

Preliminary effects determination for Kirtland's warbler based on uses of diazinon

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4/15/15

Outline

- Introduction: weight of evidence
- Species description
- Diazinon use
- Spatial overlap of species range and use sites
- Effects
 - Thresholds
 - Arrays
- Exposure
- Effects determination
 - Weight of evidence

Weight of evidence analysis for Kirtland's Warbler

- Is it likely that the fitness of an individual will be adversely affected by diazinon according to registered labels?
- Lines of evidence used to address this question
 - Mortality
 - Decreased growth
 - Decreased reproduction
 - Impacts to behavior
 - Sensory effects
 - Indirect effects (through impacts to insect diet)
 - Other stressors that may impact potential effects of diazinon
 - chemical stressors (oxon degradate, other pesticides)
 - Non-chemical stressors

Weight of evidence analysis for Kirtland's Warbler

- Species life history
- Overlap of species range and potential use sites
- Compare exposure effects data
 - Thresholds
 - Arrays
 - Consider duration of exposure relative to endpoints
- Calculate distance from edge of field where spray drift deposition is of concern
- Incidents
- Uncertainty analysis
- Refined risk assessment methods (TIM, MCnest)

Kirtland's Warbler (*Setophaga kirtlandii*)

- Endangered
 - Most recent population estimate
 - Singing Males: 2090 (in 2012)
 - No designated critical habitat
- Life history
 - Small bird (12-16 g)
 - Diet: insects and fruit
 - Spittlebugs, aphids, ants, wasps, moth larvae
 - Blueberries



Photo from: Birdzilla.com

Habitat

- Migration
 - Scrub/shrub
- Breeding: pine forests (obligate)
 - Jack and red pine
 - Dense, young (5-23 yrs old)
 - Include small open grassy areas
 - Areas >8 A, prefer areas ~80 A
 - Dry sandy soil
 - Nests on ground
 - Require dense clumps of grass or other vegetation
 - Under low hanging pine branches
- Foraging
 - Glean among pine needles, leaves of deciduous shrubs and ground
 - Females search for food within 91-122 m of nest
 - Foraging range of males is unknown



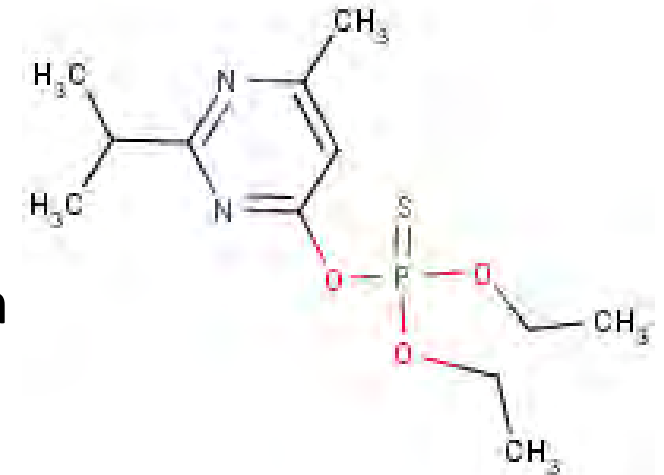
Photo from: Birds of North America

Range

- Breeds in MI and WI (May – August)
- Winter (September – April) in Bahamas
- Migrates to breeding grounds in spring (late April – mid May)
 - Returns to Bahamas in Aug-Sept
 - Known to occur in FL and SC and other sites along migratory corridor
 - Timing: Migration takes individual ≥ 13 d
 - Stops for 1.2 d (range 1-12) to forage
- Occurs on federal lands in MI and WI
 - FWS refuge
 - 190,000 A of breeding habitat are managed by state and federal agencies
 - Birds also nest on private land
 - *e.g.*, timber company land in WI

Diazinon

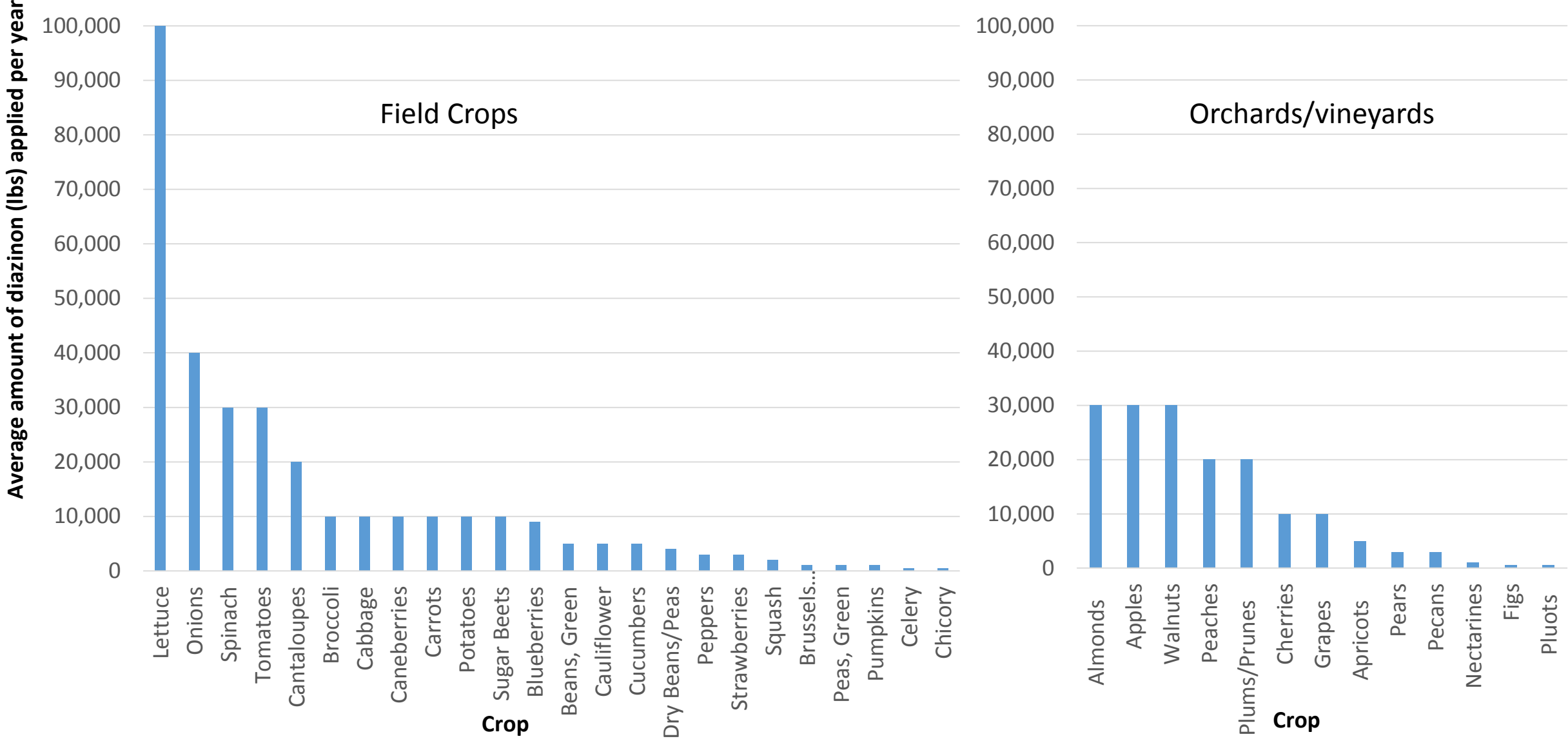
- Organophosphate insecticide
 - Mode of action = acetylcholinesterase (AChE) inhibition
- Targets include wide range of insects and mites
 - *e.g.*, aphids, larvae, scales, fire ants, fruit flies
 - There is overlap between the target species and the Kirtland warbler's diet
- Used on field crops (fruit and vegetable), orchards, vineyards and nurseries
- Dissipates from terrestrial habitats in days
 - Foliar dissipation half-life = 0.4-5.3 d



Diazinon uses relevant to the Kirtland's warbler

Crop	Foliar/soil	Application method	Single application rate (lb a.i./A)	Number of applications	Interval between applications (d)
Ginseng	Foliar	Ground	0.5	1	none
Lettuce	Foliar	Ground, aerial	0.5	1	none
Melons	Foliar	Ground	0.8	1	none
Outdoor ornamentals (nurseries)	Foliar	Ground, airblast	1	1 (per season)	none
Strawberries	Foliar and soil	Ground	1	1	none
Blueberries	Foliar	Ground, airblast	1	2	30
Pineapples	Foliar	Ground, airblast	1	2	28
Parsnips	Foliar	Ground	1	5	7
Lettuce	Soil	Ground, aerial	2	1	none
Apples	Foliar	Ground, airblast	2	2	14
Cherries	Foliar	Ground, airblast	2	2	30
Stone fruit	Foliar	Ground, airblast	2	2	60
Pears	Foliar	Ground, airblast	2	2	70
Cranberries	Foliar	Ground, airblast	3	3	14
Beans, beets, carrots, cole crops, endive, melons, onions, potatoes, radishes, rutabagas, squash, sweet potatoes	Soil	Ground	4	1	none

Estimated diazinon use in the US



Acres of potential diazinon use sites (from NASS 2012) in counties where Kirtland's warbler occurs

Orchard/bush crop	Acres
CHERRIES, TART	9589
CRANBERRIES	4685
CHERRIES, SWEET	2713
APPLES	2260
BLUEBERRIES, TAME	218
PEACHES, ALL	186
PEARS, ALL	134
PLUMS AND PRUNES	115
Nursery category	Acres
NURSERY STOCK CROPS in the open	21330
POTTED FLOWERING PLANTS in the open	410
OTHER FLORICULTURE AND BEDDING CROPS in the open	262

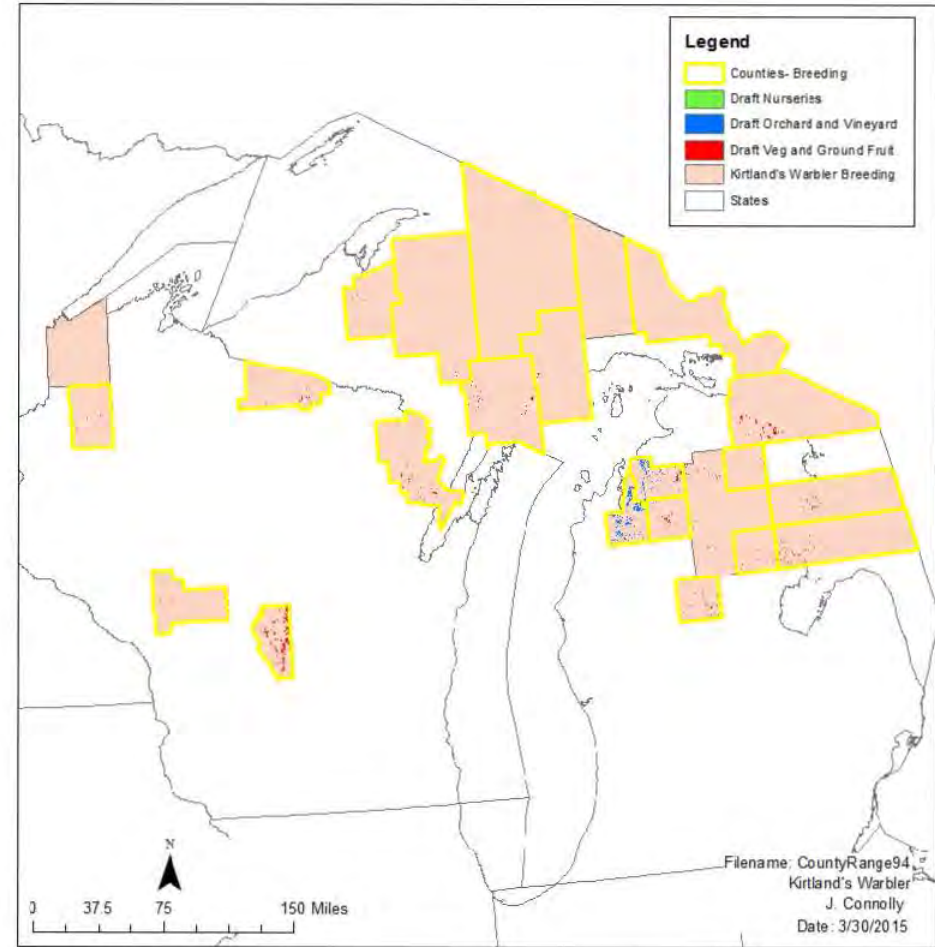
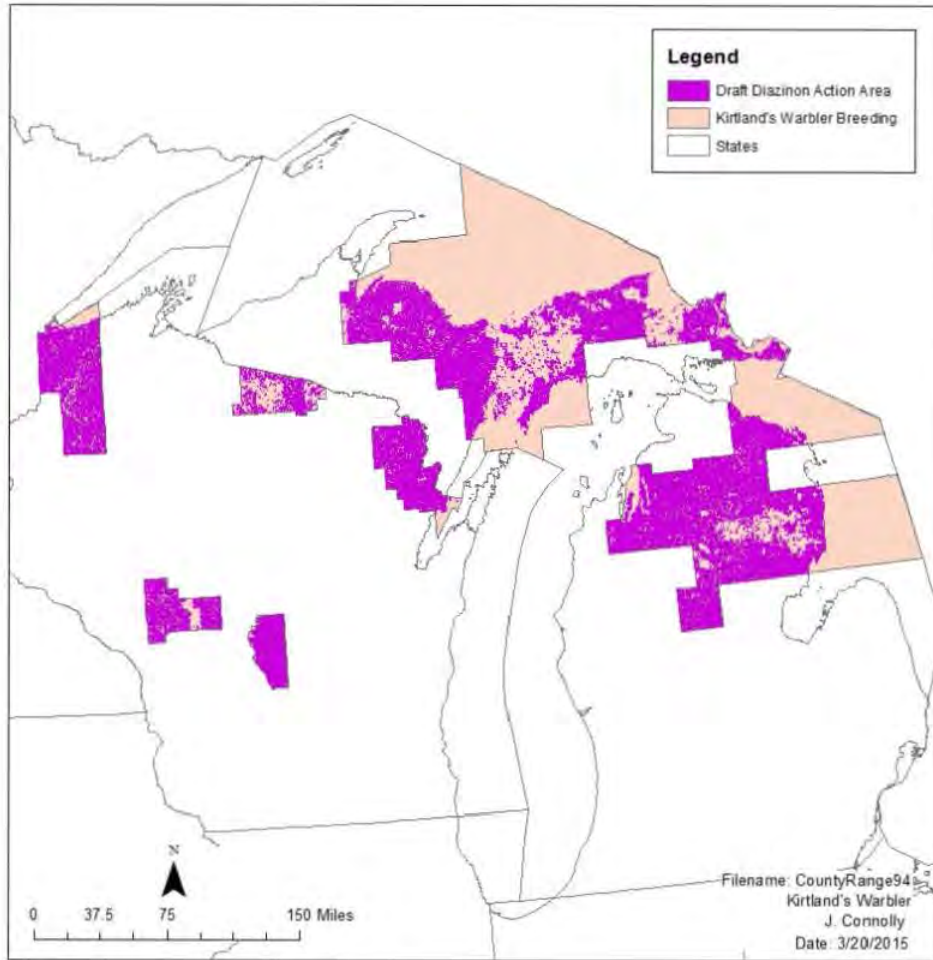
Field crop	Acres
BEANS, SNAP (BUSH AND POLE)	31128
POTATOES	16675
RADISHES	4881
DRY EDIBLE BEANS, EXCLUDING LIMAS	3417
WATERMELONS	3013
SQUASH, ALL	2920
CABBAGE, HEAD	569
SQUASH, WINTER	88
Other vegetables (including parsnips, rutabagas)	83
STRAWBERRIES	70
CANTALOUPE AND MUSKMELONS	56
SQUASH, SUMMER	45
LETTUCE, ALL	34
COLLARDS	26
ONIONS (dry + Green)	17
KALE	12
MUSTARD GREENS	8
SWEET POTATOES	8
TURNIPS	7
VEGETABLE SEEDS in the open	6
BEANS, GREEN LIMA	5
BROCCOLI	4
CARROTS	4
BEETS	3
TURNIP GREENS	3
CAULIFLOWER	2

Diazinon uses relevant to the Kirtland's warbler

Use sites with >1000 A harvested in counties where species occurs

Crop	Foliar/soil	Application method	Single application rate (lb a.i./A)	Number of applications	Interval between applications (d)
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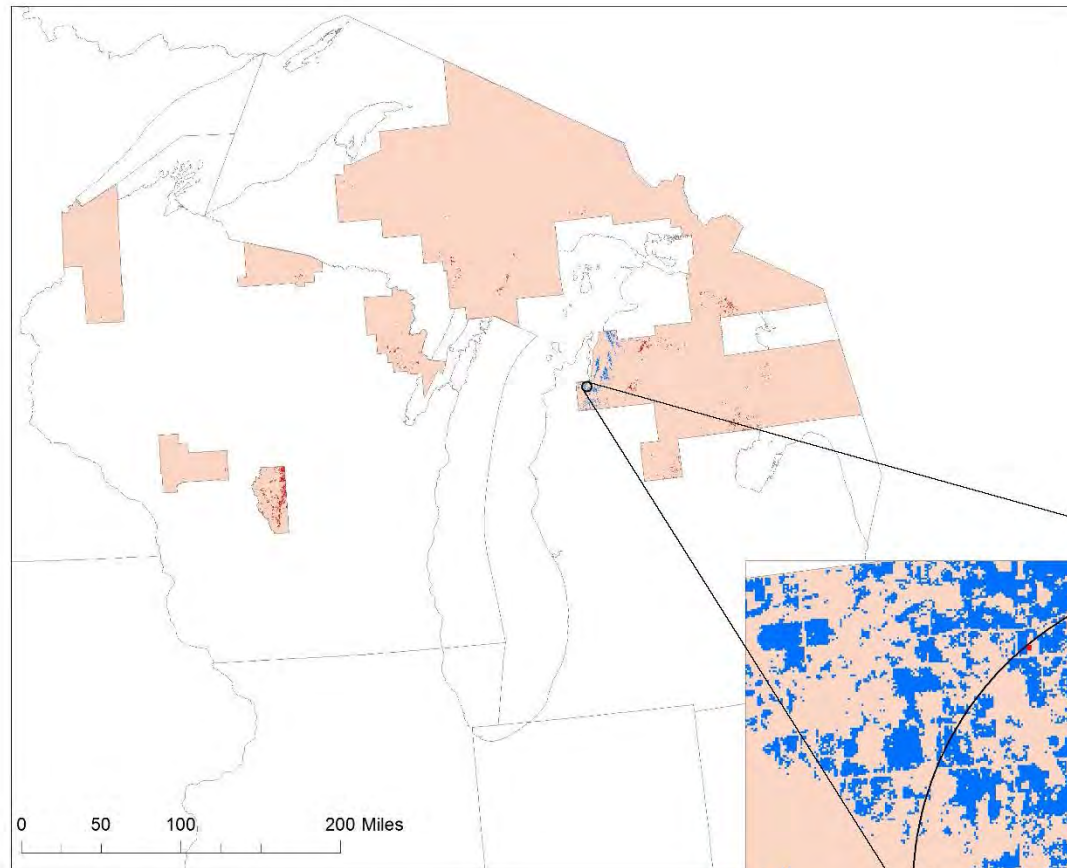
Overlap between breeding range and potential diazinon use sites



Group	Scientific Name	Common Name	Status	Action Area
Birds	<i>Setophaga kirtlandii</i> (= <i>Dendroica kirtlandii</i>)	Kirtland's Warbler	Endangered	11,609,697

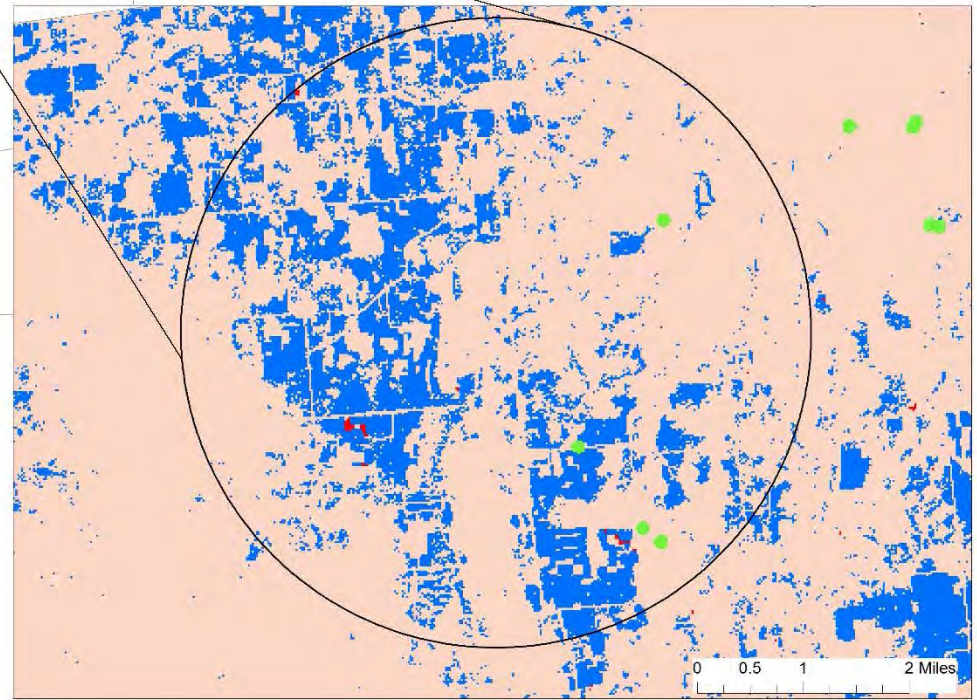
Common Name	Scientific Name	Status	Percent Overlap AA	Percent Overlap Nurseries	Percent Overlap Vegetable ground fruit	Percent Overlap Orchards and Vineyard
Kirtland's Warbler	<i>Setophaga kirtlandii</i> (= <i>Dendroica kirtlandii</i>)	Endangered	50%	0.003%	0.42%	0.25%

APPLES	BEANS	BEETS	BLUEBERRIES	BROCCOLI	CABBAGE	MELONS	CARROTS	CHERRIES	CRANBERRIES	LETTUCE	STONE FRUIT	PEARS	POTATOES	SQUASH	STRAWBERRIES
2250	10133	17	90	2	46	18	4	12302	4685	3	125	129	16634	216	14



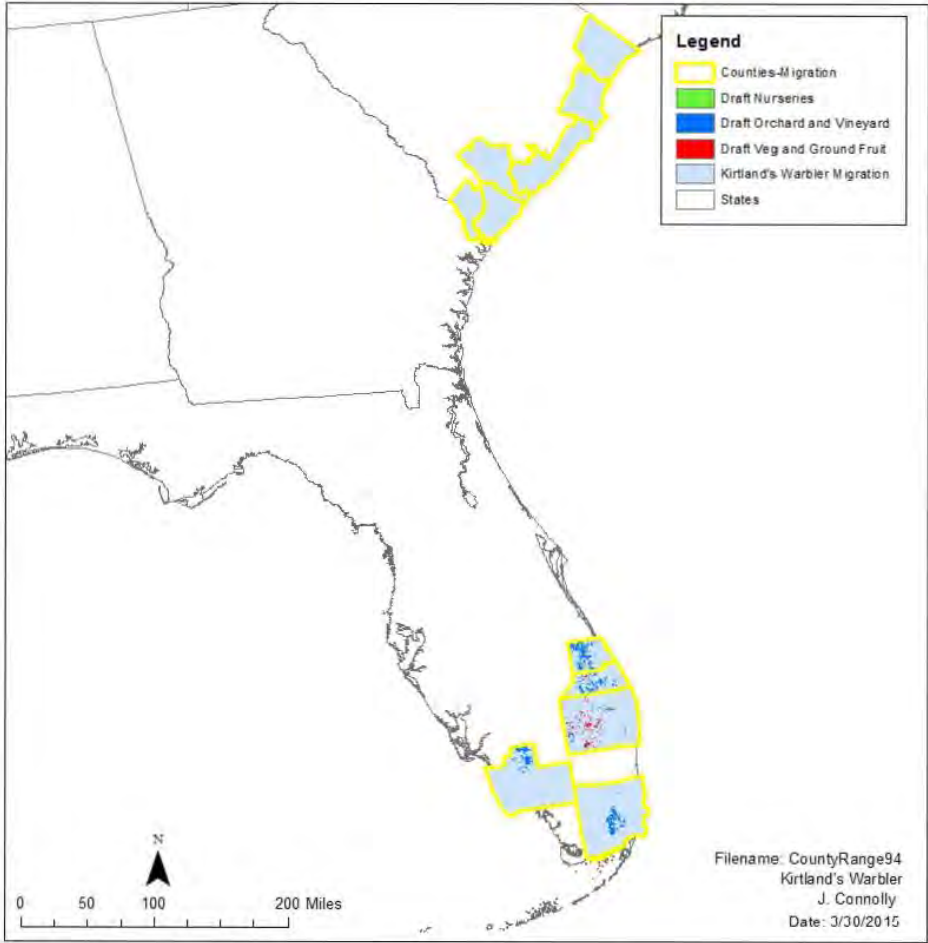
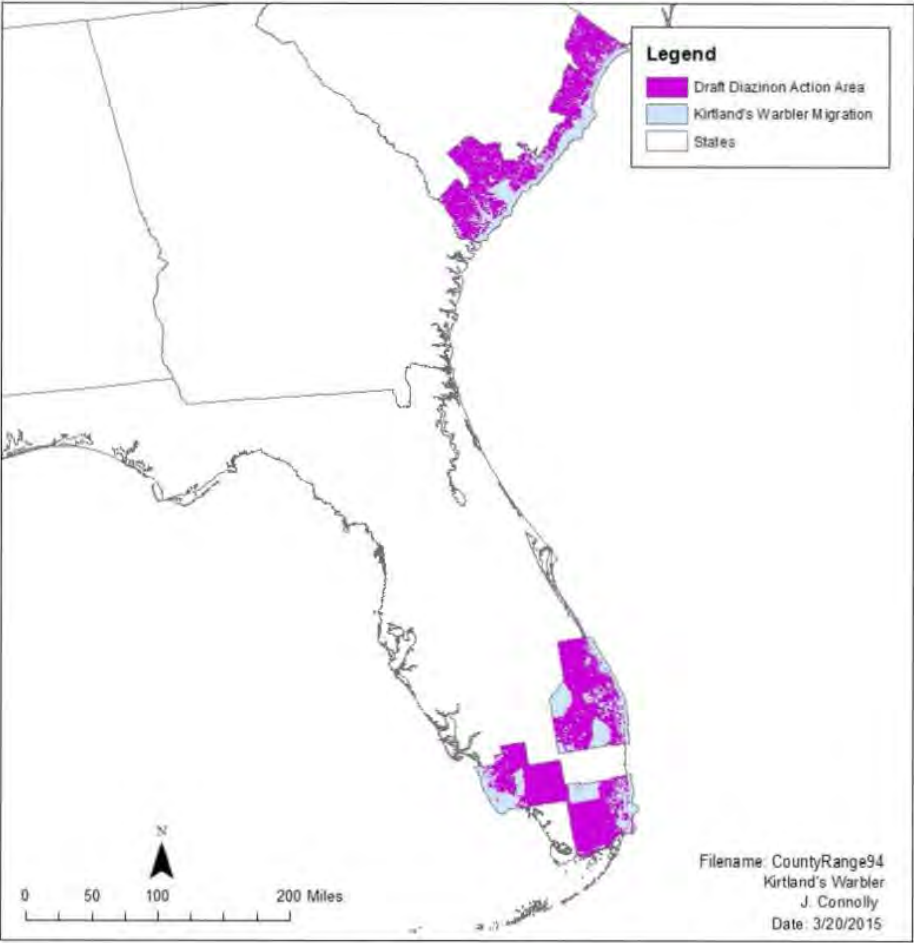
Legend

- Draft Nurseries
- Draft Orchard and Vineyard
- Draft Veg and Ground Fruit
- Kirtland's Warbler Breeding
- States



Filename: CountyRange94
Kirtland's Warbler
J. Connolly
Date: 3/30/2015

Overlap between subset of migratory range and potential diazinon use sites



Group	Scientific Name	Common Name	Status	Action Area
Birds	<i>Setophaga kirtlandii</i> (= <i>Dendroica kirtlandii</i>)	Kirtland's Warbler	Endangered	6,298,547

Common Name	Scientific Name	Status	Percent Overlap AA	Percent Overlap Nurseries	Percent Overlap Vegetable ground fruit	Percent Overlap Orchards and Vineyard
Kirtland's Warbler	<i>Setophaga kirtlandii</i> (= <i>Dendroica kirtlandii</i>)	Endangered	66%	0.05%	0.72%	7.14%

APPLES	BEANS	BLUEBERRIES	BROCCOLI	CABBAGE	MELONS	COLLARDS	KALE	LETTUCE	ONION	STONEFRUIT	PEAR	POTATOES	RADISHES	SQUASH
10	21103	128	2	523	3051	26	11	31	13	176	5	41	4881	2828

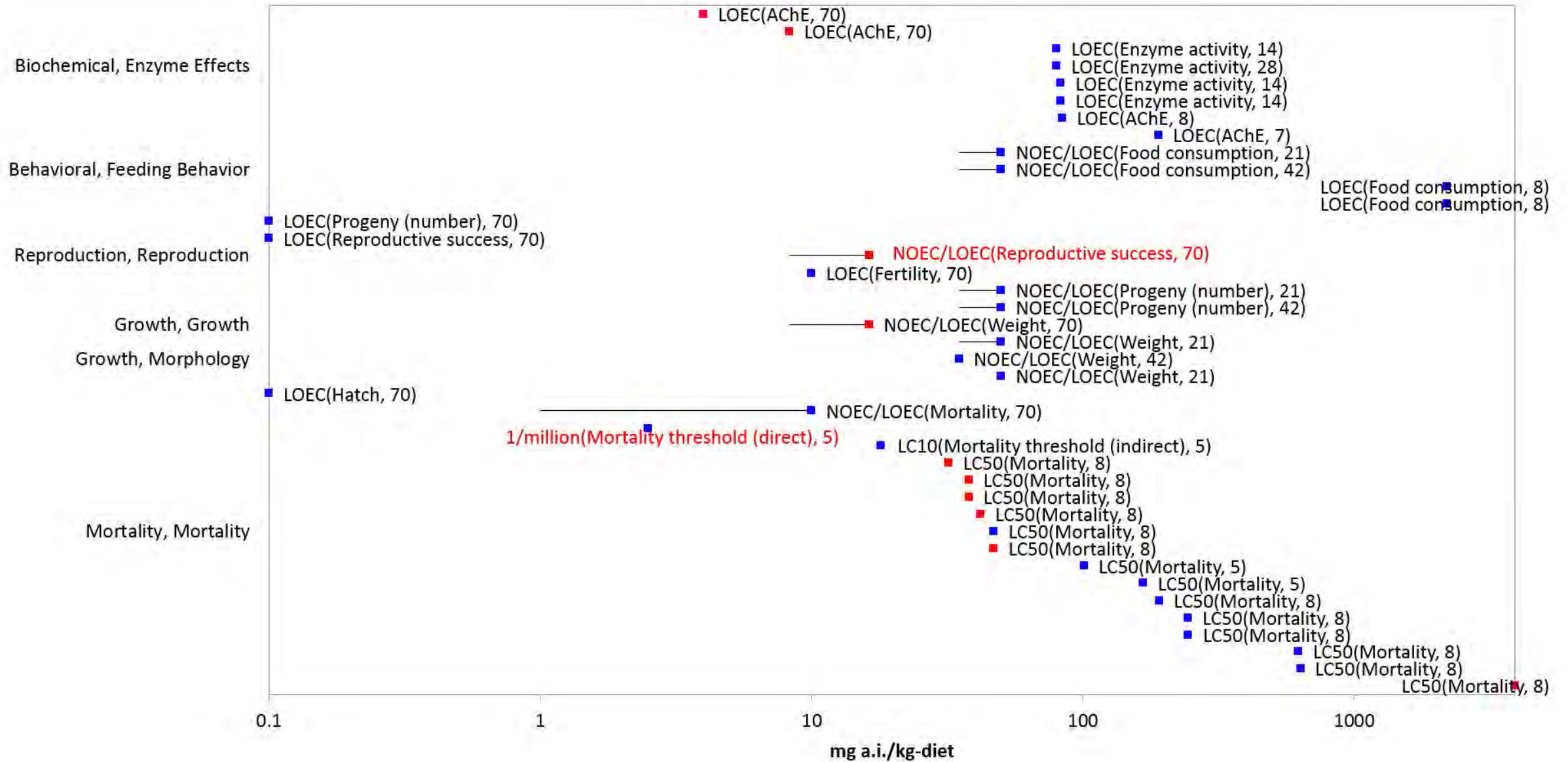
Field-level considerations for overlap of diazinon use sites and individual Kirtland's warblers

- For different crops, there may be different levels of certainty in overlap
 - An individual may be more likely to stop during migration or breed near a crop with a larger spatial extent in the counties where the species occurs
 - Is the habitat of the Kirtland's warbler comparable to that of treated fields or edge?
 - Are there known occurrences of Kirtland's warbler on fields with specific crops?
 - Observed in orchards during migration
- Does the diet of the Kirtland's warbler overlap with food items that would be on a treated field?
 - Target pests of diazinon are part of the diet (*e.g.*, aphids, ants)
 - Diazinon is registered for use on blueberries, blueberries are in the diet
- Duration of exposure
 - Migration: exposure duration will be acute (*e.g.*, 1 day), may be repeated depending upon how many times the birds stop
 - Breeding: exposure duration could be chronic (*e.g.*, occurring over weeks-months)

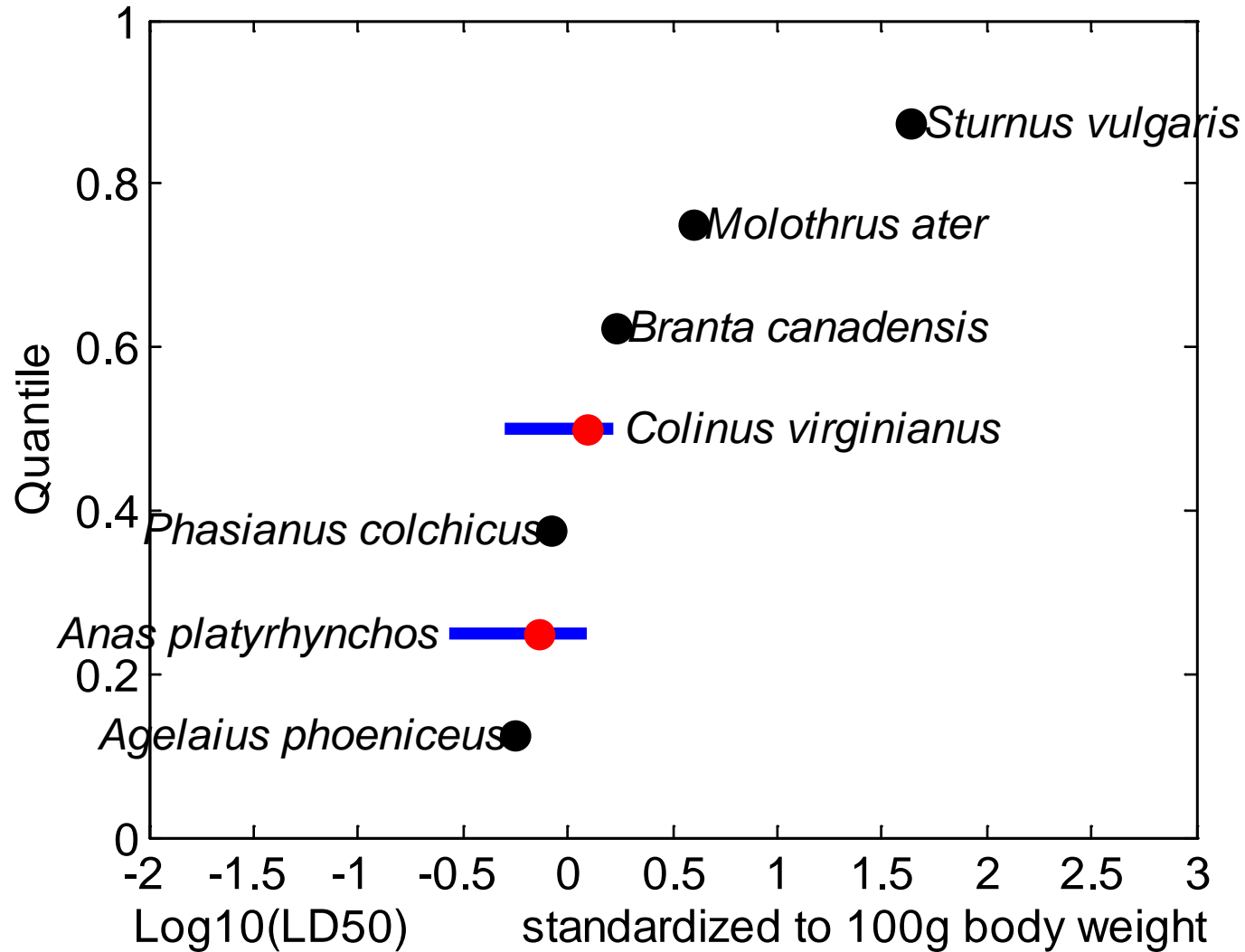
Avian thresholds for direct effects

Effect (endpoint)	Value	Unit	Test species	Duration of exposure	Source
Mortality (1/million)	2.5	mg ai/kg-diet	brown headed cowbird	5 days	MRID 40895302; LC50 = 38 mg/kg-diet; slope = 4.0
	Scaled to Kirtland's warbler: 0.037-0.041	mg ai/kg-bw	Mallard duck, bobwhite quail, ring-necked pheasant, Canada goose, red-winged blackbird, brown-headed cowbird, starling	Single dose	HC05 from SSD (0.43), slope = 3.53, scaled to 100 g BW
	0.0032	lb a.i./A	Canada goose	5 days	ECOTOX# 85970; LC50 = 0.31 (includes diet and dermal exposures); slope = 2.4
Reproduction (NOEC)	8.3	mg ai/kg-diet	Mallard duck	10 weeks	LOEC = 16.3; MRID 41322901
Behavior (sitting, inability to walk; NOEL)	Scaled to Kirtland's warbler: 1.7-1.9	mg ai/kg-bw	Mallard duck	Single dose	MRID 40895301

Array: Dietary concentration



Species sensitivity distribution (SSD; mg/kg-bw)



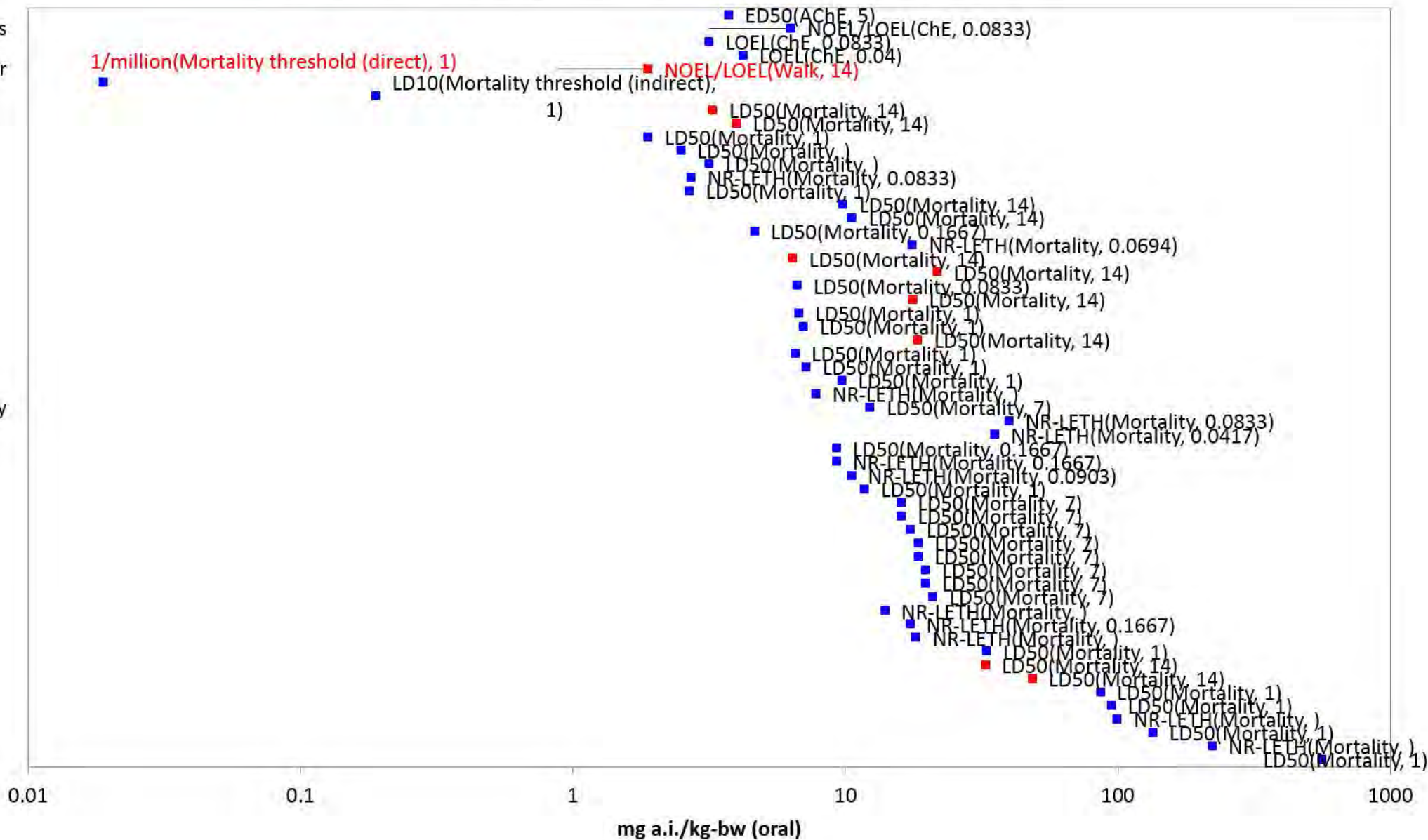
Statistic	Value
Best distribution (per AIC _c)	Log-gumbel
Goodness of fit P-value	0.70
CV of the HC ₀₅	0.39
HC ₀₅	0.43
HC ₁₀	0.54
HC ₅₀	1.51
HC ₉₀	7.63
HC ₉₅	14.15
Mortality Threshold	0.019
Indirect Effects Threshold	0.187

Array: Dose based endpoints normalized to 100 g BW

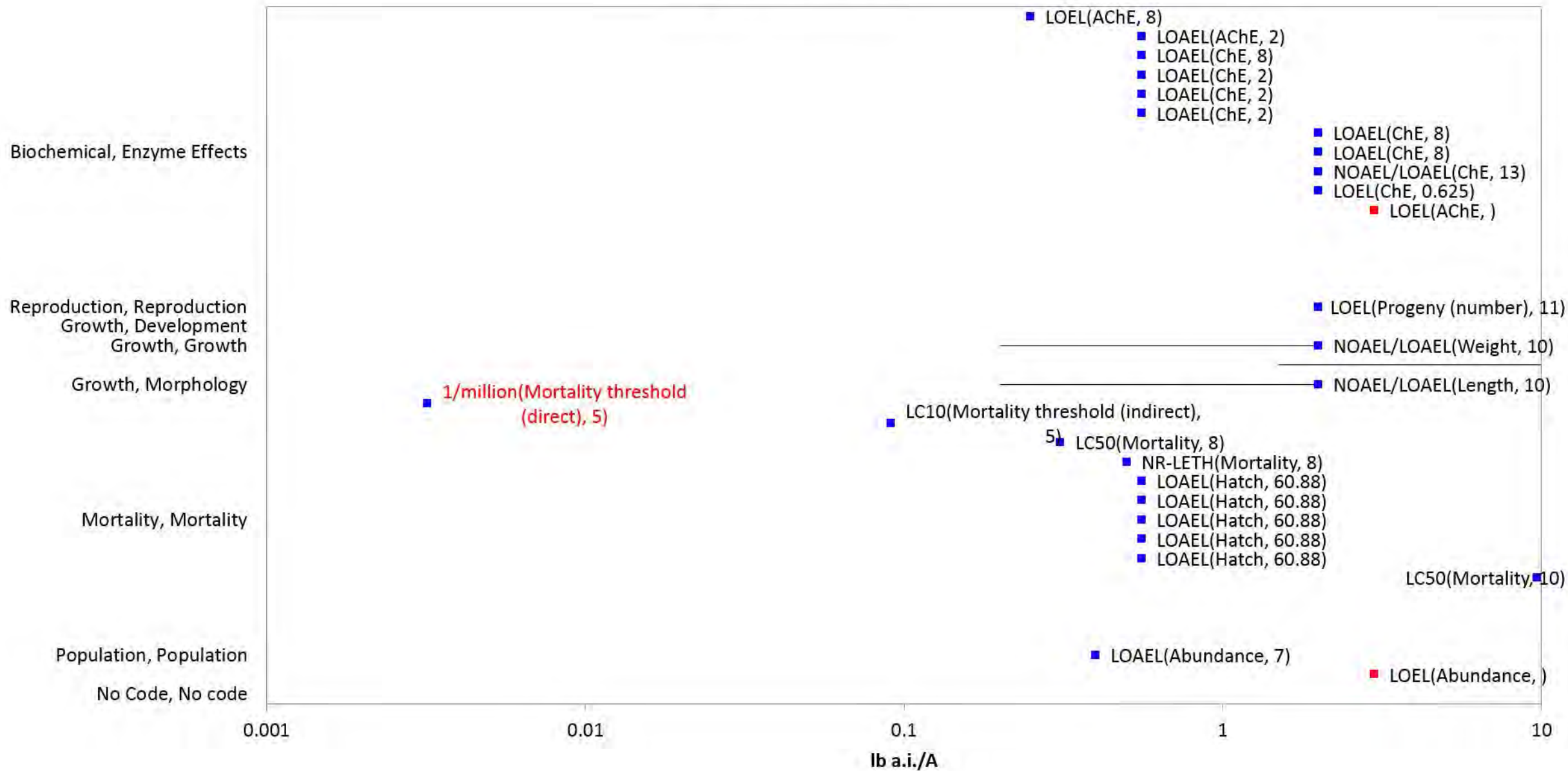
Biochemical, Enzyme Effects

Behavioral, General Behavior

Mortality, Mortality



Array: Application rate



Dietary based exposure estimates (mg a.i./kg-diet)

Food Item	Model	Lowest application rate allowed (0.5 lb a.i./A)		Highest foliar application rate allowed (3 applications of 3.0 lb a.i./A)		Highest soil application rate allowed (1 application of 4.0 lb a.i./A)	
		Mean	Upper bound	Mean	Upper bound	Mean	Upper bound
Terrestrial invertebrates (above ground)	T-REX	33	47	231	334	260	376
Terrestrial invertebrates (soil dwelling)	Earthworm fugacity	14	NA	84	NA	112	NA
Short grass	T-REX	42	120	302	854	340	960
Tall grass (surrogate for nectar and flowers)	T-REX	18	55	128	391	144	440
broadleaves	T-REX	23	68	160	480	180	540
Seeds and fruit	T-REX	3.5	7.5	25	53	28	60
Birds (and carrion)	T-HERPS	9.5-48	14-140	67-340	97-970	38-190	55-550
Mammals (and carrion)	T-HERPS	65.0-41	7.2-110	35-290	51-810	20-160	29-460
Amphibians/reptiles	T-HERPS	0.28-0.81	0.41-1.2	2.0-5.8	2.9-8.3	1.1-3.2	1.6-4.7
Aquatic plants	KABAM	0.55-550					
Aquatic invertebrates	BCF	0.03-0.82					
Fish	BCF	Up to 720					

Dose based exposures to Kirtland's Warbler (mg a.i./kg-bw)

Adults

Application rate (lb a.i./A)	Dietary dose*		Drinking water dose (dew)*	Inhalation dose		Dermal dose	
	Insects	Berries		volatilized residues	Inhalation of spray	Direct spray	Contact with treated plants*
0.5*1	41	10	0.12	7.8e-13	0.16	3.4	1.8
3.0 *3	451	147	0.83	9.8e-10	0.96	20	13
4.0*1	926	81	0.96	6.2e-12	1.3	27	14

Juveniles

Dietary dose* (insects)
56
924
1713

*Upper bound residues

Weight of evidence analysis for Kirtland's Warbler

- Is it likely that the fitness of an individual will be adversely affected by diazinon according to registered labels?
- Lines of evidence used to address this question
 - **Mortality**
 - Decreased growth
 - **Decreased reproduction**
 - **Impacts to behavior**
 - Sensory effects
 - **Indirect effects (through impacts to insect diet)**
 - Other stressors that may impact potential effects of diazinon
 - chemical stressors (oxon degradate, other pesticides)
 - Non-chemical stressors

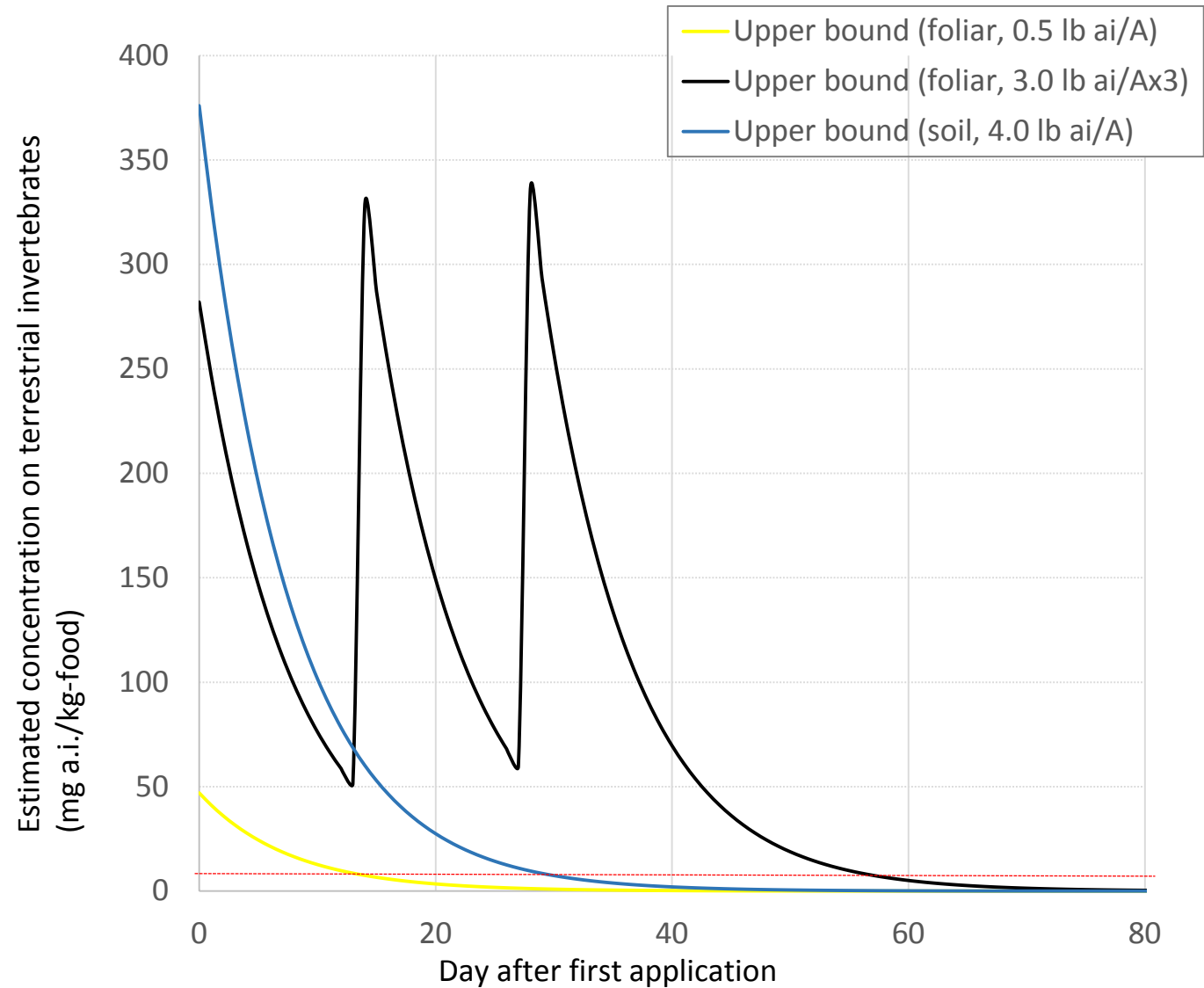
Mortality

- Mean and upper bound estimated environmental concentrations (EECs) exceed thresholds and median lethal concentrations (LC50) from several tests
 - All rates are of concern
- Exposure through insect diet is greater risk compared to fruit diet
- Risks for adults and juveniles
- Doses from multiple exposure pathways exceed thresholds and the HC90
- Several incidents of mortality have been reported since major mitigations were implemented
- The application rate threshold and LC50 is exceeded by all application rates
- Endpoints for AChE inhibition are also exceeded by exposures for all application rates
- Spray drift exposure is of concern for hundreds of feet from the edge of the field

Dietary based exposure: insect diet

- Upper bound EECs
 - exceed mortality threshold and lowest LC50 for multiple days

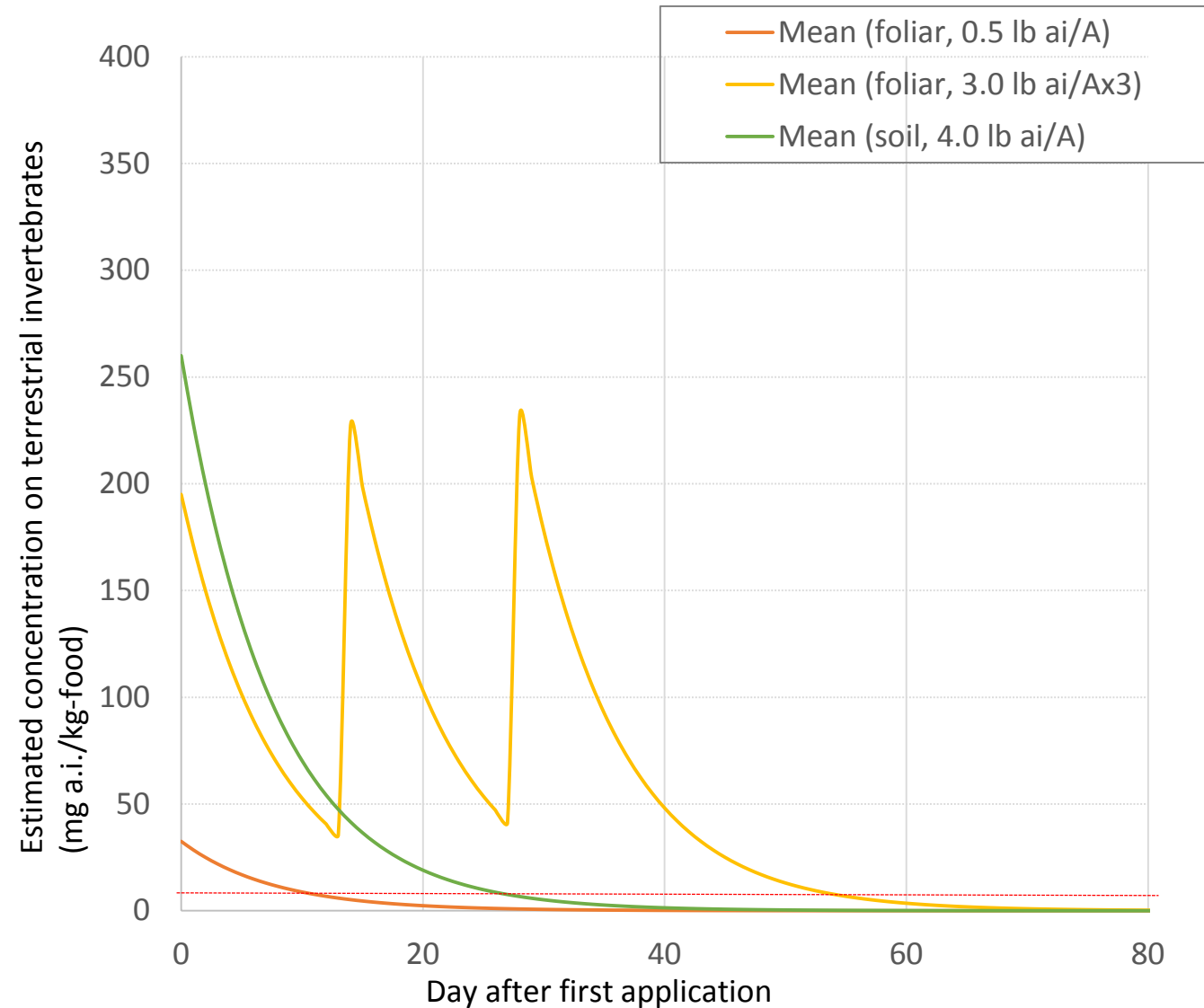
Application	Number of days where EEC exceeds endpoint	
	1/million threshold (2.5)	Lowest LC50 (38)
0.5 lb a.i./A	23	1
3 lb a.i./A*3 apps	66	44
4 lb a.i./A	39	17



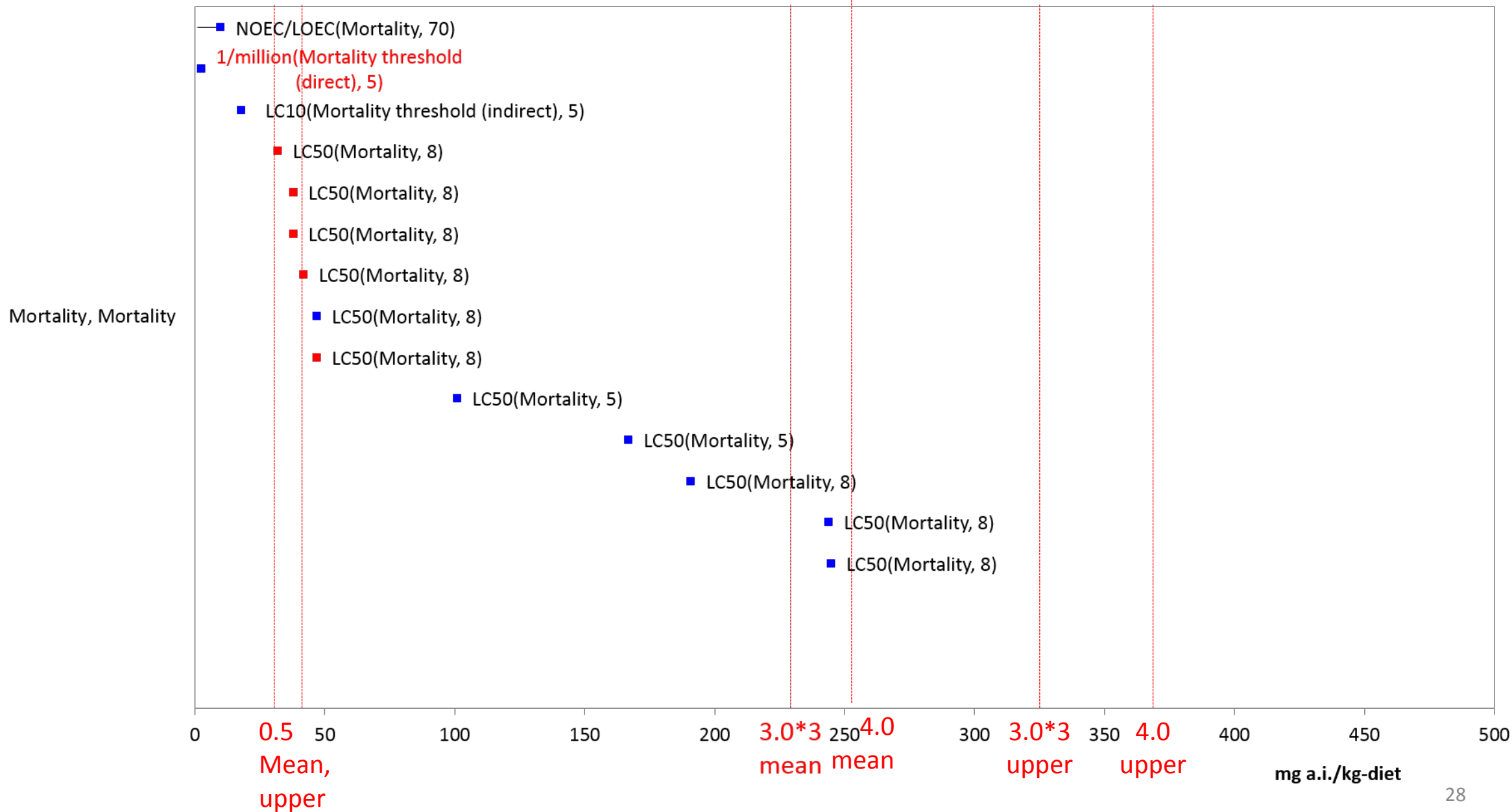
Dietary based exposure: insect diet

- Mean EECs
 - exceed mortality threshold and lowest LC50 for multiple days

Application	Number of days where EEC exceeds endpoint	
	1/million threshold (2.5)	Lowest LC50 (38)
0.5 lb a.i./A	20	0
3 lb a.i./A*3 apps	63	41
4 lb a.i./A	36	15



Dietary concentration Array – Insect EECs



Dose based exposures to Kirtland's Warblers

- EECs from several exposure pathways exceed mortality threshold
 - Volatilization not of concern
- EECs for diet exceed HC90
- EECs for dew exceed HC05 and HC10
- EECs for spray (inhalation and dermal) exceed HC10 and HC90 – relevant to males
- EECs for dermal contact exposure with foliage exceed HC50-HC90 – relevant to males

SSD Statistic	Value (mg/kg-bw)
Mortality Threshold	0.019
HC ₀₅	0.43
HC ₁₀	0.54
HC ₅₀	1.51
HC ₉₀	7.63
HC ₉₅	14

Adult doses (mg a.i./kg-bw):

Juveniles doses:

Application rate (lb a.i./A)	Dietary dose*		Drinking water dose (dew)*	Inhalation dose		Dermal dose	
	Insects	Berries		volatilized residues	Inhalation of spray	Direct spray	Contact with treated plants*
0.5*1	41	10	0.12	7.8e-13	0.16	3.4	1.8
3.0 *3	451	147	0.83	9.8e-10	0.96	20	13
4.0*1	926	81	0.96	6.2e-12	1.3	27	14

Dietary dose* (insects)
56
924
1713

*Upper bound residues

Risk in edge habitat due to spray drift transport

- Distance from edge of field to mortality threshold (0.00032 lb a.i./A based on dose-based value)
 - calculated using AgDRIFT
 - Conservative scenario used (insect diet, upper bound residues, however, does not include other routes)
 - risk extends hundreds of feet from the edge of the field for all applications
 - Deposition for most applications poses a risk out to the bounds of the model (i.e., 997 ft)
 - Airblast has shortest distances
 - Note that these distances are the farthest compared to all other thresholds (behavior and reproduction).

Application method	Boom height	Droplet spectrum	Distance (feet) from EOF to reach deposition = threshold based on Application rate (lb a.i./A)				
			0.5	1	2	3	4 (soil)
Airblast (sparse, young, dormant orchards)	NA	NA	354	486	646	764	NA
Ground	Low	Fine to medium/coarse	958	>997			
	High	Fine to medium/coarse	>997				
	Low	Very fine to fine	>997				
	High	Very fine to fine	>997				
Aerial (lettuce only)	NA	All	>997	>997	>997	NA ₃₀	

Incidents reported since 2006

Species	Number of dead birds	Location	Comments
Canada goose	39	WA	none
Canada goose, mallard duck	7, 1	IN	none
Mallard duck	8	VA	Diazinon was quantified in birds, 91-93% cholinesterase inhibition reported.
Brown headed cowbirds, common grackles, red-winged blackbirds	100	NJ	Diazinon was quantified in collected tissues

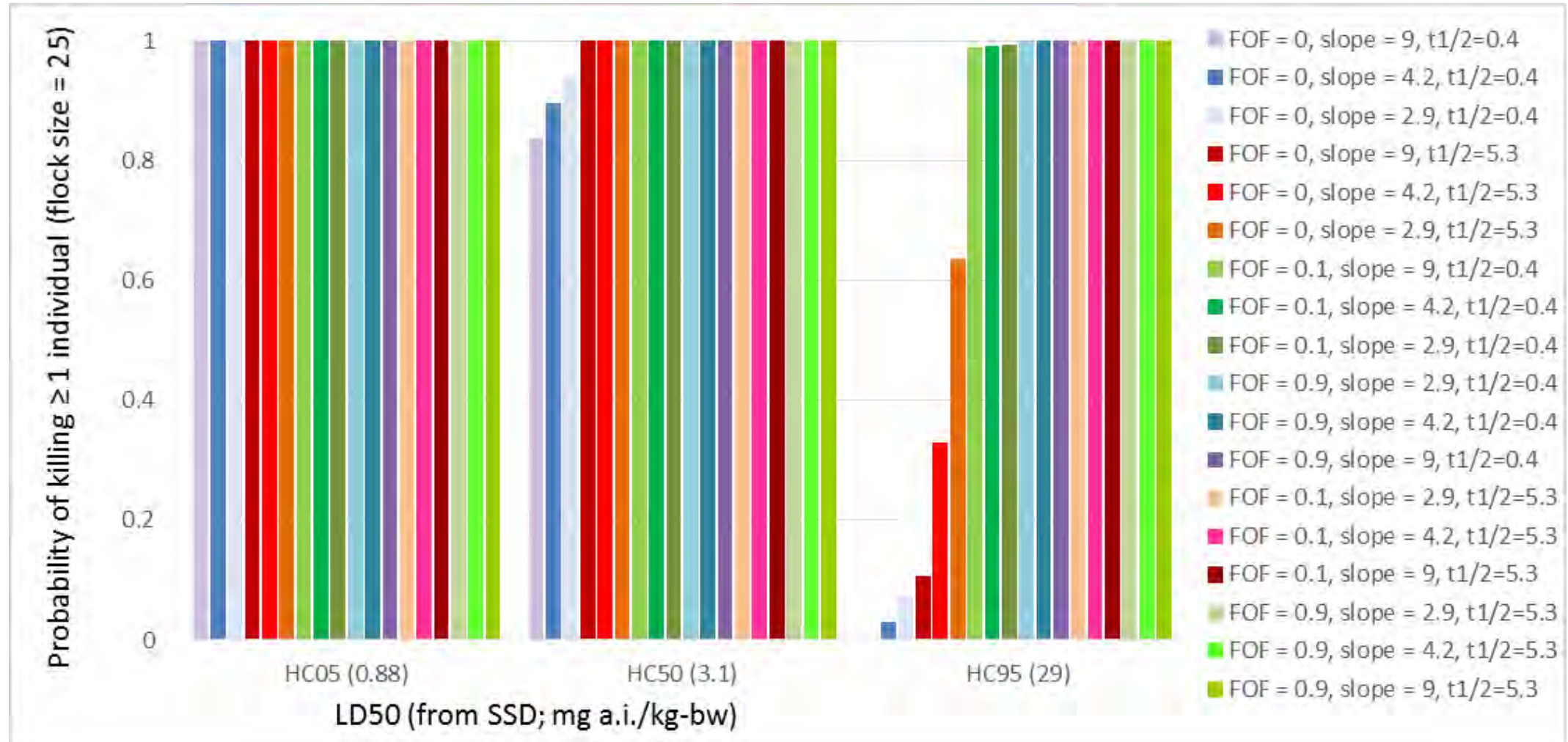
Certainty index: highly probable

Legality: unknown

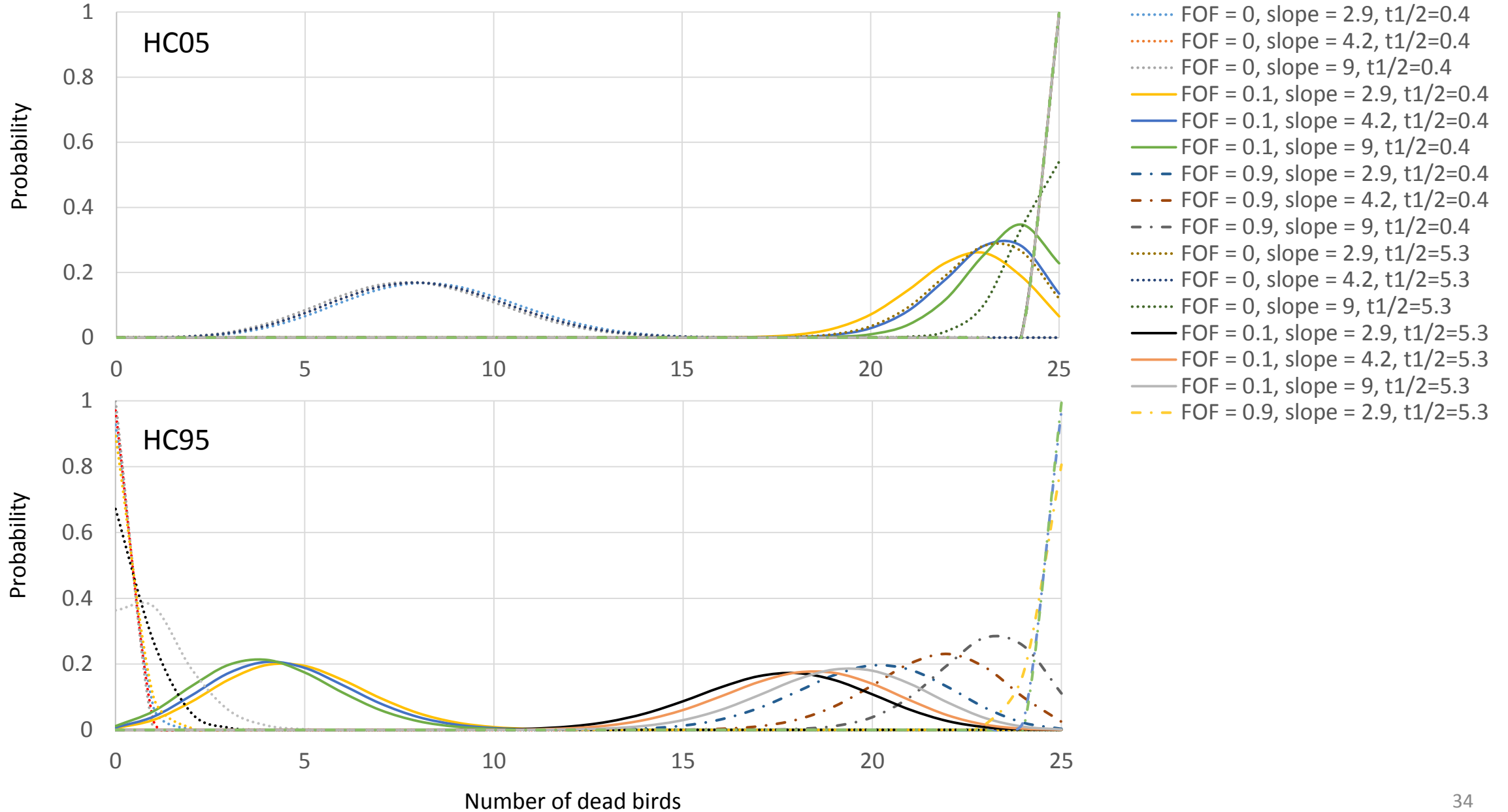
Refined analysis: TIM

- Example: Airblast application to Orchards (apples, cherries)
 - Substantial overlap between species range and crop (15,000 A) in breeding range
 - Simulated males - higher potential exposure while foraging
 - Consider foraging in edge habitat and on field
- Results
 - Probability of mortality to an individual is >99%
 - Diet is major uptake route
- Uncertainty analysis
 - Simulated range of input parameters
 - HC05, HC50, HC90
 - Slopes = 2.9, 4.2, 9
 - Half-lives = 0.4, 5.3
 - Frequency on Field (FOF) = 0, 0.1, 0.9

Diazinon use on orchards: Probability of mortality to 1 or more individual males



Probability Density Functions: Magnitude of mortality



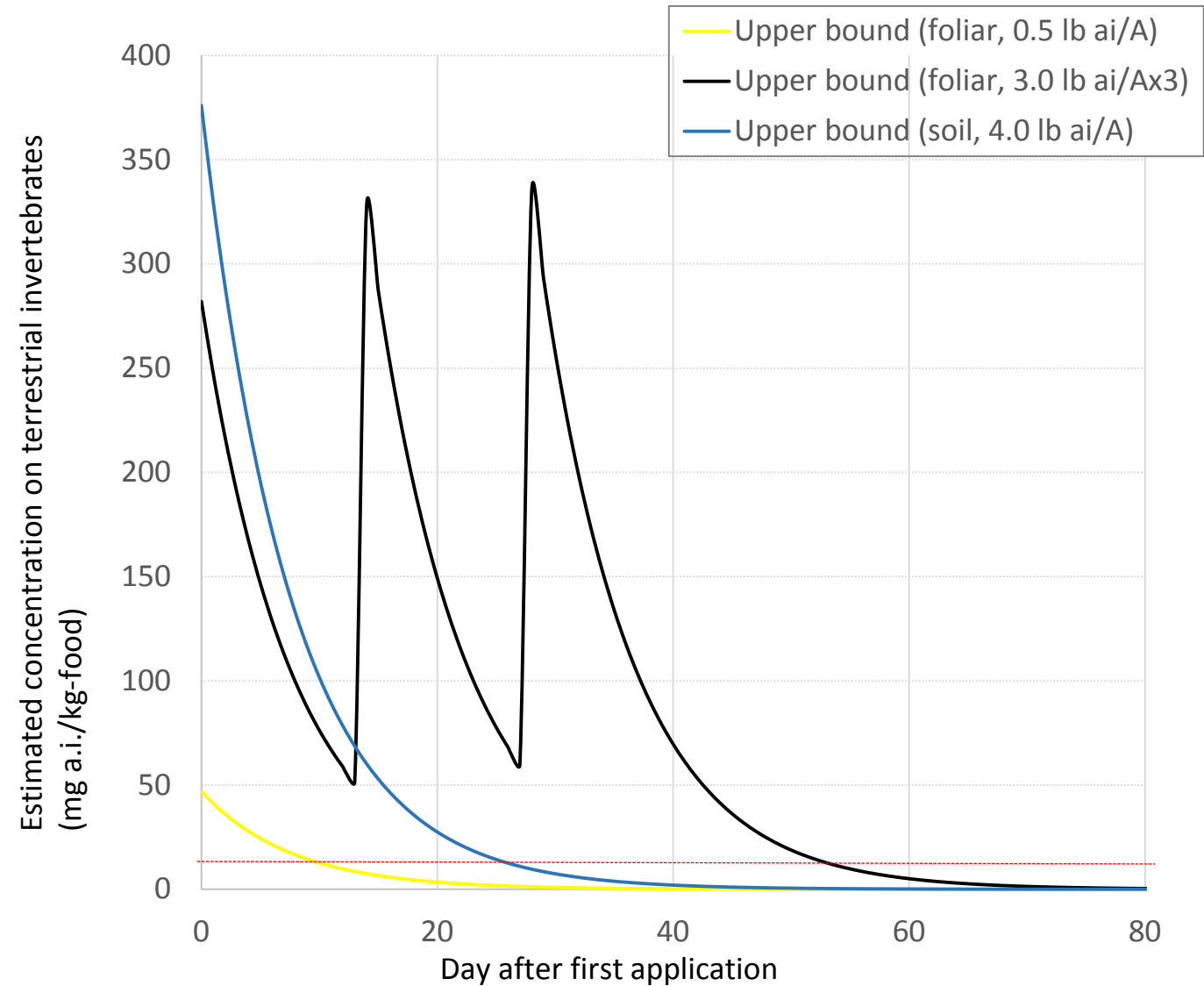
Reproduction

- Dietary based EECs (mean and upper bound) for insects exceed both the threshold (NOEC = 8.3) and LOEC (16.3) for multiple days for all uses
 - LOEC represents 41% decrease in number of surviving chicks
 - Decrease in BW of chicks (32%)
 - Increase in egg production (60% increase in days in production; 59% increase in eggs laid)
- Fruit diet is lower risk
 - Lowest rate does not exceed threshold
 - Higher rate EECs (mean and upper) exceed NOEC and LOEC for multiple days
- Spray drift
 - Aerial: risk extends hundreds of feet from edge of field
 - Ground: risk is <100 feet from edge of field
 - Airblast: spray drift does not pose a risk

Dietary based exposure: insect diet

- Upper bound EECs
 - exceed reproduction threshold and LOEC for multiple days

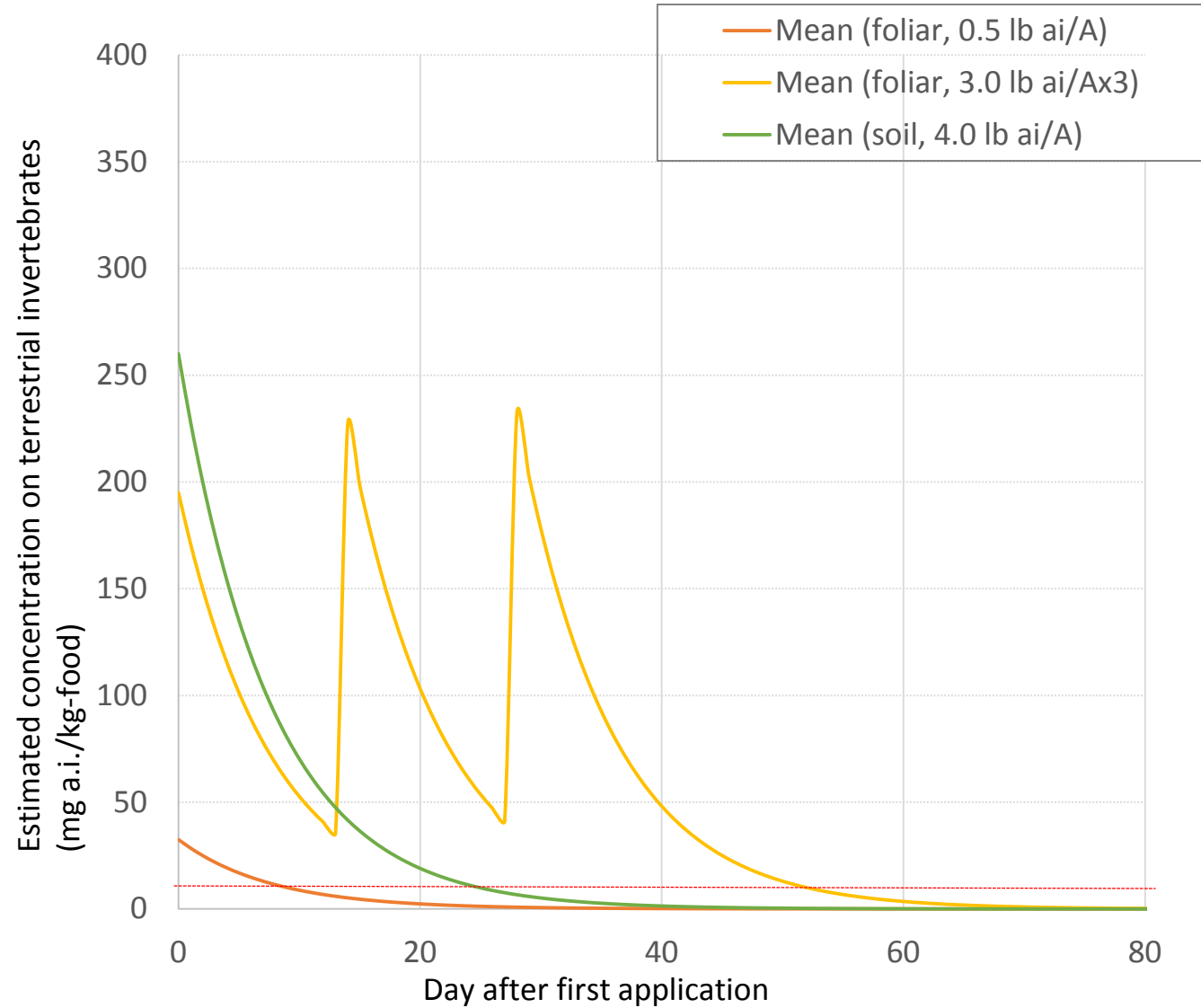
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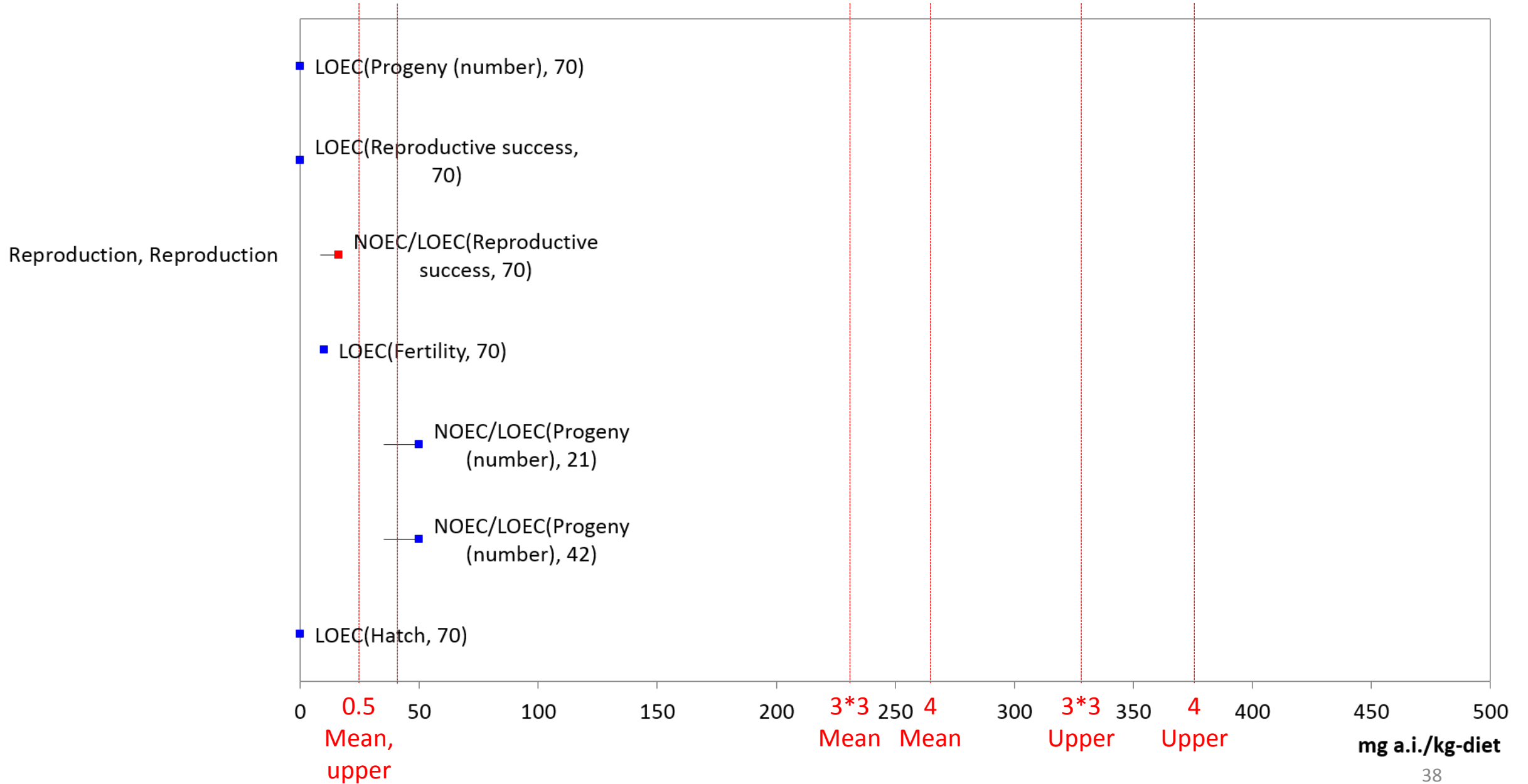
Dietary based exposure: insect diet

- Mean EECs
 - exceed reproduction threshold and LOEC for multiple days

Application	Number of days where EEC exceeds endpoint	
	NOEC (8.3)	LOEC (16.3)
0.5 lb a.i./A	11	6
3 lb a.i./A*3 apps	54	49
4 lb a.i./A	27	22



Dietary concentration Array – Insect EECs



Application rate

Reproduction, Reproduction

■ LOEL(Progeny (number), 11)

■ LOAEL(Hatch, 60.88)

■ LOAEL(Hatch, 60.88)

Mortality, Mortality

■ LOAEL(Hatch, 60.88)

■ LOAEL(Hatch, 60.88)

■ LOAEL(Hatch, 60.88)

0 0.5 1 1.5 2 2.5 3 3.5 4

lb a.i./A

Refined analysis: MCnest results

- Integrates exposure and mortality estimates from TIM and reproduction, growth and behavioral endpoints
 - Simulating adult females (only dietary route considered)
- Applications made May – July substantially reduce fecundity (>75% reduction compared to control)
 - Adult mortality is major concern
 - For birds that survive, there is some nest failure
- Applications Made in late July-August do not impact fecundity
 - Adult mortality estimates are still high
 - birds die after they have successfully reproduced

Behavior

- Behavioral threshold (dose-based) and LOEC exceeded by dietary and dermal EECs
 - Endpoint is decreased locomotion
- Dietary based EECs exceed food consumption endpoints
- AChE endpoints (dietary-based) exceeded for all application rates

Dose based exposures to adult Kirtland's Warbler

- Behavioral threshold (NOEC): 1.7-1.9 mg/kg-bw
 - Exceeded for diet and dermal exposures
- LOEC: 3.7-4.1 mg/kg-bw
 - Exceeded for diet and dermal exposures

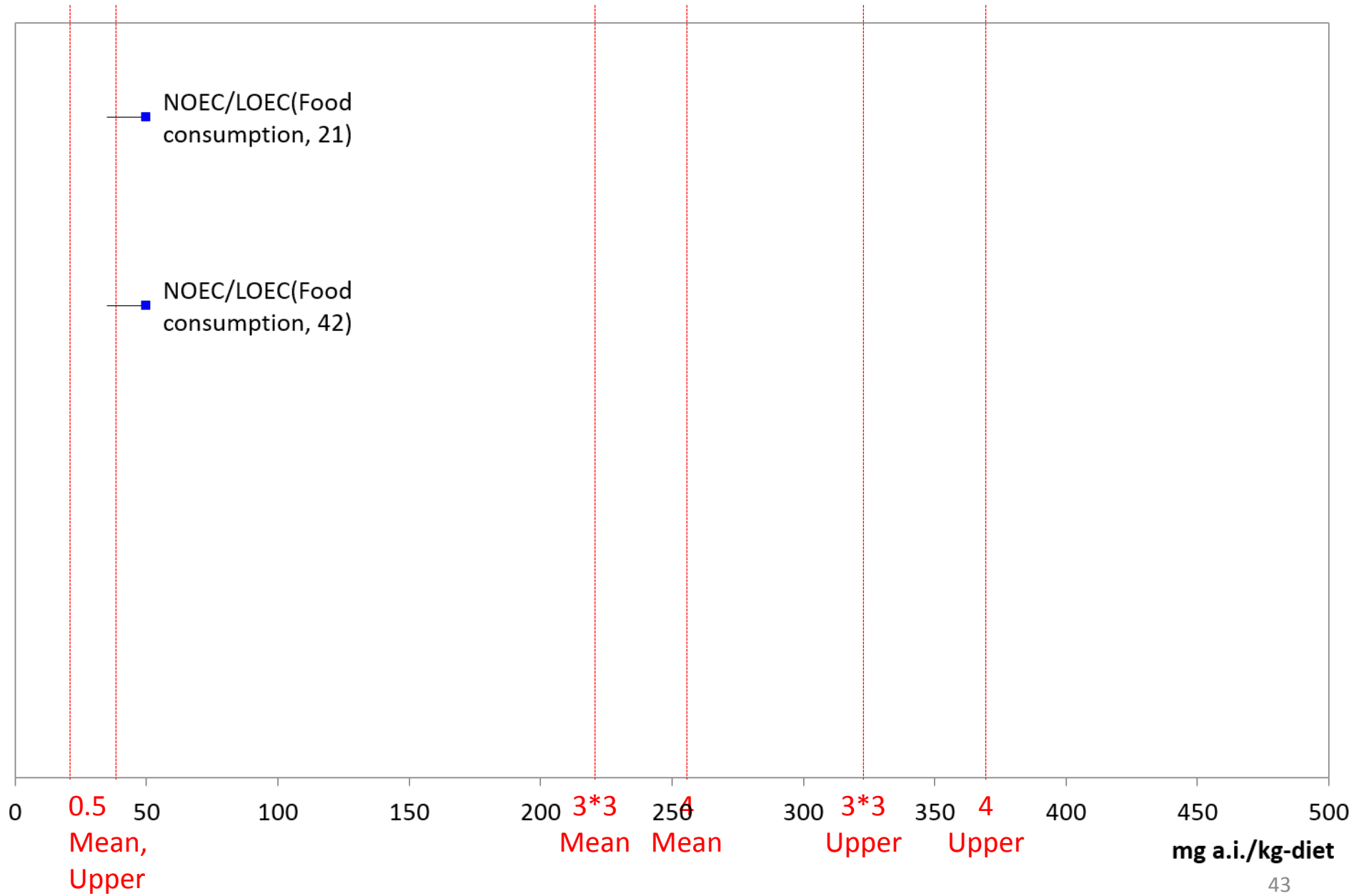
Dose (mg/kg-bw):

Application rate (lb a.i./A)	Dietary dose*		Drinking water dose (dew)*	Inhalation dose		Dermal dose	
	Insects	Berries		volatilized residues	Inhalation of spray	Direct spray	Contact with treated plants*
0.5*1	41	10	0.12	7.8e-13	0.16	3.4	1.8
3.0 *3	451	147	0.83	9.8e-10	0.96	20	13
4.0*1	926	81	0.96	6.2e-12	1.3	27	14

*Upper bound residues

Dietary concentration Array – Insect EECs

Behavioral, Feeding Behavior



Indirect effects: habitat

- No indirect effects for habitat
 - Thresholds are above most application rates

Taxa	Exposure	EC25 (lb a.i./A)	Test species
Terrestrial and wetland dicots	Drift	3.2	Cucumber (<i>Cucumis sativus</i>)
	Runoff + Drift	9.03	Carrot (<i>Daucus carota</i>)
Terrestrial and wetland monocots	Runoff + Drift	5.26	Oat (<i>Avena sativa</i>)

- Data for some woody plants (highbush blueberry and apple) show no effects at 2 lb a.i./A
 - Uncertainty due to lack of conifer data that would be relevant to jack pine
- Data for many grasses show no effects at relevant application rates

Indirect effects: diet

- No concerns for impacts to fruit
- **Potential impacts to insect diet**
 - Contact based threshold: 0.48 ug/g-bw
 - Decreases expected on treated fields (upper bound EEC ≥ 47)
 - Equivalent to spray drift deposition of 0.0051 lb a.i./A

Application method	Boom height	Droplet spectrum	Distance (in ft) from EOF to reach deposition = threshold based on Application rate (lb a.i./A)				
			0.5	1	2	3	4 (soil)
Airblast (sparse, young, dormant orchards)	NA	NA	102	141	194	233	NA
Ground	Low	Fine to medium/coarse	33	85	210	344	475
	High	Fine to medium/coarse	62	151	331	495	650
	Low	Very fine to fine	95	203	413	607	787
	High	Very fine to fine	232	410	679	886	>997
Aerial (lettuce only)	NA	Very fine to fine	>997	>997	>997	NA	
		Fine to medium	>997	>997	>997	NA	
		Medium to coarse	417	>997	>997	45	

Conclusion

- Use of diazinon is likely to adversely affect the Kirtland's warbler

Risk hypothesis	Line of evidence	Risk	Confidence
Use of diazinon according to registered labels results in exposure that reduces the fitness of an individual Kirtland's warbler based on direct effects .	Mortality due to diazinon exposure	High	High
	Decreased growth due to diazinon exposure	High	Medium
	Decreased reproduction due to diazinon exposure	High	High
	Altered behavior due to diazinon exposure	High	High
	Sensory effects due to diazinon exposure	Unknown	Low
	Impacts of other chemical stressors on diazinon effects	Not yet determined	
	Impacts of non-chemical stressors on diazinon effects	Not yet determined	
Use of diazinon according to registered labels results in exposure that reduces the fitness of an individual Kirtland's warbler based on indirect effects .	Indirect Effects due to diazinon exposure to organisms representing habitat (cover)	Low	Medium
	Indirect Effects due to diazinon exposure to organisms representing diet	High	High