**Appendix 4-7. Refined risk analysis for 11 listed birds exposed to diazinon**

1. **Introduction**

The Terrestrial Investigation Model (TIM, version 3.0 beta) is an exposure and effects model that can be used to address avian mortality levels from acute pesticide exposure in generic or specific species over a user-defined exposure window. The time frame corresponds to one growing season of the treated crop or a single sub-annual pesticide application window. The spatial scale is at the field level, but specific field dimensions are undefined. In the current version of TIM, it is assumed that the model accounts for variability in exposure among fields and represents risks to listed birds exposed to diazinon on different fields and orchards that are treated at the same rates and methods. It is assumed that the field and surrounding area meet habitat and dietary requirements for the modeled species. During the simulation, birds use the treated field and edge habitat to meet their requirements for food and water. TIM also accounts for exposure via dermal and inhalation routes for birds on the field or for adjacent habitat that receives spray drift. It is expected that the relative importance of these routes of exposure will vary based on the properties of the pesticide, its use, as well as the life history of the simulated bird species. Risk, expressed as a function of exposure (dose) and toxicity, is assessed for liquid spray applications of a pesticide made to vegetation or bare ground in the field. Pesticide application methods that may be modeled in TIM v.3.0 include: aerial, ground broadcast, air blast, ground banded and ground in furrow. For all of these application methods exposure can be assessed on treated fields and edge habitats where spray drift is transported. The model does not currently account for exposures due to seed treatments or granular formulations. A detailed description of TIM is available online at: http://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment#tim.

The MCnest (Markov Chain nest productivity, version 2.0 beta) model, is a refined risk assessment model for estimating the chronic impact of pesticides on the reproductive success of bird populations (*i.e.*, fecundity). This analysis relies upon an integrated application where MCnest utilizes the same exposure estimates generated by TIM (for individual birds and their offspring). MCnest integrates multiple effects (lines of evidence) attributed to pesticide toxicity (*i.e.,* mortality, reproduction and behavior) along with life history characteristics of specific listed species. An integrated version of TIM and MCnest is available on the provisional models web page for this risk assessment[[1]](#footnote-1).

This analysis includes a refined risk assessment for the subset of listed birds in **Table B 4.7.1**. This analysis was conducted using the integrated Terrestrial Investigation Model and MCnest. For diazinon, “Likely to Adversely Affect” (LAA) determinations are made for all 11 species based on the weight of evidence analysis conducted using the Terrestrial Effects Determination (TED) tool. The purpose of this refined analysis is to explore the utility of currently available probabilistic, refined methods for use in biological evaluations of listed species. There is also potential utility for use of these methods in the biological opinions for these species. Only a subset of species were selected to demonstrate proof of concept and explore applications of the models that may inform future method development and identification of data needs.

**Table B 4.7.1. Listed species that are included in this refined risk assessment.**

|  |  |  |
| --- | --- | --- |
| ***Scientific Name*** | **Common Name** | **Entity ID** |
| *Ammodramus savannarum floridanus* | Florida grasshopper sparrow | 133 |
| *Coccyzus americanus* | Yellow-billed Cuckoo (Western DPS) | 6901 |
| *Colinus virginianus ridgwayi* | Masked bobwhite (quail) | 89 |
| *Dendroica chrysoparia\** | Golden-cheeked warbler | 139 |
| *Empidonax traillii extimus* | Southwestern willow flycatcher | 149 |
| *Polioptila californica californica* | Coastal California gnatcatcher | 145 |
| *Setophaga kirtlandii* | Kirtland's Warbler | 94 |
| *Tympanuchus cupido attwateri* | Attwater's greater prairie-chicken | 83 |
| *Tympanuchus pallidicinctus* | Lesser prairie-chicken | 2691 |
| *Vireo atricapilla* | Black-capped Vireo | 138 |
| *Vireo bellii pusillus* | Least Bell's vireo | 123 |

\*This species has been renamed “*Setophaga chrysoparia*.”

As described in **Attachment 1-16**, selected species are consistent with the current domains of TIM and MCnest (*i.e.,* diets include arthropods or terrestrial plants) and their breeding range is located in the 48 contiguous states. The attachment included 5 additional species that are not included here. The Inyo California towhee (*Pipilo crissalis eremophilus;* entity ID 137) and the San Clemente sage sparrow (*Amphispiza belli clementeae;* entity ID 116) are not included here because their ranges only overlap with areas potentially represented by diazinon use on cattle ear tags. Since this use is outside of the domain of TIM and MCnest, these species are not included in the current analysis. The gunnison sage grouse (*Centrocercus minimus*; entity ID 4064) was not included because the parameters used to represent the life history of this species are still under development. The other two species that are not included represent separate populations of the greater sage-grouse (*Centrocercus urophasianus*). These were excluded here because they are no longer candidates for listing.

This analysis focuses on a refined risk assessment for direct effects to listed birds, including effects to mortality, growth, reproduction and behavior. This analysis does not consider indirect effects due to declines in prey or impacts to habitat.

Section 2 of this appendix describes the input parameters used in TIM and MCnest to simulate specific species and properties of diazinon, including use, fate and toxicity. Section 3 includes the results and discussion of the probabilities of mortality and declines in fecundity for the 11 species considered in this assessment.

Section 4 of this appendix also includes a proof of concept analysis that involves estimating the number of individuals within a population that are potentially exposed to diazinon. One species, the least bell’s vireo was selected for this analysis. The method relies upon known life history characteristics of the listed species, in particular, habitat usage and considers potential overlap of these habitats with diazinon use sites and habitats potentially receiving spray drift.

1. **TIM and MCnest input parameters**

TIM and MCnest are run to estimate the probability and magnitude of mortality and decline in fecundity. This section describes the input parameters used to simulate the specific species, uses of diazinon, and toxicity and physical/chemical properties of diazinon.

* 1. **Species Life History**

A species library has been developed to designate model parameters which are intended to be representative of the diets, body weights and reproductive timing associated with each species considered in this assessment. These parameter values are defined in **Supplemental Information 1**, along with source information. The integrated TIM-MCnest tool utilizes a Microsoft Excel® spreadsheet to integrate species-specific life history parameter values into the models. The endangered species library for these species is available on the provisional models web page.

* 1. **Number of birds simulated**

In order to sufficiently capture the stochasticity incorporated into TIM and MCnest, 10,000 individual birds are simulated. The fraction of mortality in these birds is used to calculate the probability associated with different magnitudes of mortality among exposed birds (referred to in model documentation as a “flock”). For this analysis, a flock size of 100 is used (as it represents percent).

* 1. **Exposure routes simulated**

TIM has the ability to account for exposures via multiple routes, including diet, drinking water, dermal and inhalation. Acute oral toxicity data with birds indicate that diazinon is very highly toxic via the oral route (chapter 2). This suggests that dietary and drinking water routes are potentially of concern. There are data available to suggest that the dermal route may cause mortality and sublethal effects (AChE inhibition) in birds (Vyas *et al*. 2006 ECOTOX #85970). Toxicity data are not available for inhalation exposures involving birds; however, TIM utilizes mammalian data as a surrogate for understanding the relative sensitivities via oral and inhalation routes. In several acute inhalation studies with laboratory rats, no mortality was observed at 1 mg a.i./L-air, which is equivalent to 120 mg a.i./kg-bw (MRIDs 42307236, 43665605, 42993303). Due to a lack of observed toxicity in these studies, inhalation exposure is not considered to be of concern for this analysis.

The version of TIM/MCnest used in this assessment does not consider several possible routes of exposure, including ingestion of or dermal contact with contaminated soil.

One notable uncertainty associated with exposure through consumption of arthropods is the conservative nature of the residue estimates. Since TIM is used to simulate exposures and resulting risks on a field scale, the arthropod residue values were selected to represent a 90th percentile field/orchard. For cases where risks are assessed to a small number of individuals exposed (e.g., <10), this conservative approach is not as influential on confidence in risk conclusions (as it is possible that they are only being exposed on one field). When a larger number of individuals is exposed, a landscape level approach is more appropriate, where individuals within the population are exposed to diazinon on multiple fields. In that case, it is unlikely that all individuals will be exposed to diazinon on 90th percentile fields. Therefore, there may be an overestimation in risk to the number of individuals impacted (overestimate in probabilities of mortality and fecundity declines). Since this analysis relies upon a beta version of TIM and MCnest, this uncertainty may be explored in future updates to the model.

* 1. **Simulated Uses**

Diazinon is used on orchards, ground fruit, vegetables, nurseries and cattle ear tags. A detailed description of the specific crops is provided in the problem formulation (chapter 1, section 1.1.2.4, Tables 1-3 and 1-4). This analysis does not include the cattle ear tag use since TIM does not assess exposure via that application method. TIM does include spray applications, which is relevant to use on orchards, ground fruit and vegetables and outdoor nurseries. For each species, diazinon use on orchards, ground vegetables and nurseries are simulated. The diazinon use(s) that have the greatest acreage in the counties inhabited by the species are simulated (**Table B 4.7.2**). Maximum application rates corresponding to those uses are simulated. Additional parameter descriptions for each type of use are provided below.

**Table B 4.7.2. Crops that have greatest acreage reported in counties inhabited by listed birds considered in this assessment.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Scientific Name*** | **Common Name** | **Orchard** | **Ground fruit and vegetable** |
| *Ammodramus savannarum floridanus* | Florida grasshopper sparrow | Peaches | Tomatoes, beans |
| *Coccyzus americanus* | Yellow-billed Cuckoo (Western DPS) | Apples | Potatoes, lettuce |
| *Colinus virginianus ridgwayi* | Masked bobwhite (quail) | Peaches, apples | none |
| *Dendroica chrysoparia* | Golden-cheeked warbler | Peaches | cabbage, cucumbers, squash, watermelons |
| *Empidonax traillii extimus* | Southwestern willow flycatcher | Almonds | lettuce, potato, broccoli |
| *Polioptila californica californica* | Coastal California gnatcatcher | Almonds | potatoes, strawberries, lettuce, tomatoes |
| *Setophaga kirtlandii* | Kirtland's Warbler | Cherries, apples | Beans |
| *Tympanuchus cupido attwateri* | Attwater's greater prairie-chicken | Peaches | Tomatoes, watermelons |
| *Tympanuchus pallidicinctus* | Lesser prairie-chicken | Apples | Beans |
| *Vireo atricapilla* | Black-capped Vireo | Peaches | Potatoes, beans |
| *Vireo bellii pusillus* | Least Bell's vireo | Almonds | Lettuce |

*Orchard crops*

For orchards, all applications may be made via air blast or ground spray. Given common practices, it is expected that air blast will be the most likely method for orchard applications, and therefore, this method is simulated using TIM/MCnest. For diazinon, a single foliar application of 2 lb a.i./A is simulated for pome fruit and stone fruit. An application of 3 lb a.i./A is simulated for almonds.

A crop height of 10 m will be used for orchards. Since inhalation exposure is not of concern for diazinon, the crop biomass parameter is not needed, so a value of 1 will be used.

Timing of application does not impact TIM outputs; however it has a substantial influence on MCnest estimates of fecundity. In cases where MCnest is run for a species, a range of dates (from April-September) are simulated to explore the influence of application timing on fecundity.

*Ground fruit and vegetable*

Diazinon is applied to soil (pre-plant) or foliage of a variety of ground fruit and vegetable crops. For soil applications, rates are generally 4 lb a.i./A. Foliar applications range 0.5-2 lb a.i./A. Applications may be made via ground methods for all uses.

Aerial applications are only allowed for lettuce. Applications may be made at 2 lb a.i./A. Since aerial applications are expected to generate greater offsite exposures to birds via spray drift, a priority is placed on modeling this use if it overlaps substantially with a species range.

Diazinon is applied pre-plant at a rate of 4 lb a.i./A to many ground fruit and vegetable crops (e.g., beans, potatoes, tomatoes).

*Nursery (outdoor)*

For diazinon use on outdoor nurseries, an application of 1 lb a.i./A may be applied via ground spray or airblast.

Crop height is assumed to be 0.3 m (approximately 1 foot).

Applications are simulated for a range of dates from April-September.

* 1. **Frequency on Field (FOF)**

Frequency on field (FOF) is the amount of foraging time in a simulation that a bird spends on the treated field. TIM requires input values for mean, minimum and maximum FOF values in order to generate a *beta pert* distribution of FOF values for the simulated species of birds. For each simulated bird, a unique FOF value is selected from this distribution. For this analysis, the species habitat and its relationship to potential diazinon use sites is used to derive the FOF parameters for each simulated species.

Based on the available information on species habitats (**Table B.4.7.3**), none of the simulated species are expected to use diazinon target areas; therefore, the FOF values for mean, min and min values of the distribution will be 0, 0 and 0. According to this approach, each of these species will be exposed to diazinon through spray drift to edge habitats only. For some species, it was necessary to alter FOF values in the Excel spreadsheet representing the species library for the TIM-MCnest tool (provided on the provisional models page). If individuals do occur on treated fields, the magnitude of mortality and declines in fecundity could potentially be underestimated.

**Table B 4.7.3. Habitat descriptions of 11 species.**

|  |  |  |
| --- | --- | --- |
| ***Scientific Name*** | **Common Name** | **Habitat description in FWS documentation\*** |
| *Ammodramus savannarum floridanus* | Florida grasshopper sparrow | large (>50 ha), treeless, relatively poorly-drained grasslands that have a history of frequent fires |
| *Coccyzus americanus* | Yellow-billed Cuckoo (Western DPS) | Open woodland with clearings and scrubs that are associated with watercourses. Breeds in riparian areas. |
| *Colinus virginianus ridgwayi* | Masked bobwhite (quail) | savanna grasslands |
| *Dendroica chrysoparia* | Golden-cheeked warbler | Forests |
| *Empidonax traillii extimus* | Southwestern willow flycatcher | Breeding: Forested wetlands or scrub-shrub wetlands-dense riparian habitat of rivers, swamps, wetlands, lakes  Wintering: brushy savanna edges, second growth, shrubby clearings and pastures, woodlands near water |
| *Polioptila californica californica* | Coastal California gnatcatcher | Coastal scrub vegetation communities |
| *Setophaga kirtlandii* | Kirtland's Warbler | Forests |
| *Tympanuchus cupido attwateri* | Attwater's greater prairie-chicken | Grasslands and open space, woodland, brushland, fallow land, cultivated land |
| *Tympanuchus pallidicinctus* | Lesser prairie-chicken | shrub-mixed grass habitat associated with sandy soil; Mixed grass prairie and conservation reserve program land |
| *Vireo atricapilla* | Black-capped Vireo | Forest grassland ecotone; deciduous/evergreen shrubland |
| *Vireo bellii pusillus* | Least Bell's vireo | Woodland including cotton-wood willow forest, Oak wood lands, and mule fat scrub;  Scrub vegetation; Palm groves and hedgerows associated with agricultural fields and residential areas;  Breed in riparian habitat, typically inhabiting structurally diverse woodlands along watercourses |

\*Species specific sources provided in Attachment 1-16.

* 1. **Pesticide Characteristics (Fate and Effects)**

The diazinon specific input parameters that are used to define the physical, chemical and transport properties that define the fate of diazinon are provided in **Table B 4.7.4**. Several of these parameter values were selected to be consistent with the values used in aquatic models.

**Table B 4.7.4. Fate input parameter values used for diazinon.**

| **Parameter** | **Value** | **Source/comments** |
| --- | --- | --- |
| Pesticide half-life in puddles (days) | 34 | Table 3-9 of Chapter 3 (exposure characterization for diazinon) |
| Koc (L/kg-oc) | 824 | Table 3-9 of Chapter 3 |
| Kow | 5900 | Log Kow = 3.77 based on mean of 3 available values 3.81 (USNLM 2009); 3.69 (MRID 42970810); 3.8 (MRID 40226101). |
| Henry’s law constant (atm/m3-mol) | 4.4e-7 | Calculated using the following formula  HENRY = (VP/760)/(Solubility/MW)  (TIM manual, appendix A), where:  MW = 304.35 g/mol (Table 3-9, chapter 3)  VP= 7.22×10-5 torr (Table 3-9, chapter 3) |
| Solubility in water (mg/L) | 65.5 | Table 3-9 of Chapter 3 |
| Dislodgeable foliar residue adjustment factor | 0.62 | Default (TIM manual, appendix A) |
| Dermal adsorption fraction | 1 | Default (TIM manual, appendix A) |
| Contaminated fractions of food items | 1 | Assume that 100% of food items are treated. Default (TIM manual, appendix A) |
| Half-life on food items (days) | 0.4, 2.2, 5.3 | Minimum, median and maximum of 5 values reported by Willis and McDowell (1987). Values are used in separate model runs to bracket results. |

**Table B 4.7.5 and 6** include the parameter values used in TIM and MCnest to define the toxicity of diazinon. The results generated by TIM are sensitive to avian acute oral LD50 and the foliar dissipation half-life. Therefore, alternative values are explored in this analysis in order to capture the influence of variability in the diazinon data on the model’s predictions. Although the model is also sensitive to the fraction of the pesticide retained on an hourly basis, data are not available to determine chemical-specific variability in this parameter value.

**Table B 4.7.5. TIM toxicity input parameter values used for diazinon.**

| **Parameter (units)** | **Value** | **Source/comments** |
| --- | --- | --- |
| Avian acute oral LD50 (mg a.i./kg-bw) | 0.43, 1.51 and 14.5 | HC5, HC50 and HC95 from SSD used to bracket risk results. Details on the SSD are provided in Appendix 2-9. |
| Body weight of animals from LD50 (g) | 100 | SSD scaled to 100 g |
| Mineau scaling factor | 0.63 | Diazinon specific value from Mineau et al. 1996.[[2]](#footnote-2) |
| Slope of avian oral LD50 | 3.5 | Median value of available species geometric means was used. Available values include the following:  Canada goose (2.4; n = 1),  mallard duck (3.5; n = 3) and  Northern bobwhite quail (5.9; n = 9). Source data are available in Appendix 2-9. |
| Avian acute inhalation LD50 (mg a.i./kg-bw) (enter 0 if no value is available) | 0 | No value is available for diazinon |
| Rat inhalation LD50 (mg a.i./kg-bw) | 120 | MRIDs 42307236, 43665605, 42993303.  No mortality observed at 1 mg a.i./L; value is not definitive. Inhalation routes are turned off in TIM. |
| Rat acute oral LD50 (mg a.i./kg-bw) | 882 | MRID 41334607 |
| Chemical specific avian dermal LD50 (enter 0 if no value is available) | 0 | No value is available for diazinon |
| Food matrix adjustment factor | 1 | Default (See TIM manual, appendix A) |
| Fraction of pesticide retained from one hour to the next | 0.9943 | MRID 41225901 |
| Ratio of juvenile to adult toxicity | 1 | Default (See TIM manual, appendix A) |

**Table B 4.7.6. MCnest toxicity input parameter values used for diazinon.**

| **Parameter (units)** | **Value (for different treatments)** | | | **Source/comments** |
| --- | --- | --- | --- | --- |
| **Level 1** | **Level 2** | **Level 3** |
| Measured concentrations (mg a.i./kg-diet) | 4.02 | 8.30 | 16.33 | X indicates level where NOEL was established for endpoint of interest. NOELs at level 3 represent levels where LOELs were not established.  Test species: Mallard duck; MRID 41322901;  Effects observed at LOECs:  1. Increase in number of eggs laid per hen (59%)  2. Decrease in number of 14-day old hatchling survivors per hen (41%)  3. Decrease in weight of surviving chicks (at day 14; 32%)  Note that AChE inhibition was observed in all test levels (level 1 was equivalent to 0.426 mg a.i./kg-bw). Although this could be used as a surrogate for a behavioral endpoint; behavioral effects that were observed in the acute oral study are used instead because a NOAEL (0.316 mg a.i./kg-bw) was established in that study. |
| Average food consumption (g/bird/day) | 119 | 120 | 122 |
| Average initial female body weight (g) | 1041 | 1055 | 1066 |
| Average initial male body weight (g) | 1194 | 1162 | 1172 |
| Average final female body weight (g) | 1041 | 1055 | 1026 |
| Average final male body weight (g) | 1218 | 1229 | 1155 |
| NOAEL for # eggs laid |  | X |  |
| NOAEL for % viable eggs/eggs set |  |  | NA |
| NOAEL for % live 3-wk embryos of viable eggs |  |  | NA |
| NOAEL for % hatchlings of eggs set |  |  | X |
| NOAEL for % 14-d chicks of hatchlings |  | X |  |
| NOAEL for % 14-d chicks of eggs set |  |  | X |
| NOAEL for egg shell thickness |  |  | X |
| NOAEL for hatchling weight |  |  | X |
| NOAEL for 14-d chick weight |  | X |  |
| NOAEL for prelaying female weight |  |  | X |
| NOAEL for prelaying male weight |  |  | X |
| Alternative behavioral threshold (for adults)\* (mg a.i./kg-bw) | 0.316 | | | Behavioral NOAEL from acute oral toxicity study with mallard duck (MRID 40895301); birds exposed to 0.681 mg a.i./kg-bw were observed sitting, were unable to walk |
| LC50 (mg a.i./kg-food) | 32 | | | Lowest available LC50; test species was mallard duck; MRID 40895302 |
| Fraction of LC50 | 0.5\*\* | | |
| Mean body weight (g) from LC50 test | 135 | | |
| Mean food ingestion rate from LC50 test (g/day) | 26 | | |

\*Used as alternative to 1/10 LD50

\*\*Study NOEC was 16 mg a.i./kg, or 0.5\*LC50.

NA = not available

* 1. **Other Parameters**

TIM uses a handful of additional parameters that are not described above. Those parameters are listed in **Table B 4.7.7**. Default assumptions are made for all of these parameters.

**Table B 4.7.7. Additional parameters used by TIM.**

| **Parameter** | **Value** | **Source/Comments** |
| --- | --- | --- |
| Random seed | 0 | No seed set by user |
| Fraction of edge habitat receiving drift | 1 | Default (See TIM manual, appendix A) |
| Length of in-field spray drift buffer (ft) | 0 | Default (See TIM manual, appendix A) |
| Fraction of organic carbon in soil | 0.015 | Default (See TIM manual, appendix A)\* |
| Bulk density of soil (kg/L) | 1.5 | Default (See TIM manual, appendix A)\* |
| Spray height (m) | 0.5 (ground/airblast)  3 (aerial) | Default (See TIM manual, appendix A); ground height is based on low boom |
| Spray duration (min) | 0.5 (ground/airblast)  1.5 (aerial) | Default (See TIM manual, appendix A) |
| Application time | 8 | It is assumed that all applications are made at 8 am. |

\*If drinking water from puddles is a substantial exposure route for birds, this parameter can be made more geographically specific based on the range of the species.

1. **TIM/MCnest Results and Discussion**
   1. **TIM Analysis**

*Likelihood of mortality to an individual*

TIM was run to examine the likelihood of mortality to birds exposed to diazinon from spray drift from orchard crops, ground fruit and vegetables and nurseries. As noted in section 2, the most sensitive input parameters for TIM include the LD50 and the foliar dissipation half-life. When median estimates of these parameters are used (*i.e.,* LD50 = 1.51 mg a.i./kg-bw and foliar dissipation half-life = 2.2 d), the following conclusions can be drawn:

* For orchards (**Table B 4.7.8**) there is high probability (83.4% or greater) of mortality to an exposed individual of all species simulated, with the exception of the masked bobwhite, which has a medium probability (28.1%) of mortality to an individual.
* For ground fruit and vegetables (**Table B 4.7.9**), there is a high probability (89.1% or greater, >99.9% for most species) of mortality to an exposed individual for all simulated species.
* For nurseries (**Table B 4.7.10**), there is high probability (80.1% or greater) of mortality to an exposed individual of all species simulated, with the exception of the masked bobwhite Atwater’s prairie chicken, which have a medium probability (24.4 and 61.1%, respectively) of mortality to an individual.

This provides additional evidence to the effects determinations in that if an individual is exposed, there is a high likelihood of mortality.

**Table B 4.7.8. Likelihood of mortality to ≥1 individuals out of 100 exposed per year. Applications of 2 lb a.i./A to pome fruit and stone fruit or 3 lb a.i./A to almonds.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Scientific Name*** | **Common Name** | **estimates of LD50 and foliar dissipation half-life** | | |
| **Conservative\*\*** | **Central†** | **Least conservative††** |
| *Ammodramus savannarum floridanus* | Florida grasshopper sparrow | >0.999 | >0.999 | 0.906 |
| *Coccyzus americanus* | Yellow-billed Cuckoo (Western DPS) | >0.999 | >0.999 | 0.743 |
| *Colinus virginianus ridgwayi* | Masked bobwhite (quail) | 0.514 | 0.281 | 0.181 |
| *Dendroica chrysoparia* | Golden-cheeked warbler | >0.999 | >0.999 | >0.999 |
| *Empidonax traillii extimus* | Southwestern willow flycatcher\* | >0.999 | >0.999 | >0.999 |
| *Polioptila californica californica* | Coastal California gnatcatcher\* | >0.999 | >0.999 | >0.999 |
| *Setophaga kirtlandii* | Kirtland's Warbler | >0.999 | >0.999 | 0.998 |
| *Tympanuchus cupido attwateri* | Attwater's greater prairie-chicken | 0.991 | 0.834 | 0.237 |
| *Tympanuchus pallidicinctus* | Lesser prairie-chicken | >0.999 | 0.954 | 0.337 |
| *Vireo atricapilla* | Black-capped Vireo | >0.999 | >0.999 | 0.999 |
| *Vireo bellii pusillus* | Least Bell's vireo\* | >0.999 | >0.999 | >0.999 |

\*Almonds simulated.

\*\* Conservative scenario represented by LD50 = 0.43 mg/kg-bw; Foliar t1/2 = 5.3 d

† Central scenario represented by LD50 = 1.51 mg/kg-bw; Foliar t1/2 = 2.2 d

†† Least conservative scenario represented by LD50 = 14.5 mg/kg-bw; Foliar t1/2 = 0.4 d

**Table B 4.7.9. Ground fruit and vegetables: Likelihood of mortality to ≥1 individuals out of 100 exposed per year. Applications of 2 lb a.i./A made to lettuce via air, all other applications represent ground spray of 4 lb a.i./A.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Scientific Name*** | **Common Name** | **estimates of LD50 and foliar dissipation half-life** | | |
| **Conservative\*\*** | **Central†** | **Least conservative††** |
| *Ammodramus savannarum floridanus* | Florida grasshopper sparrow | >0.999 | >0.999 | 0.999 |
| *Coccyzus americanus* | Yellow-billed Cuckoo (Western DPS)\* | >0.999 | >0.999 | >0.999 |
| *Colinus virginianus ridgwayi* | Masked bobwhite (quail) | 0.999 | 0.891 | 0.274 |
| *Dendroica chrysoparia* | Golden-cheeked warbler | >0.999 | >0.999 | >0.999 |
| *Empidonax traillii extimus* | Southwestern willow flycatcher\* | >0.999 | >0.999 | >0.999 |
| *Polioptila californica californica* | Coastal California gnatcatcher\* | >0.999 | >0.999 | >0.999 |
| *Setophaga kirtlandii* | Kirtland's Warbler | >0.999 | >0.999 | >0.999 |
| *Tympanuchus cupido attwateri* | Attwater's greater prairie-chicken | >0.999 | >0.999 | 0.678 |
| *Tympanuchus pallidicinctus* | Lesser prairie-chicken | >0.999 | >0.999 | 0.763 |
| *Vireo atricapilla* | Black-capped Vireo | >0.999 | >0.999 | >0.999 |
| *Vireo bellii pusillus* | Least Bell's vireo\* | >0.999 | >0.999 | >0.999 |

\*Lettuce simulated.

\*\* Conservative scenario represented by LD50 = 0.43 mg/kg-bw; Foliar t1/2 = 5.3 d

† Central scenario represented by LD50 = 1.51 mg/kg-bw; Foliar t1/2 = 2.2 d

†† Least conservative scenario represented by LD50 = 14.5 mg/kg-bw; Foliar t1/2 = 0.4 d

**Table B 4.7.10. Nurseries: Likelihood of mortality to ≥1 individuals out of 100 exposed per year. Applications of 1 lb a.i./A made via ground spray.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Scientific Name*** | **Common Name** | **estimates of LD50 and foliar dissipation half-life** | | |
| **Conservative\*\*** | **Central†** | **Least conservative††** |
| *Ammodramus savannarum floridanus* | Florida grasshopper sparrow | >0.999 | >0.999 | 0.655 |
| *Coccyzus americanus* | Yellow-billed Cuckoo (Western DPS) | >0.999 | 0.992 | 0.447 |
| *Colinus virginianus ridgwayi* | Masked bobwhite (quail) | 0.337 | 0.244 | 0.095 |
| *Dendroica chrysoparia* | Golden-cheeked warbler | >0.999 | >0.999 | 0.927 |
| *Empidonax traillii extimus* | Southwestern willow flycatcher | >0.999 | >0.999 | 0.905 |
| *Polioptila californica californica* | Coastal California gnatcatcher | >0.999 | >0.999 | 0.960 |
| *Setophaga kirtlandii* | Kirtland's Warbler | >0.999 | >0.999 | 0.894 |
| *Tympanuchus cupido attwateri* | Attwater's greater prairie-chicken | 0.914 | 0.611 | 0.156 |
| *Tympanuchus pallidicinctus* | Lesser prairie-chicken | 0.978 | 0.801 | 0.198 |
| *Vireo atricapilla* | Black-capped Vireo | >0.999 | >0.999 | 0.942 |
| *Vireo bellii pusillus* | Least Bell's vireo | >0.999 | >0.999 | 0.958 |

\*\* Conservative scenario represented by LD50 = 0.43 mg/kg-bw; Foliar t1/2 = 5.3 d

† Central scenario represented by LD50 = 1.51 mg/kg-bw; Foliar t1/2 = 2.2 d

†† Least conservative scenario represented by LD50 = 14.5 mg/kg-bw; Foliar t1/2 = 0.4 d

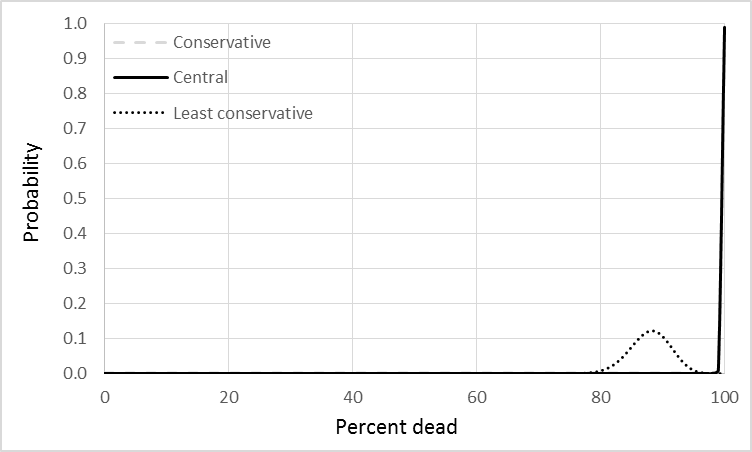
There is uncertainty associated with the relative sensitivity of the species considered in this assessment to other tested birds and the actual dissipation half-life of diazinon in areas inhabited by these species. If the species is more sensitive (*e.g.,* LD50 = 0.43 mg a.i./kg-bw) and the chemical dissipates more slowly (*e.g.*, dissipation half-life is 5.3 days), then the likelihood of mortality to 1 or more exposed individual increases. If the species is less sensitive (*e.g.,* LD50 = 14.5 mg a.i./kg-bw) and dissipates more quickly (*e.g.,* foliar dissipation half-life = 0.4 d), then the risk to an individual would decrease. Given the high likelihood of mortality when the central tendency estimates for these parameters are used (*i.e.,* HC50 and median foliar dissipation half-life), there is confidence that an exposed individual will die.

Dietary exposure was the greatest source of exposure leading to mortality (roughly 80% contribution). Dermal exposure from spray drift deposition directly on birds or dermal contact with contaminated foliage also contributed to doses leading to mortality. Based on this information, it is likely that species diet is highly influential on the estimates of mortality. For instance, insectivore species (e.g., kirtland’s warbler, vireos) have greater likelihoods of mortality compared to the two prairie chicken species, which have diets that include seeds and leaves (these food items have lower pesticide residues compared to insects).

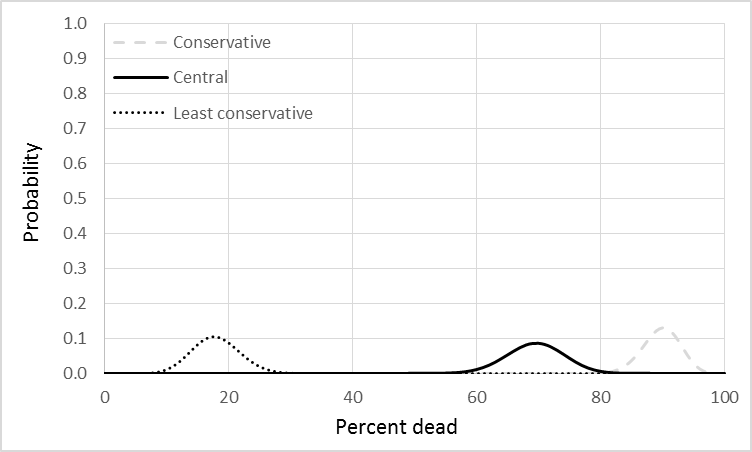
It should be noted that this analysis focuses on probabilities associated with mortalities of one or more birds out of 100 exposed. It is expected that the number of exposed individuals will vary by species and by use. The magnitude of the probability estimates for an individual may change depending on the number of individuals exposed. An analysis is provided below that involves estimates of the number of least bell’s vireos exposed to diazinon through applications to lettuce, other ground fruit and vegetables, orchards and nurseries.

*Magnitude of mortality in exposed individuals*

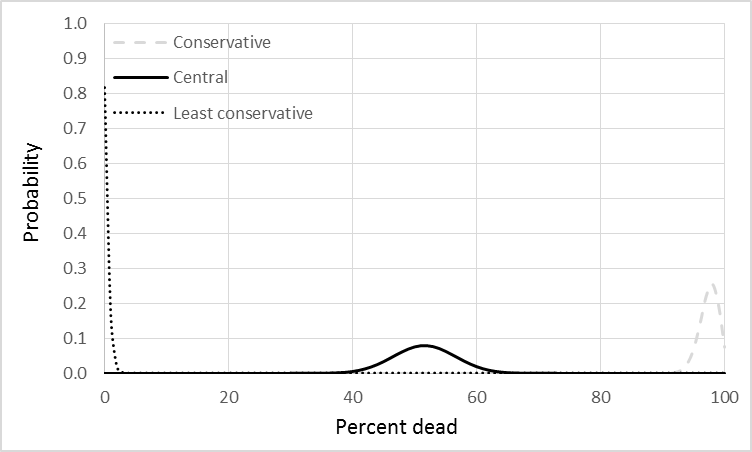
Probability distribution functions (PDFs) can be used to identify the most likely magnitude of mortality in exposed birds from a given use. PDFs for different uses can also be compared when considering relative risks associated with different uses. For instance, PDFs for the least bell’s vireo are provided in the figures below. These figures depict the most likely magnitudes of mortality associated with diazinon applications to lettuce (**Figure B 4.7.1**), ground fruit (*e.g.,* tomatoes; **Figure B 4.7.2**), almond orchards (**Figure B.4.7.3**) and outdoor nurseries (**Figure B 4.7.4**). This analysis indicates that almost all birds exposed to diazinon from applications to lettuce likely to die (approximately 99%). Risks to birds exposed to diazinon applied to other ground fruit (*e.g.,* tomatoes), orchards and nurseries is substantially lower, with an estimated magnitude of 60-80 for tomatoes, 40-60% mortality for almond orchards and 15-35% for nurseries. This information is considered useful in estimating the magnitude of effect in the portion of the population that is exposed and may be used in evaluating potential population-level impacts of diazinon on listed birds.

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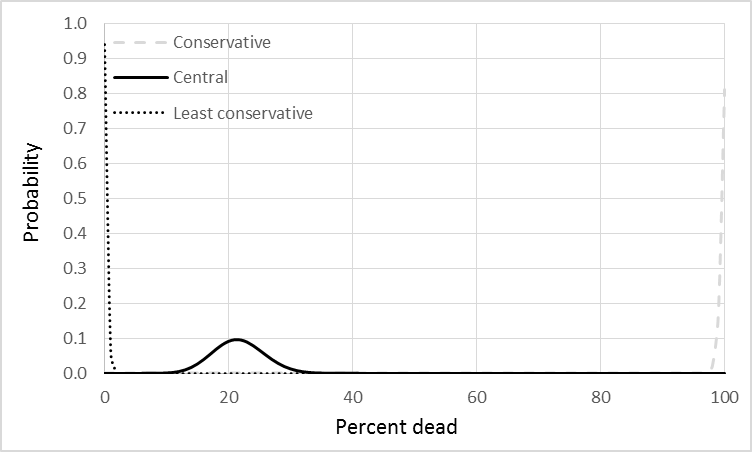
**Figure B 4.7.1. Probability distribution functions describing probability associated with killing x% of exposed least bell’s vireos. Exposures based on a single aerial application of 2 lb a.i./A diazinon to lettuce.**

****

**Figure B 4.7.2. Probability distribution functions describing probability associated with killing x% of exposed least bell’s vireos. Exposures based on a single ground spray application of 4 lb a.i./A diazinon to ground fruit or vegetables (e.g., tomatoes).**

****

**Figure B 4.7.3. Probability distribution functions describing probability associated with killing x% of exposed least bell’s vireos. Exposures based on a single air blast application of 3 lb a.i./A diazinon to almond orchards.**

****

**Figure B 4.7.4. Probability distribution functions describing probability associated with killing x% of exposed least bell’s vireos. Exposures based on a single ground spray application of 1 lb a.i./A diazinon to outdoor nursery.**

* 1. **MCnest Analysis**

When considering impacts to fecundity, mortality is the major contributor to declines; however, reproductive effects do occur in surviving birds. In general, applications made after the breeding period occur do not result in declines in fecundity because exposed adults are able to successfully reproduce prior to exposures that lead to mortality. Two examples are provided here that illustrate impacts to fecundity of birds: the yellow billed cuckoo and least bell’s vireo.

*Yellow Billed Cuckoo*

For lettuce, applications made from April 1-July 30, result in substantial declines (60-100%) in fecundity relative to control simulations for conservative and less conservative parameters for LD50 and foliar dissipation half-life (**Table B 4.7.11**). Declines in fecundity of exposed birds are expected to be less for orchards (10-40%; **Table B 4.7.12**) and nurseries (10-25% with most conservative parameters; **Table B 4.7.13**). Applications made on September 1 and later do not result in declines in fecundity because they are made after the breeding season of the yellow billed cuckoo.

**Table B 4.7.11. Fecundity declines estimated from applications of diazinon to lettuce.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Application Date** | **Decline in average fecundity of exposed individuals relative to control** | | |
| **Conservative** | **Central** | **Less conservative** |
| 1-Apr | 100% | 99% | 60% |
| 1-May | 100% | 99% | 62% |
| 31-May | 100% | 99% | 62% |
| 30-Jun | 100% | 99% | 66% |
| 30-Jul | 40% | 38% | 25% |
| 1-Sep | 0% | 0% | 0% |

**Table B 4.7.12. Fecundity declines estimated from applications of diazinon to orchards.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Application Date** | **Decline in average fecundity of exposed individuals relative to control** | | |
| **Conservative** | **Central** | **Less conservative** |
| 1-Mar | 24% | 10% | 0% |
| 1-Apr | 25% | 10% | 0% |
| 2-May | 24% | 9% | 0% |
| 2-Jun | 25% | 10% | 0% |
| 3-Jul | 41% | 19% | 0% |
| 3-Aug | 21% | 12% | 0% |
| 3-Sep | 0% | 0% | 0% |

**Table B 4.7.13. Fecundity declines estimated from applications of diazinon to nurseries.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Application Date** | **Decline in average fecundity of exposed individuals relative to control** | | |
| **Conservative** | **Central** | **Less conservative** |
| 1-Mar | 12% | 0% | 0% |
| 1-Apr | 12% | 0% | 0% |
| 2-May | 12% | 0% | 0% |
| 2-Jun | 10% | 0% | 0% |
| 3-Jul | 25% | 0% | 0% |
| 3-Aug | 13% | 0% | 0% |
| 3-Sep | 0% | 0% | 0% |

*Least Bell’s Vireo*

When considering impacts to fecundity, mortality is the major contributor to declines; however, reproductive effects do occur in surviving birds. Applications made to lettuce in the spring (March 1- June 2) result in the greatest declines (54-100%) in fecundity relative to control simulations for conservative and less conservative parameters for LD50 and foliar dissipation half-life (**Table B 4.7.14**). Applications made in the summer (July 3 and Aug 3) result in lower declines relative to controls (9-32%). Applications made September 3 and later do not result in declines in fecundity because they are made after the breeding season of the least bell’s vireo.

**Table B 4.7.14. Fecundity declines estimated from applications of diazinon to lettuce.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Application Date** | **Decline in average fecundity of exposed individuals relative to control** | | |
| **Conservative** | **Central** | **Less conservative** |
| 1-Mar | 100% | 100% | 88% |
| 1-Apr | 100% | 100% | 89% |
| 2-May | 77% | 77% | 67% |
| 2-Jun | 60% | 60% | 54% |
| 3-Jul | 32% | 32% | 29% |
| 3-Aug | 11% | 11% | 9% |
| 3-Sep | 0% | 0% | 0% |

1. **Preliminary analysis of number of individuals exposed: proof of concept with least bell’s vireo**
   1. **Method for estimating the number of individuals exposed to diazinon**

The number of individual least bells vireos exposed to diazinon is estimated by considering the amount of overlap of potential diazinon use sites and spray drift areas with the most likely areas inhabited by a species (“preferred habitat”). That amount of overlap is multiplied by the most recent population estimate. The method considered here generates an average annual number of birds exposed based on 5 years of land cover data for potential diazinon use sites and 9 years of diazinon usage data. This method also generates an estimate of the maximum number of individuals exposed in a given year based on maximum estimates of usage and acreage of potential diazinon use sites. This section describes the data and method for estimating the number of exposed individuals.

*Identification of Species-Specific Preferred Habitats*

ArcGIS (v10.3.1) is used to select the most likely areas inhabited by the least bell’s vireo from within the range data provided by FWS. USGS’ GAP land cover data[[3]](#footnote-3) representing preferred habitat of the least bell’s vireo are identified. The land covers comprising “preferred habitat” were selected based on species-specific habitat preference information in FWS documentation[[4]](#footnote-4). The specific land covers used to define preferred habitats are provided in **Supplemental Information 2**. These assumptions may be refined with input from species experts on the appropriate GAP land covers that may represent preferred habitat.

*Calculation of Percent overlap of preferred habitat with diazinon exposure areas*

Individual years of land cover data from 2010-2014[[5]](#footnote-5), representing potential diazinon use sites (*i.e.,* orchards and ground vegetable/fruit) were buffered with 1,000 foot and 2,500 foot spray drift buffers[[6]](#footnote-6). A 2,500 foot buffer was used in cases where lettuce represents a substantial portion of the acres of a crop that represents the vegetable and ground fruit layer. A 1,000 foot buffer was used for all other diazinon uses. On an annual basis, the amount of overlap of preferred habitat and pesticide exposure areas (use sites + spray drift) is estimated. Several years of available data are used to account for the variability from one year to the next. The nursery land cover was also buffered out 1,000 feet to account for spray drift.

When transitioning from the individual and field level to the population and landscape scale, it is not reasonable to assume that diazinon is applied on all potential use sites within a season. Available Data (**Appendix 1-8**) includes national level usage data based on 9 years of past use of diazinon by crop. This includes estimates of the average and maximum percent of the crop treated. These estimates currently represent the best available estimates of percent crop treated that can be used at the landscape scale.

For each year, the amount of overlap is further refined by considering the proportion of potential use sites that are expected to be treated with diazinon. This is accounted for using national-level estimates of percent of crop treated (**Table B 4.7.15 and 16**; data from Screening Level Usage Analysis (SLUA) provided in **Attachment 1-8**). The appropriate percent of crop treated value is identified using the crops with the greatest number of acres as identified in USDA’s census of agriculture data[[7]](#footnote-7) available for the counties where the species occurs. No estimated usage data are available for nurseries. Therefore, the most conservative values available for a single crop (*i.e.,* 35% average and 60% max for lettuce) are used as a surrogate. This approach uses 9 years of past usage data (2004-2012) to represent the average usage of diazinon per crop so that a best estimate of the number of individuals exposed over several years can be generated. The maximum amount of usage over that time period is also used to calculate an upper bound on the number of exposed individuals in a given year.

There are uncertainties associated with this approach related to extrapolating from national level usage data to regional, state or county level ranges of the species of interest because there may be variation in usage due to pest pressure or other factors. There is also uncertainty associated with lack of usage data for nurseries. In addition, the SLUA includes data that are not necessarily consistent with current labels that have been revised because of the Registration Eligibility Decision (RED) in 2006 (SLUA data are from 2004-2012). Given the timing of the implementation of the RED and use of existing stocks of pre-RED products, it is expected that usage data from 2010-present are representative of current labels. These uncertainties are also explored using recent Pesticide Usage Reporting (PUR) data[[8]](#footnote-8) provided by the state of California.

**Table B 4.7.15. Estimated percent of orchard crops in US treated with diazinon (based on data reported from 2004-2012).**

|  |  |  |
| --- | --- | --- |
| **Crop** | **Average** | **Maximum** |
| Apricots | 20 | 40 |
| Plums/Prunes | 10 | 25 |
| Cherries | 5 | 15 |
| Peaches | 5 | 15 |
| Apples | 5 | 10 |
| Pears | 5 | 10 |
| Almonds | <2.5 | 10 |
| Nectarines | <2.5 | <2.5 |

**Table B 4.7.16. Estimated percent of vegetable and ground fruit crops in US treated with diazinon (based on data reported from 2004-2012).**

|  |  |  |
| --- | --- | --- |
| **Crop** | **Average** | **Maximum** |
| Lettuce | 35 | 60 |
| Spinach | 25 | 60 |
| Caneberries | 30 | 50 |
| Carrots | 15 | 40 |
| Cantaloupes | 15 | 35 |
| Blueberries | 20 | 25 |
| Cabbage | 15 | 25 |
| Onions | 15 | 25 |
| Broccoli | 5 | 20 |
| Cauliflower | 10 | 20 |
| Garlic | 10 | 15 |
| Strawberries | 5 | 15 |
| Celery | 5 | 10 |
| Cucumbers | 5 | 10 |
| Honeydews | 5 | 10 |
| Peppers | <2.5 | 10 |
| Squash | 5 | 10 |
| Tomatoes | 5 | 10 |
| Watermelons | 5 | 10 |
| Beans, Green | <2.5 | 5 |
| Dry Beans/Peas | <1 | <2.5 |
| Peas, Green | <1 | <2.5 |
| Potatoes | <1 | <2.5 |
| Pumpkins | <1 | <2.5 |
| Sugar Beets | <1 | <2.5 |

There is uncertainty in using the orchard/vineyard land cover to represent potential diazinon use sites because diazinon is registered for use on a limited number of orchard crops (*i.e.*, almonds, stone fruit and pome fruit). Census of agriculture data for counties inhabited by several of the least bell’s vireo indicates substantial acreage (59%) represented by non-registered crops, including citrus, grapes, pecans and walnuts. As a result, an additional factor (0.41) is used to account for the proportion of the orchard/vineyard land cover that represents registered diazinon use sites. This factor is calculated on a by dividing the amount of acres represented by diazinon use sites by the total amount of acreage represented by the majority of the orchard crops (according to the census of agriculture).

*Estimation of number of exposed individuals*

Finally, the number of individuals exposed is calculated by multiplying the percent of overlap of the preferred habitat with pesticide use by the population estimate for that species. The most recent (from 2006) population estimate of the least bell’s vireo is 2,692[[9]](#footnote-9).

*Additional assumptions and uncertainties*

In this approach, it is assumed that individuals are uniformly distributed on the preferred habitat areas within the range. It is also assumed that breeding pairs have sufficient resources on preferred habitats and establish territories that would lead to maximum distance between pairs (*i.e.*, uniform distribution). This approach has the potential to underestimate the number of individuals exposed if they are grouped in an area that overlaps with a diazinon use site/spray drift zone. More refined GIS data are needed to define areas of higher density distribution of the species.

In addition, the current approach does not distinguish between exposures in the breeding range and in the migratory range. There is uncertainty associated with short term exposures to diazinon that may occur when individuals stop to gorge during migration. Methods for estimating the number of individuals exposed during migration are still being developed. Because the migratory range of the Least bell’s vireo occurs outside of the US and the US range represents the breeding range, this uncertainty is of less concern.

* 1. **Results and Discussion**

The annual percent overlap estimates for the proportion of the preferred habitats receiving spray drift from potential use sites is provided in **Table B 4.7.17**. These values are multiplied by the mean and maximum proportions of the total crop treated with diazinon (based on the SLUA). For orchards, almonds represent the largest extent of the acres in the counties inhabited by this species (considering orchard crops for which diazinon is registered). For vegetable and ground fruit, lettuce and tomatoes represent the largest proportion of acreage in the counties where this species occurs. Given that diazinon may be applied aerially to lettuce but not to any other uses, the exposure from these crops is expected to be different. Also, the percent of the crop treated with diazinon differs widely for lettuce (average: 35%) and tomatoes (5%). According to census of agriculture data, the ratio of acres of lettuce to tomatoes is approximately 2:1. For this analysis, 68% of the acres of ground fruit and vegetables are assumed to be represented by lettuce and the other 32% represented by tomatoes. The orchard and nursery overlaps are based on 1,000 foot spray drift buffers while the vegetable and ground fruit overlaps are based on a 2,500 spray drift buffer (because aerial applications are allowed for lettuce).

**Table B 4.7.17. Percent of least bell’s vireo preferred habitat potentially receiving spray drift from diazinon use sites.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year (land cover data)** | **Orchard\*** | **Veg ground fruit:**  **lettuce** | **Veg ground fruit: tomatoes** | **Nursery** |
| 2010 | 5.4 | 11.4 | 3.0 | 0.80 |
| 2011 | 3.5 | 10.1 | 2.8 |
| 2012 | 6.3 | 8.5 | 2.4 |
| 2013 | 7.7 | 8.6 | 2.4 |
| 2014 | 7.2 | 10.1 | 2.9 |
| Mean | 6.0 | 9.7 | 2.7 | NA |

**\* Values account for orchard adjustment factor of 0.41**

Based on the estimated population size for this species of 2692 and the usage and percent of range exposed, it is most likely that an average of 107 individuals will be exposed on an annual basis (due to spray drift from vegetable and ground fruit, orchards and nurseries). If maximum usage is considered, an annual average of 194 individuals will be exposed. On any given year it is estimated as many as 221 individuals may be exposed. Of the uses considered, lettuce results in the greatest number of exposed individuals (**Table B 4.7.18 and 19**).

This approach assumes that all applications of diazinon to lettuce are made via aerial methods, which results in the greatest extent of spray drift deposition. If applications are made via ground spray, fewer individuals are exposed per year, with an annual average of 61 and a maximum of 104 in a given year. **Table B 4.7.20** compares the relative number of individuals exposed via spray drift from ground and aerial applications to lettuce.

**Table B 4.7.18. Estimated number of least bell’s vireo exposed to diazinon. Usage data based on average national level estimates from SLUA (2004-2012).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year (land cover data)** | **Orchard** | **Veg ground fruit: lettuce** | **Veg ground fruit: tomatoes** | **Nursery** | **Total** |
| 2010 | 4 | 108 | 4 | 8 | 124 |
| 2011 | 2 | 95 | 4 | 109 |
| 2012 | 4 | 80 | 3 | 95 |
| 2013 | 5 | 81 | 3 | 97 |
| 2014 | 5 | 95 | 4 | 112 |
| Mean | 4 | 92 | 4 | NA | 107 |

**Table B 4.7.19. Estimated number of least bell’s vireo exposed to diazinon. Usage data based on maximum (in a given year) national level estimates from SLUA (2004-2012).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year (land cover data)** | **Orchard** | **Veg ground fruit: lettuce** | **Veg ground fruit: tomatoes** | **Nursery** | **Total** |
| 2010 | 15 | 185 | 8 | 13 | 221 |
| 2011 | 10 | 163 | 8 | 194 |
| 2012 | 17 | 137 | 7 | 174 |
| 2013 | 21 | 139 | 6 | 179 |
| 2014 | 19 | 164 | 8 | 204 |
| Mean | 16 | 158 | 7 | NA | 194 |

**Table B 4.7.20. Estimated number of least bell’s vireo exposed to diazinon from ground vs. aerial applications to lettuce.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year (land cover data)** | **Average usage (SLUA)** | | **Maximum usage (SLUA)** | |
| **Ground** | **Aerial** | **Ground** | **Aerial** |
| 2010 | 61 | 108 | 104 | 185 |
| 2011 | 56 | 95 | 96 | 163 |
| 2012 | 49 | 80 | 83 | 137 |
| 2013 | 48 | 81 | 83 | 139 |
| 2014 | 57 | 95 | 98 | 164 |
| Mean | 61 | 108 | 104 | 185 |

As noted previously, there is uncertainty in using national-level estimated annual usage data (SLUA). PUR data for the state of California indicate that diazinon usage on almonds in 2011-2014 was 0.02-0.1% of acreage. This value is much lower than the maximum of 10% reported in the SLUA for 2004-2012. PUR usage on tomatoes (processing) indicate an average of 1.7%, with a max of 3.5% from 2011-2014. CA usage data on lettuce was 3.6% on average (maximum of 10% in 2011), which is much lower than the SLUA (35% average, 60% maximum). This decrease in usage may not be attributed to the change in scale from national-level to state-level, but rather reflective of a downward trend in use of diazinon following RED mitigations. When state average PUR data from 2011-2014 are used in place of SLUA data for lettuce, almonds and tomatoes, the number of individual least bell’s vireos is substantially lower, with 99 individuals per year for these three crops for the SLUA as opposed to 12 individuals per year estimated using the PUR (**Table B 4.7.21**).

**Table B 4.7.21. Estimated number of least bell’s vireo exposed to diazinon based on average usage data from SLUA (national-level) and CA PUR (state level).**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year (land cover data)** | **Almonds** | | **Lettuce** | | **Tomatoes** | |
| **SLUA** | **PUR** | **SLUA** | **PUR** | **SLUA** | **PUR** |
| 2010 | 4 | 0 | 108 | 11 | 4 | 1 |
| 2011 | 2 | 0 | 95 | 10 | 4 | 1 |
| 2012 | 4 | 0 | 80 | 8 | 3 | 1 |
| 2013 | 5 | 0 | 81 | 8 | 3 | 1 |
| 2014 | 5 | 0 | 95 | 10 | 4 | 1 |
| Mean | 4 | 0 | 92 | 11 | 4 | 1 |

A county-level analysis was conducted using census of agriculture data for specific orchard and ground fruit and vegetable crops and PUR acres treated data reported in those counties for the same crops. Only data from 2012 were used so that the acres treated and acres grown in each county were consistent (the limiting factor is the availability of census of agriculture data, which are collected every 5 years). When the 27 counties inhabited by this species are considered, up to 2 individuals may be exposed to diazinon from orchards and 3 from ground fruit and vegetable crops. For orchards, it appears most likely that an individual may be exposed from apples, cherries or pears, with low likelihood of exposure to almonds. When considering ground fruit and vegetables, most likely exposures involve diazinon use on tomatoes and lettuce, as well as onion, strawberries and lettuce.

Based on 5 years of land cover data for potential diazinon use sites and 9 years of national-level diazinon usage data, the average estimated number of individuals exposed per year is 107 individual least bell’s vireos (4% of the population). When considering an upper bound of the number of individuals exposed based on maximum estimates of usage and acreage of potential diazinon use sites, as many as 221 least Bell’s vireos (8% of the population) may be exposed in a given year. Aerial applications to lettuce are most likely contributing to the majority of the exposed individuals. When considering the TIM results (Figure B 4.7.1), it is most likely that the majority (99%) of these exposed individuals will die. When considering impacts to fecundity, if applications occur during the breeding season (*i.e.,* spring and summer), mortality in adult birds leads to substantial declines in number of broods and fledglings per female. If adult birds survive diazinon exposures, there is potential for reproductive effects. There is uncertainty associated with the number of estimated Least Bell’s vireos exposed to diazinon in a given (due to application of national level usage data, some of which may not be reflective of current diazinon labels). When local usage data from PUR is used for CA, the estimated number of individuals exposed per year is an order of magnitude lower (*i.e.,* 11).

This analysis was conducted to explore methods for estimating the number of individuals exposed using currently available data and to identify data needs. Major uncertainties associated with this approach include: assumptions of uniform distributions of individuals within a population, use of national level usage data from 9 years to represent potential usage over the next 15 years and lack of consideration of exposure during migration. GIS data providing information of distributions (and densities) of individuals during migration and the breeding season would be helpful to address the first two uncertainties.

1. https://www.epa.gov/endangered-species/provisional-models-endangered-species-pesticide-assessments [↑](#footnote-ref-1)
2. **Mineau, P., B.T. Collins, A. Baril. 1996.** On the use of scaling factors to improve interspecies extrapolation to acute toxicity in birds. Reg. Toxicol. Pharmacol. 24:24-29. [↑](#footnote-ref-2)
3. US Geological Survey, Gap Analysis Program (GAP). May 2011. National Land Cover, Version 2. Available online at: http://gapanalysis.usgs.gov/gaplandcover/ [↑](#footnote-ref-3)
4. Habitat of least bell’s vireo includes woodland including cotton-wood willow forest, Oak wood lands, and mule fat scrub; Scrub vegetation; Palm groves and hedgerows associated with agricultural fields and residential areas (Attachment 1-16).

   Breed in riparian habitat, typically inhabiting structurally diverse woodlands along watercourses [↑](#footnote-ref-4)
5. See Attachments 1-2 and 1-3 for sources of land cover data sets for orchards, ground fruit and vegetables and nurseries in the 48 contiguous states. [↑](#footnote-ref-5)
6. Spray drift buffers of 1,000 feet and 2,500 feet are based on the estimation bounds of the AgDRIFT model, which is used to predict spray drift deposition for ground and aerial applications, respectively. [↑](#footnote-ref-6)
7. NASS: Census of Agriculture, 2012: Full Report *U.S. Dept. of Agriculture.*  Washington, DC : Department of Agriculture.   Washington, DC : <http://www.agcensus.usda.gov/Publications/2012/index.php#full_report> [↑](#footnote-ref-7)
8. Available online at: http://www.cdpr.ca.gov/docs/pur/purmain.htm [↑](#footnote-ref-8)
9. https://www.nwf.org/~/media/PDFs/Wildlife/LeastBellsVireo.ashx [↑](#footnote-ref-9)