute dermal median lethal dose to rats is greater than 2,800 mg/kg. The acute inhalation median lethal concentration to rats is greater than 5.18 mg/L.

Spinosad is practically non-toxic to birds. The acute oral median lethal dose of spinosad was greater than 2,000 mg/kg for both bobwhite quail and mallard duck (Dow Agrosciences, 1998). The acute dietary median lethal concentration to various bird species are as follows: bobwhite quail = 5,253 ppm, mallard duck = 5,156 ppm, field sparrow = 5,970 ppm, mourning dove = 17,857 ppm, and blue titmouse = 6,670 ppm (Borth *et al.*, 1996). Although no data were located about reptiles and amphibians, it is anticipated that the acute toxicity to those species should be similar to birds and is expected to also be very low.

Spinosad acts as a contact and stomach poison against insects and it is particularly effective against caterpillars (Lepidoptera) and all stages of flies (Diptera) (Adan *et al.*, 1996). The symptoms of intoxication in insects are unique and are typified by initial flaccid paralysis followed by weak tremors and continuous movement of crochets and mandibles (Thompson *et al.*, 1995). The effects occur rapidly and there is little to no recovery.

The mode of toxic action of this compound against insects has been shown to relate to the widespread excitation of isolated neurons in the central nervous system (Salgado *et al.*, 1997). This is caused by persistent activation of nicotinic acetylcholine receptors and prolongation of acetylcholine responses. This prolonged response leads to involuntary muscle contractions and tremors. This mode of toxic action is unique to spinosad. Therefore, no known cross-resistance to other insecticides is anticipated. Under certain conditions, spinosyns have also had effects on gamma-aminobutyric acid receptors, but the contribution of these effects to symptoms have not yet been elucidated.

The toxicity of spinosad to invertebrates is dependent upon the species and life stage. The median lethal dose of spinosad to Lepidoptera (butterflies and moths) ranges from 0.022 mg/kg (very highly toxic) for the native budworm to 19 mg/kg (slightly toxic) for cotton leafworm (Sparks *et al.*, 1995; Thompson *et al.*, 1995). This suggests a relatively wide variability in the susceptibility of caterpillars. The application rates specified on other spinosad labels for products used to control pest caterpilllars are generally feom 30 to 40 grams a.i./hectare (compared to 0.3 grams a.i./hectare for spinosad bait spray applications). Based upon exposure calculations applied in this risk assessment, spinosad bait spray applications would result in no mortality to tolerant caterpillars like the cotton leafworm and very high mortality to susceptible species like the native budworm. Neither of these species would represent the most likely outcome from bait spray applications. Based upon the available data on adequate control for pest species, it would seem likely that most caterpillars would experience low mortality. The approach taken to assess this mortality in the risk assessment was to average the median lethal dose data and apply an average slope to that data, Using this probit data point and slope, the resulting curve was the basis for mortality results that represent most caterpillars.

The median lethal dose to house flies is 0.9 mg/kg. Immature fly stages such as maggots occur in fruit and in other unexposed locations. The half-life data for spinosad suggest that it is unlikely to persist until maggots are exposed, so the mortality to maggots is not anticipated. The median lethal dose to yellow fever mosquitoes is 0.1 mg/kg.

Ants, such as the Argentine ant, (LD_{50} = 185.6 mg/kg) are very tolerant of spinosad. Other Hymenoptera, such as honey bees (LD_{50} = 11.5 mg/kg) and the red headed pine sawfly (LD_{50} = 2.8 mg/kg), are more sensitive (Borth *et al.*, 1996; Thompson *et al.*, 1995). Spinosad is slightly toxic to parasitic wasps such as *Encarsia formosa* (LD_{50} = 29.1 mg/kg).

Beetles are quite tolerant of spinosad (LD_{50} ranges from 25 to greater than 200 mg/kg) as are cat fleas (LD_{50} = 120 mg/kg), green lacewings (LD_{50} > 200 mg/kg), minute pirate bugs (LD_{50} = 200 mg/kg), and German cockroaches (LD_{50} = 367 mg/kg). Onion thrips are highly susceptible to spinosad (LD_{50} = 0.11 mg/kg). Although spinosad is moderately toxic to the 2-spotted spider mite (LD_{50} = 2.1 mg/kg), it is practically nontoxic to the mite, *Phytoseiulus persimilis* (LD_{50} > 200 mg/kg).

Laboratory toxicity studies do not completely reflect actual exposures under field conditions. In particular, exposure to honey bees from field applications have been shown to be quite low due to the repellant nature of the bait (Rendon et al., 2000). Although spinosad has high acute oral toxicity when administered as a topical application, toxicity in field-sprayed apple blossoms showed no statistical difference in mortality between honey bees from treated and control groups (King and Hennessey, 1996). Honey bees are neither attracted to nor stimulated to feed upon spinosad bait. In addition, review of the studies of spinosad toxicity to pollinators indicates that dried residues of spinosad following application pose no risk to pollinators (Mayes et al., 2003). This drying of residues would be expected to require no more than three hours in the field. The low application rate of spinosad in the bait formulation used for fruit fly control has been shown to pose no risks to foraging honey bees, honey bee brood development, and hive condition (Rendon et al., 2000; Burns et al., 2001). Other beneficial arthropods observed to not be affected by spinosad in treated cotton fields include trichogrammatid wasps, assassin bugs, ladybird beetles, predatory mites, fire ants, big-headed bugs, damsel bugs, green lacewings, and spiders (Peterson *et al.*, 1996). Another field study found no adverse effects from spinosad on populations of predators, some decreases in parasitic Hymenoptera populations, and some pest species (plant bugs, cotton aphids, and spur-throated grasshoppers), but it was effective against Lepidoptera caterpillars (Murray and Lloyd, 1997). Recent review of beneficial arthropods shown to be affected by spinosad applications in some studies indicates potential effects to minute pirate bugs, some mites, some parasitic wasps, earwigs, some rove beetles, some spiders, and some nontarget flies (Thompson, 2003; Cisneros et al., 2002). Although spinosad may be highly toxic to some parasitic wasps, it is not attractive to them and has less adverse effects on those species than occur from malathion bait sprays (Vargas et al., 2001; Vargas et al., 2002).

Spinosad is slightly to moderately toxic to fish. The 96-hour median lethal concentration of spinosad determined for fish are as follows: bluegill = 5.9 mg/L, rainbow trout = 30 mg/L, carp = 5 mg/L, and sheepshead minnow = 7.9 mg/L (Borth *et al.*, 1996). A 21-day median lethal concentration of spinosad was determined for rainbow trout to be 4.8 mg/L. The toxicity of spinosad to aquatic forms of amphibians would be expected to be comparable to fish.

Spinosad is slightly to moderately toxic to most aquatic invertebrates. The median lethal concentration of spinosad to daphnia was determined to be 92.7 mg/L (Borth *et al.*, 1996). Grass shrimp were more sensitive and had a 96-hour median lethal concentration for spinosad of 9.76 mg/L (Dow Agrosciences, 1998). Spinosad was found to be highly toxic to marine molluscs with a median lethal concentration of spinosad at 0.295 mg/L for eastern oyster.

Spinosad is of slight to moderate acute toxicity to algae. The median lethal concentration of spinosad was determined to be 106 mg/L for green algae and 8.09 mg/L for blue green algae (Borth *et al.*, 1996).

C. Environmental Quality

The hazards of spinosad to environmental quality are minimal. This is largely related to environmental fate factors discussed in greater detail in the third chapter of this risk assessment. Spinosad persists for a few hours in air or water. The compound binds readily to organic matter in soil and water. This binding in soil prevents leaching to groundwater. There is also strong adsorption of spinosad to the organic matter on leaf surfaces. The photodegradation of spinosad residues occurs readily on plants and tolerances on crops are not of great concern to EPA (EPA, 1998a). The rapid breakdown and lack of movement in the environment ensure that no permanent effects can be anticipated to the quality of air, soil, and water. No adverse effects to ambient air quality or water quality would be expected for these applications.

III. Environmental Fate and Exposure Analysis

This chapter discusses estimated environmental concentrations and exposures of spinosad from bait spray applications in APHIS fruit fly programs.

The input data for the GLEAMS model for all ecoregions except the Marine Pacific Forest was presented in the Medfly Nontarget Risk Assessment (APHIS, 1992). The input parameters used in the GLEAMS model for estimating concentrations of pesticides in soil, runoff water, and groundwater in the Marine Pacific Forest Ecoregion are presented in table 3–1. The representative soil series chosen for the fruit-growing areas of Washington State was Burch loam, which has traditionally been the most productive soil series for fruit production in the region.

Table 3–1. Site-Specific Hydrology and Erosion Parameters for the GLEAMS Model for the Marine Pacific Forest Ecoregion—Burch Loam at Wenatchee, WA Site

Parameter	Site Model Data
Typical Soil	Loam
HYDROLOGY DATA	
Hydrological Group	B
Saturated Conductivity	0.20
Evaporation Parameter	4.5
SCS Curve no.	61
Hydraulic Slope	0.08
Soil Porosity	0.40
Field Capacity	0.26
Wilting Point	0.11
Organic Matter (%)	1
EROSION DATA	
Surface Clay	0.20
Surface Silt	0.35
Surface Sand	0.45
Clay Surface	20
Organic Matter Surface Area	1,000
Flow Profile Slope	0.02
Soil Erosion Factor	0.398
Contouring Factor	0.6

Table 3–2 presents selected chemical and physical properties of spinosad used in some of the environmental fate, exposure, and risk analyses. Spinosad consists of several metabolites or factors that account for the toxic action. In particular, spinosyn factors A and D are of primary

concern. The log octanol-water coefficient (log K_{ow}) at pH 7 for spinosyn A is 3.9 and for spinosyn D is 4.4. Although the value for spinosyn A may differ slightly from that of formulated spinosad, it should have similar chemical properties. Other physical and chemical properties are summarized in appendix 1.

Table 3–2. Chemical-Specific Data Used for Toxicological Assessments[a]

Chemical	Molecular Weight	Log K_{ow}	Log K_p	K_p (cm/hour)	Density (g/cc)	Water Solubility (mg/L)
spinosyn A	732	3.9	-4.0	0.0001	applied product = 1.09	235
spinosyn D	746	4.4	-4.5	0.00003		0.332

[a] Data taken from appendix 2, unless otherwise specified
K_{ow} = Octanol-water partition coefficient; K_p = permeability coefficient

Table 3–3 briefly summarizes the output from the GLEAMS modeling by presenting the highest concentrations of spinosad in surface soil and interstitial soil water (groundwater) for a 2-year storm at each of the seven potential program sites.

Table 3–3. Summary of GLEAMS Modeling for Maximum Levels of Spinosad in the Upper 1 cm of Soil (µg/g) and Interstitial Soil Water (µg/L)

Media	Site						
	Brownsville	Gulfport	Los Angeles	Miami	Orlando	Santa Clara	Chelan County
Soil	0.0005	0.0004	0.0004	0.0005	0.0005	0.0004	0.0004
Water	0.0330	0.0416	0.0220	0.0220	0.0050	0.0025	0.0282

A. Fate of Spinosad

1. Air

Sunlight exposure is expected to result in rapid photodegradation of spinosad. This rapid breakdown of the parent compounds in sunlight indicates that any residual particles of spinosad will not persist in the atmosphere. Spinosad insecticide has low vapor pressure (not volatile), and any drift from aerial applications would be expected to readily deposit on surfaces of leaves or soil. The lack of any detectable residues in air samples monitored after spinosad application for the Mexican Fruit Fly Eradication Program in San Diego County by California Department of Pesticide Regulation (CDPR, 2003) verifies that exposure to spinosad residues in the atmosphere is unlikely.

2. Soil

The photolysis half-life in soil is 8.68 days for spinosyn A and 9.44 days for spinosyn D (Dow Agrosciences, 1998). The aerobic soil half-life of both spinosyn factors is 14.5 days. The rapid degradation in sunlight is anticipated to result in no persistence when residues are deposited on the soil surface from applications. The residues in the bait could persist longer (protected from sunlight), but degradation would be rapid when exposed to precipitation and weathering. Although spinosyn A is highly water soluble, it has a high octanol/water partition coefficient that results in strong adsorption to organic matter (Borth *et al.*, 1996). Spinosyns A and D are immobile in soil and will not leach into groundwater (EPA, 1998). The half-lives in pre-sterilized soils were substantially longer than in unsterilized soils, and the degradation in soils has been largely attributed to microbial action (Hale and Portwood, 1996).

The concentration of spinosad in soil after a large regional storm (2-year storm) following aerial bait spray application is shown for each of the seven ecoregions in table 3–4.

Table 3–4. Estimated Concentration of Spinosad in Soil (µg/g)

Ecoregion 1—California Central Valley and Coastal					
Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0004	0.0001	0.0000	0.0000
	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0000
	20–30	0.0000	0.0000	0.0000	0.0000
Ecoregion 2—Basin and Range					
Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0004	0.0002	0.0001	0.0000
	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0003
	20–30	0.0000	0.0000	0.0000	0.0000
Ecoregion 3— Lower Rio Grande Valley					
Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0005	0.0003	0.0001	0.0000
	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0000
	20–30	0.0000	0.0000	0.0000	0.0000
Ecoregion 4—Southeastern and Gulf Coastal Plain					
Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0005	0.0004	0.0001	0.0000

	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0000
	20–30	0.0000	0.0000	0.0000	0.0000

Ecoregion 5—Mississippi Delta

Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0004	0.0003	0.0001	0.0000
	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0000
	20–30	0.0000	0.0000	0.0000	0.0000

Ecoregion 6—Floridian

Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0005	0.0004	0.0001	0.0000
	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0000
	20–30	0.0000	0.0000	0.0000	0.0000

Ecoregion 7—Marine Pacific Forest

Chemical	Soil Depth	Occurrence of Simulated Storm Event (Post Application)			
		0 Hours	24 Hours	48 Hours	72 Hours
Spinosad	0–1	0.0004	0.0002	0.0001	0.0000
	1–10	0.0000	0.0000	0.0000	0.0000
	10–20	0.0000	0.0000	0.0000	0.0000
	20–30	0.0000	0.0000	0.0000	0.0000

3. Water

Although spinosad is not applied directly to water bodies, there is potential runoff and drift of insecticidal particles. The rapid photolysis in water results in a half-life less than a day to 2 days (Borth *et al.*, 1996; Cleveland et al., 2002). Spinosyn A is water soluble (235 ppm at pH 7), but spinosyn D is of low water solubility (0.332 ppm at pH 7). The octanol/water partition coefficient for both spinosyns is high, which indicates that both compounds will adhere readily to organic matter and not remain suspended in the water. However, this rate of partitioning to organic matter and sediments is not so rapid as to replace the primary dissipation of spinosad by photolysis (Cleveland et al., 2002). Biotic transformations of spinosad may also contribute to dissipation, but this degradation is only predominant under dark conditions.

The estimated concentration of spinosad in runoff water from non-paved areas within the watershed and the amount of runoff produced after a large regional storm (2-year storm) following an aerial bait spray application are shown in table 3–5 for the seven ecoregions. Estimated average daily concentrations of spinosad in water from direct aerial bait spray applications and runoff for all seven ecoregions are presented in table 3–6. The concentration of spinosad in directly sprayed water bodies was determined to range from below detection to 91 ng/L. Monitoring data from studies in California and Texas indicated that all water residues were below the detection limit (CDPR, 2003; USDA, APHIS, 2002b). Monitoring study data from Guatemala indicate that water residues can range from below the detection limit to as high as 4.6 ppb (USDA, APHIS, 2002a, 2001, 2000). The larger number of samples taken from Guatemala makes these studies more thorough. All monitoring results are well below the maximum concentrations estimated from the models applied to this risk assessment. The information from the models is used to determine the routine and extreme concentrations used in nontarget aquatic species exposure scenarios and the drinking water concentrations applied to nontarget terrestrial species. Based upon the available monitoring data, application of these modeling results is not unreasonable for conservative calculation of exposure to spinosad and associated risk.

Table 3–5. Concentration of Spinosad in Runoff Water (Estimated by GLEAMS) by Ecoregion

Amount or Concentration of Chemical	24 Hours	48 Hours	72 Hours
Floridian			
2-year storm (cm)	10.16	10.16	10.16
Amount of runoff (cm)	0.27	0.19	0.19
Spinosad (µg/L)	0.0220	0.0117	0.0075
Mississippi Delta			
2-year storm (cm)	10.67	10.67	10.67
Amount of runoff (cm)	1.06	0.57	0.38
Spinosad (µg/L)	0.0416	0.0211	0.0161
Southeastern/Gulf Coastal Plains			
2-year storm (cm)	10.67	10.67	10.67
Amount of runoff (cm)	0.00	0.00	0.00
Spinosad (µg/L)	0.0000	0.0000	0.0000
Lower Rio Grande Valley			
2-year storm (cm)	8.13	8.13	8.13
Amount of runoff (cm)	0.00	0.00	0.00
Spinosad (µg/L)	0.0000	0.0000	0.0000
Basin and Range			
2-year storm (cm)	5.08	5.08	5.08
Amount of runoff (cm)	0.00	0.00	0.00
Spinosad (µg/L)	0.0000	0.0000	0.0000
California Central Valley and Coastal			
2-year storm (cm)	5.08	5.08	5.08
Amount of runoff (cm)	0.00	0.00	0.00
Spinosad (µg/L)	0.0000	0.0000	0.0000
Marine Pacific Forest			
2-year storm (cm)	5.08	5.08	5.08
Amount of runoff (cm)	0.00	0.00	0.00
Spinosad (µg/L)	0.0000	0.0000	0.0000

Table 3–6A. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 1—California Central Valley and Coastal					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.061	0.040	0.027	0.018
1 meter (m)	0.028	0.019	0.013	0.008	0.005
2 m	0.014	0.009	0.006	0.004	0.003
Storm 24 hours after application	0	24	48	72	96
GLEAMS Runoff	0.00	0.00	0.00	0.00	0.00
2 m Lake	0.014	0.039	0.027	0.018	0.012
0.76 m Stream	0.037	0.063	0.041	0.028	0.018
Storm 72 hours after application	0	24	48	72	96
GLEAMS Runoff	0.00	0.00	0.00	0.00	0.00
2 m Lake	0.014	0.009	0.006	0.014	0.009
0.76 m Stream	0.037	0.000	0.000	0.040	0.027

Table 3–6B. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 2—Basin and Range					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.085	0.078	0.071	0.066
1 m	0.028	0.026	0.024	0.021	0.020
2 m	0.014	0.013	0.012	0.011	0.010
Storm 24 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.043	0.039	0.036	0.033
0.76 m Stream	0.037	0.060	0.055	0.051	0.046
Storm 72 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.013	0.012	0.031	0.029
0.76 m Stream	0.037	0.0000	0.0000	0.056	0.052

Table 3–6C. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 3—Lower Rio Grande Valley					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.059	0.038	0.024	0.015
1 m	0.028	0.018	0.012	0.007	0.004
2 m	0.014	0.009	0.005	0.004	0.003
Storm 24 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.045	0.029	0.019	0.012
0.76 m Stream	0.037	0.079	0.050	0.032	0.021
Storm 72 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.009	0.005	0.017	0.011
0.76 m Stream	0.037	0.0000	0.0000	0.056	0.036

Table 3–6D. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 4—Southeastern and Gulf Coastal Plain					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.085	0.078	0.071	0.066
1 m	0.028	0.026	0.024	0.021	0.020
2 m	0.014	0.013	0.012	0.011	0.010
Storm 24 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.038	0.036	0.033	0.030
0.76 m Stream	0.037	0.054	0.050	0.046	0.042
Storm 48 hours after application	0	24	48	72	96

GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.013	0.030	0.029	0.026
0.76 m Stream	0.037	0.0000	0.046	0.043	0.039

Table 3–6E. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 5—Mississippi Delta					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.082	0.073	0.065	0.058
1 m	0.028	0.025	0.022	0.020	0.018
2 m	0.014	0.013	0.011	0.010	0.009
Storm 48 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.033	0.0000	0.0000
2 m Lake	0.014	0.013	0.037	0.033	0.029
0.76 m Stream	0.037	0.0000	0.055	0.049	0.044

Table 3–6F. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 6—Floridian					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.083	0.074	0.067	0.061
1 m	0.028	0.025	0.022	0.021	0.019
2 m	0.014	0.013	0.012	0.010	0.009
Storm 24 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.046	0.0000	0.0000	0.0000
2 m Lake	0.014	0.047	0.043	0.038	0.035
0.76 m Stream	0.037	0.064	0.058	0.053	0.047
Storm 48 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.037	0.0000	0.0000
2 m Lake	0.014	0.013	0.037	0.033	0.029
0.76 m Stream	0.037	0.0000	0.055	0.049	0.045

Table 3–6G. Estimated Average Daily Spinosad Concentration (µg/L) From Direct Aerial Spray and Runoff into Water Bodies

Ecoregion 7—Marine Pacific Forest					
Water Body Depth	**Time (hours)**				
	0	24	48	72	96
30.5 cm (1 ft)	0.091	0.072	0.059	0.049	0.042
1 m	0.028	0.022	0.018	0.015	0.013
2 m	0.014	0.011	0.009	0.007	0.006
Storm 24 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.041	0.033	0.028	0.022
0.76 m Stream	0.037	0.062	0.048	0.039	0.032
Storm 72 hours after application	0	24	48	72	96
GLEAMS Runoff	0.0000	0.0000	0.0000	0.0000	0.0000
2 m Lake	0.014	0.011	0.009	0.022	0.019
0.76 m Stream	0.037	0.0000	0.0000	0.048	0.039

4. Plants

The rapid photodegradation of spinosad is expected to result in no persistence on leaf surfaces. The half-life on cotton was determined to be 3.4 hours. Any washoff or weathering from leaves is also anticipated to readily degrade. The degradation products are of no greater toxicological concern than the parent compounds, spinosyn A and spinosyn D (EPA, 1998). The low residues on plants are expected to become readily incorporated into the general carbon pool.

5. Humans and Animals

A study analyzed the metabolism by rats (EPA, 1998). There was 95 percent elimination of the residues of spinosad within 24 hours. Metabolism was minimal and the parent compounds were excreted either unchanged or as N- and O-demethylated glutathione conjugates. The metabolism resulted in compounds of comparable or lower toxicity than the parent compounds. Elimination of residues occurred through urine (34 percent), bile (36 percent), and tissues and carcass (21 percent). The rapid excretion of this compound in mammals accounts for the low acute toxicity. Bioconcentration potential is low. Bioconcentration factors in rainbow trout were determined to be 19 for spinosyn A and 33 for spinosyn D (Dow Agrosciences, 1998).

B. Potential Exposure

The potential exposure depends primarily on the method of application, time of application, and the rate of application. The current insecticide application rate being considered involves analysis of applications of bait spray using spinosad as the toxicant to adult fruit flies. The insecticide application rate is 0.00025 pounds a.i. of spinosad per acre.

This risk assessment handles exposure assessment like that which would be expected from a regular operational treatment that could be applied over urban neighborhoods. This approach provides information about exposure and risk for an operational program if these methods are to be used in the Medfly Cooperative Eradication Program or other eradication programs of fruit flies. The exposure assessment considers both aerial and ground applications of spinosad bait spray.

The human exposure scenarios considered in this risk assessment include three general types (routine, extreme, accidental) and two specific types (pica and a toddler in a swimming pool). Routine exposure scenarios assume that the recommended application rates are used and that recommended safety precautions are followed. Furthermore, routine exposures are based on the most likely estimates of modeling parameters such as food or water consumption rates and values for skin surface exposure. Extreme exposure scenarios assume that recommended procedures and precautions are not followed and use more conservative, but still plausible, modeling parameters that increase the estimate of exposure. Accidental exposure scenarios assume some form of equipment failure or gross human error. Although accidental exposures are worst case scenarios within the context of the risk assessment, they are designed, nonetheless, to represent realistic, not catastrophic, events. A catastrophic event, such as the crash of a full airplane (although plausible), by definition requires emergency action rather than risk assessment. Pica refers to the tendency of individuals to orally consume unnatural items as food. The soil consumption scenario for pica behavior considers the toddler who ingests 10 grams of soil per day (chemical concentration in consumed soil at upper limit). The swimming pool scenario considers both the potential oral and dermal exposure of a toddler over a 4-hour daily swimming/bathing time. These scenarios are designed to analyze realistic situations that could be expected to occur if an eradication program were undertaken with spinosad bait spray.

Exposure to spinosad bait spray involves simultaneous exposure to insecticide and bait in the formulation. Since the basic mode of toxic action of both chemicals is considered to be different and the hazards from the bait are minimal, the hazards from human exposures consider only the level of the exposure to spinosad relative to the RRV(s) for that compound. If exposure is much less than the RRV, then the risk can be considered minimal. The hazards from nontarget species exposures consider the level of the exposure to spinosad relative to the LD_{50} for terrestrial species or the LC_{50} for aquatic species.

1. Human Occupational Exposure

The potential human occupational exposures to spinosad were determined for pilots, backpack applicators, hydraulic rig applicators, mixers/loaders, and ground personnel. The ground personnel include kytoon handlers, flaggers, and quality control crew. Exposure was calculated using the methods developed in the Human Health Risk Assessment, APHIS Fruit Fly Programs (SERA, 1992). The results of occupational exposure calculations for spinosad are presented in table 3–7. The highest potential occupational exposure was determined to be to the ground personnel. Routine exposures to ground personnel were calculated to be 9.82×10^{-4} mg spinosad/kg/day. Extreme scenario exposures to ground personnel were calculated to be 2.68×10^{-3} mg spinosad/kg/day. These relatively low exposures have not been associated with any adverse effects in laboratory or public health studies.

Table 3–7. Occupational Exposures to Spinosad

Group	Exposure Scenario	Dose (mg/kg/day)
Pilots	Routine	4.56×10^{-7}
	Extreme	4.18×10^{-6}
Backpack applicators	Routine	1.61×10^{-6}
	Extreme	4.02×10^{-6}
Hydraulic rig applicators	Routine	8.04×10^{-7}
	Extreme	3.04×10^{-6}
Mixers/loaders	Routine	9.80×10^{-7}
	Extreme	6.52×10^{-6}
Ground personnel	Routine	9.82×10^{-4}
	Extreme	2.68×10^{-3}

2. General Public

The potential general public exposures to spinosad were determined for scenarios involving soil consumption, consumption of contaminated water, swimming pool exposure, consumption of contaminated vegetation, and contact with contaminated vegetation. Calculations of exposure were done using the methods developed in the Human Health Risk Assessment APHIS Fruit Fly Programs (SERA, 1992). The results of general public exposure calculations for spinosad are presented in table 3–8. This risk assessment concerns bait spray applications of spinosad only. The likelihood of public exposure to spinosad from these applications is high, particularly if aerial applications are required in residential areas. The highest potential general public exposure was determined to be for the exposure scenario of a child consuming contaminated runoff water. This had a potential exposure of 1.05×10^{-5} mg spinosad/kg/day. These relatively low exposures have not been associated with any adverse effects in laboratory or public health studies.

Table 3–8. General Population Exposures to Spinosad

Group	Exposure Scenario	Dose (mg/kg/day)
Soil consumption	Routine	8.93×10^{-9}
	Extreme	1.34×10^{-8}
	Pica	5.36×10^{-7}
Consumption of contaminated water	Runoff water	1.05×10^{-5}
	Surface water	4.38×10^{-7}
Swimming pool exposure	4 hours (toddler)	1.79×10^{-9}
Consumption of contaminated vegetation	Routine (adult)	6.84×10^{-7}
	Extreme (adult)	3.54×10^{-6}
Contact with contaminated vegetation	Routine (adult)	3.84×10^{-7}
	Extreme (adult)	8.93×10^{-7}

3. Wildlife

This chapter presents the results of the exposure analysis of specific nontarget organisms to spinosad concentrations in the environment as a result of Fruit Fly program activities. The estimated doses are based on the environmental concentrations presented in the fate section of chapter 3 and the exposure models and scenarios. The dose calculations for the seven ecoregions where fruit flies could occur are described in detail in appendix E of the Medfly Nontarget Risk Assessment (APHIS, 1992). The estimated routine and extreme exposures from spinosad aerial bait spray applications in aquatic habitats are given in table 3–9.

The potential fruit fly program area consists of portions of 48 States. It is not feasible to include all species which could be exposed to pesticides used in the program activities or all ecological regions of the country. The selection of the seven ecoregions was based upon likelihood of future programs. Species at different trophic levels which are representative of the various habitats in these seven ecoregions were considered. As detailed in appendix C of the Medfly Nontarget Risk Assessment (APHIS, 1992), a variety of organisms were used to encompass a broad range of dietary patterns, habitats, and behavior. For this risk assessment, the selection of common species that inhabit or are likely to inhabit the potential fruit fly program areas includes 18 mammals, 31 birds, 15 reptiles, 9 amphibians, 17 fish, and 34 invertebrates. Qualitative assessments involving terrestrial and aquatic plants are made whenever sufficient data are available.

For this risk assessment, a multiple-pathway terrestrial model and an aquatic exposure model developed for the Medfly Nontarget Risk Assessment (APHIS, 1992) were used. The multiple-pathway model is used to estimate exposure levels for terrestrial organisms through oral, dermal, and inhalation routes. This model provides an estimate of total does to nontarget terrestrial species and attempts to quantify numerous direct and indirect routes of exposure. Parameters estimated as model inputs were conservative. The use of a conservative estimate increases the likelihood that error will be false positive rather than false negative. Although the models are useful for predicting which species may be potentially at risk, they do not predict which species will definitely be at risk from program treatments. EPA developed a simpler and somewhat less conservative model to estimate dose (Urban and Cook, 1986). This model is used to provide a second estimate of exposure levels for bait spray applications. For aquatic species, exposure was assumed to be completely characterized by the ambient concentrations of pesticides in the water.

The selection of species for analysis in this risk assessment was based on several criteria. All vertebrate and invertebrate classes are represented by aquatic and terrestrial species. The criteria include the different life stages for some species, species with different body sizes and food requirements, and species from different trophic levels. The range of species analyzed in this risk assessment is intended to be representative of the range of species present in each ecoregion. Consequently, estimates of potential risk for a particular species may be extrapolated to other species of common habitat, behavior, and physiology. The exposure assumptions and the species selected for the seven ecoregions where fruit flies could occur are described in detail in the Medfly Nontarget Risk Assessment (APHIS, 1992) and the Fruit Fly Nontarget Risk Assessment APHIS, 1998).

Table 3–9. Estimated Routine and Extreme Exposure Scenarios Regarding Spinosad Concentrations in Aquatic Habitats After Aerial Application (µg/L)

Aquatic Habitat	Exposure Scenario	Ecoregion						
		1	2	3	4	5	6	7
Stream	routine	0.027	0.037	0.036	0.037	0.037	0.037	0.037
	extreme	0.063	0.060	0.079	0.054	0.064	0.064	0.062
Lake	routine	0.012	0.033	0.012	0.030	0.029	0.035	0.022
	extreme	0.039	0.043	0.045	0.038	0.047	0.047	0.041
Pond	routine	0.005	0.020	0.004	0.020	0.018	0.019	0.013
	extreme	0.028	0.028	0.028	0.028	0.028	0.028	0.028
Wetland	routine	0.018	0.066	0.015	0.066	0.058	0.061	0.042
	extreme	0.091	0.091	0.091	0.091	0.091	0.091	0.091

Exposures of aquatic species to spinosad from bait spray applications are expected to be very low. The water solubility of spinosyn A ensures rapid mixing in the water, but all residues will readily adsorb to organic matter and the rapid degradation of spinosad ensures that only short durations of exposure (not expected to be more than several hours) are possible for given treatments. Applying the minimum depth (0.3 m) considered in analyses of bodies of water in the Nontarget Risk Assessment for the Medfly Cooperative Eradication Program (USDA, APHIS, 1992) to spinosad bait spray applications, a direct application would only result in water concentrations of 9.1×10^{-6} mg spinosad per liter. Spinosad does not bioaccumulate or bioconcentrate and the doses taken up by aquatic organisms from this low water concentration will be very low.

Dose estimates for nontarget terrestrial organisms in all ecoregions for spinosad bait spray applications are presented in tables 3–10 to 3–14.

The potential exposures of terrestrial wildlife other than some insect species to spinosad bait spray will be very low. Since the toxicity of these formulations to insects occurs primarily through ingestion and dermal contact, the exposure routes of most concern are oral and dermal. Oral exposure may occur through grooming of the body, but doses sufficient to induce toxic responses would occur primarily through feeding. There are several invertebrate species other than fruit flies that may be attracted and feed on the bait spray. In particular, the plant bugs (miridae), ground beetles (carabidae), midges and gnats (nematocerous Diptera), pomace flies, other acalypterate muscoid flies, ants (formicidae), and soil mites (Acari) are attracted in large numbers to the protein hydrolysate used in malathion bait spray (Troetschler, 1983). These species are less likely to get high exposures to spinosad. Most terrestrial invertebrates are not attracted to the bait or fructose in spinosad bait spray formulations. Use of spinosad bait spray makes the likelihood of nontarget insect toxicity considerably less for most insects than would be anticipated from use of malathion bait spray. Honey bees (CICP, 1988), lacewings (Hoy, 1982), springtails, aphids, whiteflies, tumbling flower beetles, calypterate muscoid flies, and spiders (Troetschler, 1983) are not attracted to the present bait for spinosad. The ammonium acetate in the spinosad bait is less attractive to many species and is known to repel some species. Mortality to most of these species has been noted with malathion bait spray applications due to contact insecticidal activity. The exposures of these species by dermal route are likely to be lower as a result of lower application rates. Furthermore, the tolerance for spinosad is greater for most species except the flies and caterpillars. In particular, beetles, bees, lacewings, ants, spiders, grasshoppers, roaches, true bugs, and adult Lepidoptera are less likely to be adversely affected when spinosad bait spray is applied (than when malathion bait spray is applied). The low application rates of spinosad bait spray make caterpillars less likely to have mortality than from other formulations of spinosad.

Table 3–10. Spinosad Dose Estimates for Aerial Bait Spray Applications (mg/kg)—Mammals

Organism	Ecoregion 1		Ecoregion 2		Ecoregion 3		Ecoregion 4		Ecoregion 5		Ecoregion 6		Ecoregion 7	
	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme
Opossum	0.004	0.005	0.004	0.006	0.004	0.006	0.003	0.005	0.004	0.006	0.004	0.006	0.003	0.005
Desert Shrew	0.569	1.063	0.742	1.394	0.662	1.238								
Least Shrew					0.662	1.238	0.465	0.864	0.354	0.655	0.410	0.764		
E. Pipistrelle Bat					0.273	0.515	0.188	0.363	0.139	0.270	0.165	0.319		
W. Pipistrelle Bat	0.236	0.444	0.312	0.587									0.188	0.363
Desert Cottontail	0.012	0.014	0.013	0.016										
Eastern Cottontail					0.012	0.014	0.011	0.013	0.010	0.011	0.010	0.011		
W.Grey Squirrel	0.021	0.039											0.017	0.031
E. Grey Squirrel					0.025	0.046	0.017	0.031	0.013	0.023	0.015	0.028		
Cotton Mouse							0.021	0.038	0.021	0.038	0.021	0.038		
White-footed Mouse					0.029	0.055			0.021	0.040				
Deer Mouse	0.026	0.047	0.032	0.060									0.021	0.038
Raccoon	0.020	0.033	0.024	0.042	0.021	0.038	0.016	0.027	0.013	0.021	0.014	0.024	0.016	0.027
Fox, Gray	0.009	0.016	0.012	0.021	0.010	0.019	0.007	0.013	0.006	0.010	0.006	0.012		
Coyote/ Dog	0.003	0.004	0.003	0.005	0.003	0.004	0.002	0.003	0.002	0.003	0.002	0.003	0.002	0.003
Cat	0.007	0.013	0.009	0.016	0.008	0.015	0.005	0.011	0.004	0.009	0.004	0.009	0.005	0.011
Mule Deer	0.003	0.003	0.003	0.004									0.003	0.003
White-tailed Deer					0.003	0.003					0.003	0.003	0.003	0.003

Table 3–11: Spinosad Dose Estimates for aerial bait spray applications (mg/kg)–Birds

Organism	Ecoregion 1		Ecoregion 2		Ecoregion 3		Ecoregion 4		Ecoregion 5		Ecoregion 6		Ecoregion 7	
	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme
Pied-billed Grebe	0.005	0.008	0.006	0.010	0.006	0.009	0.004	0.006	0.004	0.004	0.004	0.004	0.004	0.006
Great Blue Heron	0.004	0.005	0.004	0.007	0.004	0.006	0.003	0.004	0.002	0.003	0.002	0.004	0.003	0.004
Cattle Egret	0.023	0.041	0.030	0.054	0.027	0.048	0.018	0.031	0.013	0.023	0.015	0.027		
Mottled Duck							0.003	0.008	0.002	0.005	0.002	0.006		
Mallard	0.004	0.009	0.005	0.012	0.005	0.011								
Turkey Vulture	0.002	0.004	0.003	0.004	0.003	0.004	0.002	0.003	0.001	0.002	0.001	0.002		
Red-tailed Hawk	0.007	0.013	0.009	0.017	0.008	0.015	0.004	0.009	0.004	0.005	0.004	0.007	0.004	0.009
American Kestrel	0.024	0.043	0.031	0.056			0.018	0.032	0.013	0.023	0.015	0.027	0.018	0.032
Northern Bobwhite					0.029	0.054	0.019	0.033	0.013	0.022	0.015	0.027		
Gambel's Quail			0.037	0.067										
California Quail	0.019	0.036												
Killdeer	0.069	0.126	0.090	0.167	0.079	0.146	0.053	0.097	0.038	0.071	0.058	0.083	0.053	0.097
Mourning Dove	0.017	0.032	0.022	0.042	0.020	0.037	0.012	0.021	0.007	0.013	0.009	0.016	0.012	0.021
Great Horned Owl (east/ central)														
male			0.004	0.007	0.004	0.006	0.003	0.007	0.002	0.003	0.002	0.004	0.003	0.007
female			0.004	0.007	0.004	0.006	0.003	0.006	0.002	0.003	0.002	0.004	0.003	0.006
Great Horned Owl (Pacific)														
male	0.004	0.006												
female	0.004	0.005												
Burrowing Owl	0.017	0.030	0.022	0.039	0.020	0.035	0.013	0.023			0.012	0.020	0.013	0.023
Lesser Nighthawk	0.065	0.120	0.086	0.159	0.075	0.139								

Table 3–11—continued

Table 3–11—continued

Organism	Ecoregion 1		Ecoregion 2		Ecoregion 3		Ecoregion 4		Ecoregion 5		Ecoregion 6		Ecoregion 7	
	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme
Common Nighthawk					0.073	0.137	0.050	0.094	0.036	0.069	0.043	0.081	0.050	0.094
Ruby-throated Hummingbird							0.050	0.094	0.026	0.064	0.041	0.077		
Black-chinned Hummingbird	0.069	0.128	0.091	0.170	0.079	0.148							0.050	0.094
Anna's Hummingbird	0.066	0.122	0.087	0.162									0.050	0.094
Belted Kingfisher	0.010	0.018	0.013	0.023			0.006	0.013	0.004	0.008	0.005	0.009	0.006	0.013
Northern Flicker	0.051	0.094	0.066	0.123			0.039	0072	0.029	0.052	0.034	0.062	0.039	0.072
Western Kingbird	0.072	0.136	0.096	0.179	0.084	0.157							0.056	0.106
Eastern Kingbird							0.056	0.106	0.077	0.117	0.057	0.092		
American Robin	0.054	0.096	0.068	0.124	0.061	0.111	0.042	0.074	0.032	0.055	0.036	0.063	0.042	0.074
Northern Mockingbird	0.074	0.137	0.097	0.180	0.086	0.158	0.074	0.137	0.041	0.074	0.057	0.088	0.074	0.137
European Starling	0.056	0.100	0.072	0.131	0.064	0.116	0.044	0.077	0.032	0.055	0.038	0.065	0.044	0.077
Red-winged Blackbird	0.046	0.086	0.061	0.114	0.053	0.100	0.034	0.063	0.023	0.044	0.028	0.053	0.034	0.063
Eastern Meadowlark					0.083	0.153	0.054	0.098	0.038	0.069	0.045	0.081		
Western Meadowlark	0.071	0.131	0.094	0.173									0.054	0.098
House Sparrow	0.087	0.117	0.114	0.154	0.101	0.135	0.066	0.129	0.047	0.060	0.056	0.071	0.066	0.129

Table 3–12. Spinosad Dose Estimates for Aerial Bait Spray Applications (mg/kg)—Reptiles

Organism	Ecoregion 1		Ecoregion 2		Ecoregion 3		Ecoregion 4		Ecoregion 5		Ecoregion 6		Ecoregion 7	
	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme
Desert Iguana	0.021	0.031	0.021	0.033										
Side-blotched Lizard	0.101	0.185	0.122	0.224									0.095	0.176
Carolina Anole					0.128	0.237	0.095	0.176	0.078	0.144	0.088	0.162		
Eastern Fence Lizard					0.124	0.197	0.089	0.143	0.071	0.115	0.079	0.128		
Western Fence Lizard	0.107	0.200	0.140	0.263									0.089	0.143
Canyon Lizard					0.119	0.219								
Gopher Snake	0.006	0.013	0.008	0.016	0.007	0.013	0.004	0.126	0.006	0.167			0.004	0.126
Garter Snake	0.003	0.044	0.032	0.056	0.025	0.050	0.018	0.035	0.013	0.026	0.015	0.030	0.018	0.035
Desert Tortoise	0.002	0.004	0.003	0.004										
Eastern Box Turtle							0.029	0.034	0.028	0.026	0.029	0.029		
Western Box Turtle			0.042	0.077	0.037	0.067	0.026	0.047						
Hognose Snake			0.030	0.054	0.027	0.047	0.018	0.030	0.013	0.021	0.014	0.025		

Table 3–13. Spinosad Dose Estimates for Aerial Bait Spray Applications (mg/kg)—Amphibians

Organism	Ecoregion 1		Ecoregion 2		Ecoregion 3		Ecoregion 4		Ecoregion 5		Ecoregion 6		Ecoregion 7	
	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme
Western Toad	0.171	0.318											0.141	0.261
Woodhouse Toad			0.223	0.418			0.141	0.261	0.104	0.194				
Texas Toad					0.201									
Southern Toad							0.144	0.266	0.106	0.197	0.125	0.233		
Pacific Treefrog	0.230	0.425	0.302	0.558									0.210	0.390
Green Treefrog					0.263		0.188	0.348	0.143	0.266	0.168	0.313		

Table 3–14. Spinosad Dose Estimates for Aerial Bait Spray Applications (mg/kg)—Terrestrial Invertebrates

Organism	Ecoregion 1		Ecoregion 2		Ecoregion 3		Ecoregion 4		Ecoregion 5		Ecoregion 6		Ecoregion 7	
	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme	Routine	Extreme
Earthworm	0.179	0.331	0.227	0.422	0.197	0.377	0.140	0.239	0.107	0.171	0.119	0.194	0.140	0.239
Slug	0.130	0.227	0.167	0.294	0.147	0.261	0.111	0.191	0.088	0.148	0.101	0.173	0.111	0.191
Sowbug	0.182	0.196	0.243	0.450	0.213	0.394	0.157	0.295	0.121	0.230	0.145	0.274		
Spider, Orb Web	0.463	1.06	0.613	1.415	0.538	1.240	0.328	0.775	0.218	0.531	0.259	0.926		
Mayfly, adult	0.219	0.394	0.292	0.525	0.255	0.460	0.204	0.380	0.164	0.310	0.197	0.372	0.204	0.380
Dragonfly, adult	0.251	0.465	0.330	0.613	0.290	0.539	0.213	0.400	0.164	0.310	0.195	0.368	0.213	0.400
Grasshopper	0.182	0.312	0.231	0.404	0.205	0.357	0.155	0.263	0.124	0.205	0.142	0.239	0.155	0.214
Lacewing, larva	1.076	2.007	1.428	2.665	1.252	2.335	0.909	1.718	0.692	1.318	0.826	1.431	0.909	1.718
Water Strider	0.235	0.463	0.308	0.609	0.271	0.536	0.188	0.367	0.139	0.270	0.164	0.319	0.188	0.367
Beetle, grub	0.210	0.449	0.274	0.589	0.242	0.519	0.188	0.396	0.151	0.313	0.178	0.369	0.188	0.396
Beetle, adult	0.468	0.842	0.595	1.053	0.537	0.971	0.408	0.738	0.338	0.609	0.380	0.690	0.408	0.738
Butterfly, Monarch	0.121	0.219	0.159	0.288	0.139	0.254	0.105	0.191	0.082	0.150	0.096	0.178	0.105	0.191
Moth, Geometer	0.187	0.341	0.247	0.453	0.139	0.397	0.162	0.299	0.125	0.233	0.149	0.278	0.162	0.299
Caterpillar	0.397	0.585	0.423	0.768	0.374	0.676	0.272	0.488	0.211	0.372	0.246	0.439	0.272	0.488
Maggot (larva)	0.266	0.572	0.354	0.763	0.310	0.667	0.237	0.499	0.186	0.387	0.222	0.463	0.237	0.499
Tachina, adult (parasitic fly)	0.312	0.575	0.414	0.764	0.362	0.670	0.268	0.502	0.206	0.388	0.246	0.465	0.268	0.502
Ant, Seed-eater	0.366	0.672	0.481	0.889	0.424	0.780	0.303	0.557	0.230	0.421	0.271	0.500	0.303	0.557
Honey Bee, Nectar forager	0.430	0.663	0.571	0.878	0.499	0.770	0.293	0.447	0.188	0.286	0.223	0.339	0.293	0.447
Parasitic Wasp	0.687	1.256	0.909	1.665	0.795	0.595	0.595	1.099	0.461	0.855	0.547	1.021	0.595	1.099

IV. Risk Characterization

This chapter combines information on the exposure assessment from previous chapters with the available toxicity data to express a measure of potential effects to populations of exposed nontarget species. The methods applied to determine risk are the same as those used in the Medfly Nontarget Risk Assessment (APHIS, 1992).

A. Human Health

Characterization of risk requires that certain standards be set for determining whether an exposure will result in hazards to human health. For this risk assessment, we will refer to the maximum acceptable exposure that poses no evident risk to human health as the regulatory reference value (RRV). The RRV selected for spinosad for occupational exposures is 0.27 mg/kg/day and for general population exposures is 0.027 mg/kg/day. A safety factor of 10 was applied for occupational exposure to the NOEL to make allowance for inter-species variability between the test animal and humans. An additional safety factor of 10 was applied for general population exposure to make allowance for intra-species variability and the potential for wider ranges in sensitivity within the general population than the occupational population.

The risks to workers from potential exposure to spinosad in eradication programs are very low. The highest potential occupational exposure to spinosad occurred in the extreme exposure scenario for ground personnel. The exposure to spinosad in this scenario was 2.68×10^{-3} mg/kg/day. The RRV is more than 100-fold greater than this exposure, so no adverse occupational effects can be expected from use of spinosad. No adverse effects to program workers can be expected when proper safety precautions are taken and proper application procedures are followed.

The risks to the general public from potential exposure to spinosad applied in the eradication programs are also very low. The highest potential exposure to spinosad occurs in the extreme scenario for a child consuming contaminated runoff water. The maximum potential exposure in this scenario to spinosad was 1.05×10^{-5} mg/kg/day. The RRV for spinosad is more than 1,000-fold greater than the exposures, so no adverse effects are anticipated to the general public, even under accidental exposure scenarios.

B. Wildlife

Ecological risk assessments, by definition, attempt to characterize effects on dynamic environments in which a great many species interact with complex and often not fully characterized interdependencies. Although the general geographic areas in which fruit fly program activities can be anticipated, the exact locations of potential treatment areas and the populations of nontarget species inhabiting these areas are not known. In an attempt to include most of the exposures which are likely to occur in these areas, this risk assessment characterizes a range of exposure scenarios to a diverse and representative group of organisms in each ecoregion. Results of our assessment were compared to an ecological risk assessment prepared for spinosad applications in cotton (Cleveland et al., 2001). Although the application rates to cotton are higher and their assessment methodology related to the cotton agroecosystem and use patterns, the low effects to most nontarget species were similar to, if not somewhat higher than, the risks determined from our analysis of spinosad bait spray applications. In particular, the lower rate of spinosad bait spray applications results in no issues of concern for aquatic invertebrates such as daphnia.

Routine exposure scenarios express the most likely conditions resulting from the program activities. Estimates of mortality for routine exposure scenarios for spinosad bait spray in the ecoregions are given in table 6–1 for aerial bait spray applications and in 6–2 for ground bait spray applications. These estimates are based upon the determined exposure, potential for receiving that exposure, and available information about toxicity. Although there was available data for many taxa, data for surrogate species were used for some susceptible terrestrial invertebrates when toxicity values were sparse. Toxicity data (median lethal dose) for 2-spotted spider mite were applied as surrogate data for slugs, sowbugs, and spiders. Toxicity data for Colorado Potato Beetle were applied as surrogate data for grasshoppers. Toxicity data for black cutworm were applied as surrogate data for beetle grubs. As was discussed in the section on hazard, there is wide variability in the susceptibility of caterpillars to spinosad, and selection of a highly tolerant or highly susceptible species would not provide results that are representative of actual mortality. The approach taken to assess a representative caterpillar mortality in the risk assessment was to average the median lethal dose and apply an average slope to that data. Using this probit data point and slope, the resulting curve was the basis for mortality results calculated to represent caterpillars.

The exposure of nontarget organisms to spinosad in bait spray applications is less than to malathion. The toxicity of the active ingredients in spinosad bait spray to mammals, birds, reptiles, fish, and amphibians is less than malathion also. As a result, the potential for exposure to most taxa is negligible and no mortality is expected to mammals, birds, reptiles, fish, and amphibians from spinosad bait spray applications.

Unlike malathion formulations (toxic to all organisms by all routes of exposure), the active ingredients in spinosad formulations are only toxic to certain invertebrates primarily by dermal exposure and ingestion, so the number of nontarget invertebrate species affected by these compounds is slightly diminished. Any invertebrate organism that is attracted to and feeds upon the bait will be exposed, but this is only a limited number of species. In addition, the low toxicity to most species indicates that the number of adversely affected organisms would be expected to be less than with malathion bait. A small number of phytophagous invertebrates may be killed by consumption of contaminated leaves from spinosad bait spray applications. In particular, Lepidoptera caterpillars are susceptible to increased mortality, but the low application rates of spinosad bait spray limit exposure of these species. Predators in fields treated with spinosad have had very little, if any, mortality and these species should not be affected by spinosad bait spray applications. The short half-life of spinosad (relative to malathion) results in less exposure, and internal feeders such as fly maggots are not expected to actually receive exposure. Since ground applications are applied specifically to host plants, the number of nontarget insects exposed will be less than from aerial applications. It is estimated that there will be 50 percent less mortality to populations of most nontarget species from ground applications than from aerial applications. The decreases to populations of these affected nontarget invertebrates that are not directly attracted to the bait spray would be expected to be temporary and their populations would recover after program use of spinosad bait spray ceases. Recent review of the beneficial arthropods shown to be affected by spinosad applications in some studies indicates potential effects to minute pirate bugs (anthocoridae), some mites, some parasitic wasps, some rove beetles (staphylinidae), some spiders, and some nontarget flies (Thompson, 2003). The low application rates of spinosad in the bait spray formulation minimize potential effects to most of these species.

The safety of the insecticide applications to most terrestrial wildlife is considerable. The risks of adverse effects on survival of mammals, birds, reptiles, and terrestrial amphibians are very low and of a magnitude similar to that of human health risks. Label application rates of spinosad to plants produce exposures at levels below any that could be expected to cause phytotoxic responses.

The primary route of toxic action (oral) in invertebrates determines the number of species likely to be at maximum risk of adverse effects. Considerable exposure is expected for those invertebrates attracted to the bait. These species include plant bugs, midges, gnats, acalypterate muscoid flies (such as fruit flies), some ants, and soil mites. Of this exposed group, the only susceptible species are the midges, gnats, acalypterate muscoid flies, and some mites. The other species are more tolerant of spinosad. Populations of the susceptible insects are likely to be reduced considerably due to the toxic action of the insecticide. The risk to most other species is much lower. Species that are not attracted to the protein hydrolysate have lower potential exposure and are at lower risk. This group includes honey bees, lacewings, springtails, aphids, whiteflies, tumbling flower beetles, calypterate muscoid flies, and spiders. The ammonium acetate in the spinosad bait repels some species such as honey bees and thereby, decreases the likelihood of exposure. Many of the species that are not expected to be affected by spinosad bait spray are adversely affected by malathion bait spray through contact exposure or greater sensitivity. However, there are some species that are highly susceptible to spinosad toxicity. Although the baits are not attractive to these species, their greater susceptibility makes it likely that these species will have high mortality unless protection or mitigation measures are applied to prevent exposure.

Aquatic species are at very low risk of adverse effects. The concentration of spinosad in water is several orders of magnitude less than any concentration known to adversely affect aquatic organisms. The water solubility ensures that residues would not bioconcentrate in tissues, so adverse effects would not be expected from the short residual exposures. The short half-life in water indicates that adverse effects from spinosad would have to occur within a few hours of application, and the concentration in water is lower than would be expected to affect these species.

Table 6–1. Mortality Estimates from Routine Exposures of Nontarget Species to Aerial Spinosad Bait Spray Applications by Ecoregion

Species	Mortality Estimate by Ecoregion						
	1	2	3	4	5	6	7
Opossum	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Shrew	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Bat	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cottontail	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Squirrel	<1.0	N/A	<1.0	<1.0	<1.0	<1.0	<1.0
Mouse	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Raccoon	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fox	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Coyote/Dog	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cat	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Deer	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Terrestrial Birds							
Pied-billed grebe	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Great blue heron	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cattle egret	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Duck	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Turkey Vulture	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Red-tailed hawk	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
American kestrel	<1.0	<1.0	N/A	<1.0	<1.0	<1.0	<1.0
Quail	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Killdeer	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mourning dove	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Great horned owl	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Burrowing owl	<1.0	<1.0	<1.0	<1.0	N/A	<1.0	<1.0
Nighthawk	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hummingbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Belted kingfisher	<1.0	<1.0	N/A	<1.0	<1.0	<1.0	<1.0
Northern flicker	<1.0	<1.0	N/A	<1.0	<1.0	<1.0	<1.0
Kingbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
American robin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Northern mockingbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
European starling	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Red-winged blackbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Meadowlark	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
House sparrow	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table 6–1—continued

Table 6–1—continued

Terrestrial Reptiles							
Desert iguana	<1.0	<1.0	N/A	N/A	N/A	N/A	N/A
Side-blotched lizard	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Carolina anole	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
Eastern fence lizard	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
Western fence lizard	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Canyon lizard	N/A	N/A	<1.0	N/A	N/A	N/A	N/A
Gopher snake	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Garter snake	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Desert tortoise	<1.0	<1.0	N/A	N/A	N/A	N/A	N/A
Eastern box turtle	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Western box turtle	N/A	<1.0	<1.0	<1.0	N/A	N/A	N/A
Hognose snake	N/A	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Terrestrial Amphibians							
Toad	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tree frog	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Terrestrial Invertebrates							
Earthworm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Slug	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sowbug	<1.0	2.14	1.24	<1.0	<1.0	<1.0	<1.0
Spider	9.0	13.4	11.2	4.8	1.9	3.1	N/A
Mayfly	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Grasshopper	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lacewing	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Water strider	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Beetle, grub	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Beetle, adult	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Butterfly	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Moth	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Caterpillar	6.25	6.66	5.89	4.28	3.32	3.87	4.28
Maggot	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fly	100	100	100	100	100	100	100
Ant	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Honey bee	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Wasp	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Fish (habitat)							
Golden shiner (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Golden shiner (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table 6–1—continued

Table 6–1—continued

Speckled dace (stream)	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Mexican tetra (stream)	N/A	N/A	<1.0	N/A	N/A	N/A	N/A
Silvery minnow	N/A	N/A	N/A	<1.0	<1.0	N/A	N/A
Goldfish (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sheepshead minnow (stream)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Sheepshead minnow (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
California killifish (stream)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
California killifish (wetland)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
Swamp darter	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Mosquitofish (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mosquitofish (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Rainbow trout (stream)	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Rainbow trout (lake)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
Arroyo chub (stream)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
Bluegill sunfish (stream)	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
Bluegill sunfish (lake)	<1.0	N/A	<1.0	<1.0	<1.0	<1.0	<1.0
Bluegill sunfish (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Largemouth bass (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Largemouth bass (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Channel catfish (stream)	N/A	N/A	<1.0	N/A	<1.0	<1.0	N/A
Channel catfish (lake)	N/A	N/A	N/A	N/A	<1.0	<1.0	<1.0
Yellow bullhead catfish (stream)	N/A	N/A	N/A	<1.0	<1.0	N/A	N/A
Yellow bullhead catfish (lake)	N/A	N/A	N/A	N/A	<1.0	N/A	N/A
Yellow bullhead catfish (pond)	<1.0	N/A	<1.0	<1.0	<1.0	<1.0	<1.0
Longnose gar (lake)	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
longnose gar (pond)	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
longnose gar (wetland)	N/A	N/A	N/A	N/A	N/A	<1.0	N/A

Table 6–1—continued

Table 6–1—continued

Lake chubsucker (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Aquatic Reptiles							
Snapping turtle (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Western pond turtle (wetland)	<1.0	N/A	N/A	N/A	N/A	N/A	<1.0
Water snake (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Aquatic Amphibians (larval forms)							
Bullfrog (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	N/A
Tiger salamander (wetland)	<1.0	N/A	N/A	<1.0	<1.0	N/A	<1.0
Amphiuma (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Aquatic Invertebrates							
Hydra (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Leech (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Leech (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Leech (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Sponge, freshwater	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Clam, freshwater (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Snail, freshwater (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Snail, freshwater (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Scud (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Crayfish (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Crayfish (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Water flea (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly, larva (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly, larva (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Mayfly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mayfly, larva (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Stonefly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Caddisfly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Backswimmer (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table 6–1—continued

Table 6–1—continued

Backswimmer (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Beetle (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mosquito, larva (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mosquito, larva (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0

Table 6–2. Mortality Estimates from Routine Exposures of Nontarget Species to Ground Spinosad Bait Spray Applications by Ecoregion

Species	Mortality Estimate by Ecoregion						
	1	2	3	4	5	6	7
Opossum	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Shrew	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Bat	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cottontail	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Squirrel	<1.0	N/A	<1.0	<1.0	<1.0	<1.0	<1.0
Mouse	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Raccoon	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fox	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Coyote/Dog	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cat	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Deer	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Terrestrial Birds							
Pied-billed grebe	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Great blue heron	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cattle egret	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Duck	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Turkey Vulture	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Red-tailed hawk	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
American kestrel	<1.0	<1.0	N/A	<1.0	<1.0	<1.0	<1.0
Quail	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Killdeer	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mourning dove	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Great horned owl	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Burrowing owl	<1.0	<1.0	<1.0	<1.0	N/A	<1.0	<1.0
Nighthawk	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hummingbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Belted kingfisher	<1.0	<1.0	N/A	<1.0	<1.0	<1.0	<1.0
Northern flicker	<1.0	<1.0	N/A	<1.0	<1.0	<1.0	<1.0

Table 6–2—continued

Table 6–2—continued

Kingbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
American robin	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Northern mockingbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
European starling	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Red-winged blackbird	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Meadowlark	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
House sparrow	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Terrestrial Reptiles							
Desert iguana	<1.0	<1.0	N/A	N/A	N/A	N/A	N/A
Side-blotched lizard	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Carolina anole	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
Eastern fence lizard	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
Western fence lizard	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Canyon lizard	N/A	N/A	<1.0	N/A	N/A	N/A	N/A
Gopher snake	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Garter snake	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Desert tortoise	<1.0	<1.0	N/A	N/A	N/A	N/A	N/A
Eastern box turtle	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Western box turtle	N/A	<1.0	<1.0	<1.0	N/A	N/A	N/A
Hognose snake	N/A	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Terrestrial Amphibians							
Toad	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tree frog	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Terrestrial Invertebrates							
Earthworm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Slug	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sowbug	<1.0	1.57	1.12	<1.0	<1.0	<1.0	N/A
Spider	5.0	7.2	6.1	2.9	1.5	2.1	N/A
Mayfly	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Grasshopper	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lacewing	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Water strider	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Beetle, grub	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Beetle, adult	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Butterfly	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Moth	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Caterpillar	3.13	3.33	2.95	2.14	1.66	1.94	2.14

Table 6–2—continued

Table 6–2—continued

Maggot	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fly	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Ant	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Honey bee	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Wasp	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Fish (habitat)							
Golden shiner (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Golden shiner (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Speckled dace (stream)	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Mexican tetra (stream)	N/A	N/A	<1.0	N/A	N/A	N/A	N/A
Silvery minnow	N/A	N/A	N/A	<1.0	<1.0	N/A	N/A
Goldfish (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sheepshead minnow (stream)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Sheepshead minnow (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
California killifish (stream)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
California killifish (wetland)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
Swamp darter	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Mosquitofish (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mosquitofish (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Rainbow trout (stream)	<1.0	<1.0	N/A	N/A	N/A	N/A	<1.0
Rainbow trout (lake)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
Arroyo chub (stream)	<1.0	N/A	N/A	N/A	N/A	N/A	N/A
Bluegill sunfish (stream)	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
Bluegill sunfish (lake)	<1.0	N/A	<1.0	<1.0	<1.0	<1.0	<1.0
Bluegill sunfish (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Largemouth bass (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Largemouth bass (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Channel catfish (stream)	N/A	N/A	<1.0	N/A	<1.0	<1.0	N/A
Channel catfish (lake)	N/A	N/A	N/A	N/A	<1.0	<1.0	<1.0
Caterpillar	50.0	50.0	50.0	50.0	50.0	50.0	50.0

Table 6–2—continued

Table 6–2—continued

Yellow bullhead catfish (stream)	N/A	N/A	N/A	<1.0	<1.0	N/A	N/A
Yellow bullhead catfish (lake)	N/A	N/A	N/A	N/A	<1.0	N/A	N/A
Yellow bullhead catfish (pond)	<1.0	N/A	<1.0	<1.0	<1.0	<1.0	<1.0
Longnose gar (lake)	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
longnose gar (pond)	N/A	N/A	<1.0	<1.0	<1.0	<1.0	N/A
longnose gar (wetland)	N/A	N/A	N/A	N/A	N/A	<1.0	N/A
Lake chubsucker (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/A
Aquatic Reptiles							
Snapping turtle (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Western pond turtle (wetland)	<1.0	N/A	N/A	N/A	N/A	N/A	<1.0
Water snake (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Aquatic Amphibians (larval forms)							
Bullfrog (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	N/A
Tiger salamander (wetland)	<1.0	N/A	N/A	<1.0	<1.0	N/A	<1.0
Amphiuma (wetland)	N/A	N/A	N/A	<1.0	<1.0	<1.0	N/A
Aquatic Invertebrates							
Hydra (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Leech (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Leech (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Leech (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Sponge, freshwater	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Clam, freshwater (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Snail, freshwater (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Snail, freshwater (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Scud (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Crayfish (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Crayfish (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Water flea (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dragonfly, larva (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table 6–2—continued

Table 6–2—continued

Dragonfly, larva (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Mayfly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mayfly, larva (lake)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Stonefly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Caddisfly, larva (stream)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Backswimmer (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Backswimmer (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0
Beetle (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mosquito, larva (pond)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mosquito, larva (wetland)	<1.0	N/A	N/A	<1.0	<1.0	<1.0	<1.0

C. Environmental Quality

The risks from applications of spinosad to environmental quality are minimal. Spinosad persists for only a few hours in air or water due to rapid photodegradation. The water solubility and rapid photodegradation ensure that any evidence of absorption into permeable substrates or adsorption to inert surfaces is not evident shortly after sunlight, rainfall or weathering. This rapid breakdown ensures that no permanent effects can be anticipated on the quality of air, soil, and water. The frequency of spinosad bait spray applications for fruit fly control does not result in cumulative impacts to environmental media. Environmental monitoring data from California (CDPR, 2003), Texas (USAD, APHIS, 2002b), and Guatemala (USDA, APHIS, 2002a, 2001, 2000) verify that there are no concerns about adverse impacts from spinosad bait spray applications to these environmental media.

V. Conclusions

Applications of spinosad in bait spray pose low risk to program personnel, the general public, environmental quality, and most nontarget organisms. Risks are low to mammals, birds, reptiles, amphibians, fish, aquatic invertebrates, and plants. Risks are also low to most terrestrial invertebrates. Populations of those species attracted to the protein hydrolysate bait in malathion bait spray are at elevated risk. This includes acalypterate muscoid flies (such as fruit flies), some plant bugs (miridae), midges, gnats, ants, and soil mites. Many species at high risk in eradication programs using malathion bait spray against fruit flies are not at risk in programs using spinosad bait. Nontarget invertebrates at risk of adverse effects from malathion bait spray applications and unlikely to be affected by spinosad bait spray include earthworms, slugs, grasshoppers, lacewings, water striders, beetles, and ants. A major consideration before conducting spinosad bait spray applications is the determination of any endangered or threatened invertebrate species attracted to the protein hydrolysate within or adjacent to the proposed treatment area. Presence of susceptible endangered or threatened invertebrate species attracted to the bait would require measures to prevent exposure of these organisms. This could be accomplished through the use of buffers or similar measures to prevent exposure. Honey bees are not attracted to spinosad bait, and applications have been shown to have no adverse effects on foraging honey bees or hive production. In the absence of susceptible endangered and threatened species, applications of spinosad bait spray would not be anticipated to pose any significant adverse risks to environmental quality, human health or survival of wildlife.

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APPENDIX

Appendix 1. Chemical and Physical Properties of Spinosad

Note: All physical properties pertain to 20–25 °C temperatures unless otherwise noted.

Spinosad

Spinosyn A
CAS # 131929–60–7

Spinosyn D
CAS # 131929–63–0

Density (g/cm^2):
1.09

Henry's constant ($atm\text{-}m^3/mol$)
$9.82x10^{-10}$
$4.87x10^{-7}$

Organic Carbon Partition Coefficient (K_{oc}):
708 (Spinosyn A)
(calculated by equation in Briggs, 1990)
1259 (Spinosyn D)

Octanol/Water Partition Coefficient (K_{ow}):
7943 (spinosyn A)
(Log K_{ow} = 3.9 (spinosyn A), 4.4 (spinosyn D))
25118 (spinosyn D)

Plant Washoff fraction:
0.9

Soil Half-life (days):
9.4–17.3 days (spinosyn A)
14.5 days (spinosyn D)

Acqueous Photolysis Half-life (days):
<1 day

Vapor pressure (mm Hg):
$2.4x10^{-10}$ (spinosyn A)
$1.6x10^{-10}$ (spinosyn D)

Water Solubility (mg/L):
235 (spinosyn A)
0.329 (spinosyn D)