A Probabilistic Model and Process to Assess Acute Lethal Risks to Birds

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EXECUTIVE SUMMARY

Background

EPA is implementing a new tiered process to conducting ecological risk assessments, which will be used under the FIFRA regulatory framework. This approach will include probabilistic tools and methods at the more refined, higher levels (tiers) to provide information regarding the probability or likelihood of the impact as well as the magnitude or severity of the effect. This new process will be used to better characterize the impact of pesticides on non-target terrestrial and aquatic organisms. The results of these analyses will in turn be used by risk management divisions in decision-making.

Under this new tiered approach, screening level (deterministic) assessments are first conducted and are generally based on conservative assumptions and generic data. More complex probabilistic assessments, representing increasingly realistic biological and exposure scenarios, are performed for those pesticides judged at the screening level to potentially pose the most serious risk and that are believed to require further characterization to determine appropriate regulatory action.

The Environmental Fate and Effects Division (EFED) in EPA's Office of Pesticide Programs conducted a screening level assessment for agricultural uses of ChemX on a variety of crops using existing EFED deterministic methods. This deterministic assessment, which was based on risk quotients, indicated high avian acute risk. An evaluation of the field studies, data from monitoring programs, open literature, and well documented incident reports provided confirmatory evidence of the occurrence of acute impacts to birds following ChemX application under current, approved label rates and methods. Thus, the weight-of-the evidence for the effects on birds was compelling, leading to a high level of certainty in concluding acute high risks to birds. In addition, significant concerns were raised about potential chronic exposure to birds and for possible impacts to other non-avian wildlife as well.

As a result of the potentially significant risk to non-target terrestrial species, ChemX was identified as a candidate for a more refined, higher level assessment using probabilistic techniques. The refined assessment approach presents the risk in more quantitative terms, providing an estimate of the probability and magnitude of adverse effects. Owing to the existence of a comparatively more robust avian toxicological data set, the scope of the refined risk assessment is confined to direct acute effects on birds.

Overview of the Refined Assessment

Use Scenarios

The use scenarios for the refined assessment were selected based on a use profile of ChemX and the results of the screening level assessment. Scenarios were selected based on (1) the large volume of ChemX used, (2) total acres potentially treated, and (3) the high risk quotients calculated along with the supporting field evidence.

This resulted in the selection of the following use scenarios: at-plant and foliar application of flowable ChemX to corn and foliar application to alfalfa. Both scenarios take place in the spring and in the midwestern region of the United States. It should be noted that other regions of the country, notably western states, may also be important when considering alfalfa. However, the results of an analysis of midwestern alfalfa are believed to be representative of risks to avian species in western states as well.

For both corn and alfalfa, the scenarios were based on single applications of ChemX. The application rates used ranged from the lowest to the highest on the label along with typical rates, which are those that fall within the range of application rates reported to encompass the largest percentage of treated acres. In some cases, only a single application rate was identified on the label. The following table presents a complete picture of the use scenarios considered in the refined assessment. The application rate is presented in ounces (oz)/1000 feet (ft) and pounds (lb) active ingredient (ai)/acre. It should be noted that 2.5 oz/1000 ft is equivalent to 1 lb ai/acre.

Crop	Application Method	Application Rate	Rationale for Selection of Application Rate
corn	at plant in-furrow	2.5 oz/1000 ft	only rate on label
corn	at plant banded	2.5 oz/1000 ft, 7 inch band	only rate on label
corn	foliar	1 lb ai/acre	maximum rate
corn	foliar	0.75 lb ai/acre	typical rate
corn	foliar	0.25 lb ai/acre	24-c minimum rate
alfalfa	foliar	1 lb ai/acre	maximum rate
alfalfa	foliar	0.5 lb ai/acre	typical rate
alfalfa	foliar	0.125 lb ai/acre	minimum rate

Selection of Focal Species

In screening level assessments, the species tested under the standard guideline studies (40 CFR 158) are assumed to be representative of avian species in general, and therefore results of these tests along with conservative exposure assumptions are used to make predictions for all species. In contrast, focal species are selected for use in more refined assessments to provide more realistic and appropriate biological scenarios. The focal species provide information specific to that species and are also considered representative of other species with similar biological/behavioral characteristics sharing a treated area. Selection criteria for focal species included, but were not limited to, species likely to be found in fields treated by the pesticide, and their natural history.

In selecting focal species for the refined assessment, EFED considered the results of field studies. Avian species in and around corn and alfalfa fields where ChemX was being applied and which were reported dead were considered. In addition, open literature on birds inhabiting corn and alfalfa fields and their surrounding habitat as well as information on the feeding and nesting habits of birds associated with these crops were evaluated. Based on these criteria, the following species were selected for midwestern corn and alfalfa:

Corn

Species	Diet Preferences	Feeding Sites	Nesting Sites
Meadow Lark (eastern and western)	insectivore	ground	ground
Horned Lark	omnivore	ground	ground
Vesper Sparrow	omnivore	ground	ground
Red-winged Blackbird	omnivore	ground	shrubs
Mourning Dove	granivore	ground	tree
Killdeer	insectivore	ground	ground

Alfalfa

Species	Diet Preferences	Feeding Sites	Nesting Sites
Dickcissel	omnivore	ground	ground
Western Meadowlark	insectivore	ground	ground
Grasshopper Sparrow	omnivore	ground	ground
Mourning Dove	granivore	ground	tree
Vesper Sparrow	omnivore	ground	ground
Mallard Duck	herbivore	ground	ground

Construct of the Refined Terrestrial Risk Assessment Model

EFED has developed a refined assessment model to estimate the magnitude and probability of acute effects to non-target avian species from pesticides. The basic structure of the model can be expressed by the general equation:

$$Risk = f(exposure, toxicity) .$$

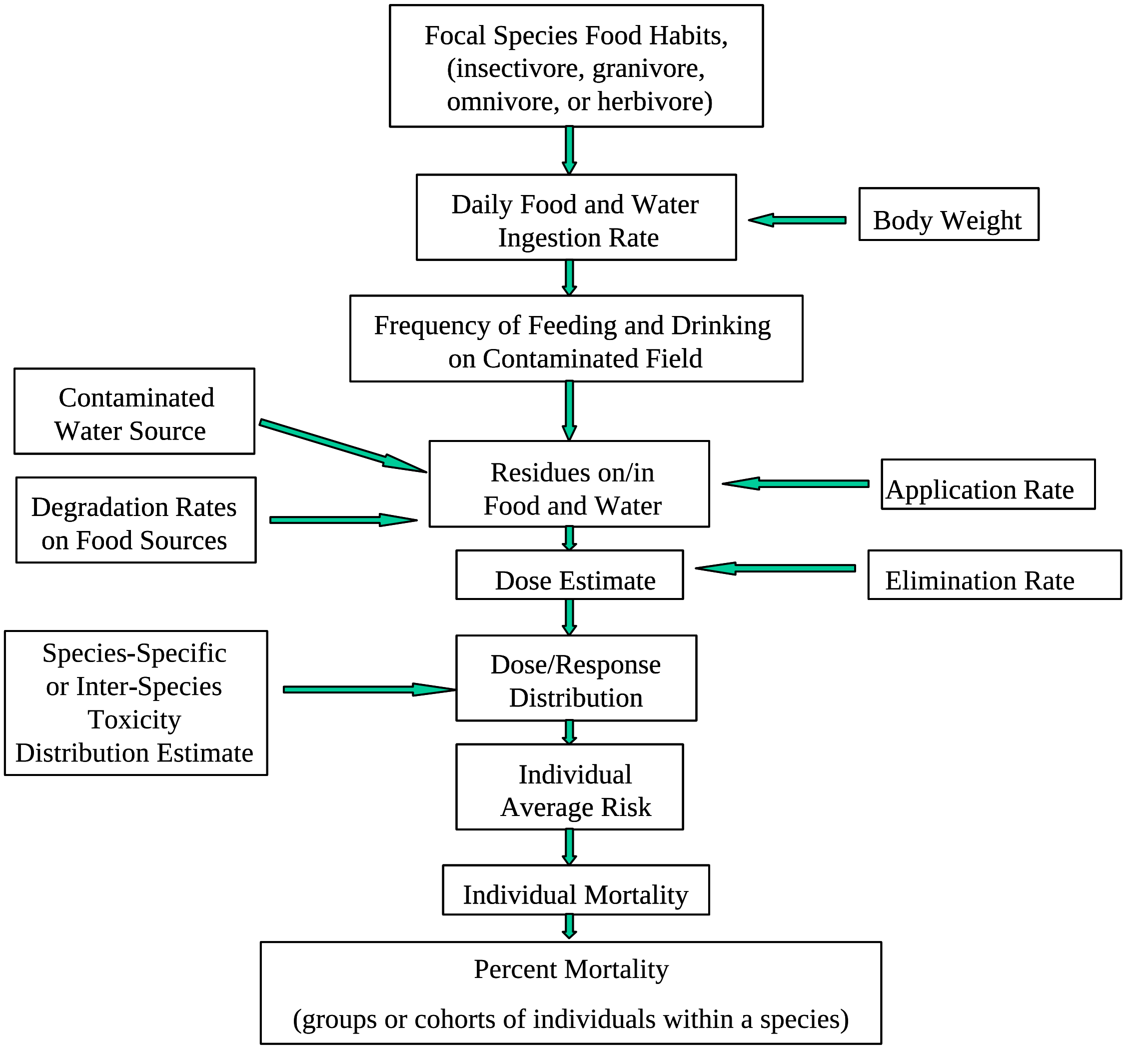
Since risk is a function of exposure and toxicity, the model is based on the characterization of exposure and effects. Distributions were developed for the major exposure and effects variables, which were combined using a Monte Carlo analysis to estimate the probability and magnitude of effects.

The major parameters addressed in the model are:

- Food habits of selected focal species, which are proportioned for each food type consumed;
- Daily ingestion rate of food and water as a function of body weight;
- Frequency of feeding and drinking on the sprayed field;
- Water sources (dew, puddles, and ponds);
- Distribution of residues on the food and water sources as a function of application rate;
- Degradation rates of food residue estimates, and
- Inter- and intra-species sensitivity distributions.

A flow diagram illustrating the overall relationship of the model construct is provided in Figure E-1.

Figure E-1. Conceptual Model Flow Diagram



Model Input Data

The conceptual model presented may be used to conduct a refined assessment. The model uses probabilistic techniques to quantify acute mortality for a variety of pesticides based on oral exposure from food and water taken in treated fields. The input data, however, will vary. For the refined assessment of ChemX, the following input data were used in the model simulations:

- The use scenarios for midwestern corn and alfalfa described previously. Aerial applications were run with existing on-field puddles, rain events forming puddles on the day following application, and no rain events;
- The focal species identified earlier;
- The three assumptions of bird sensitivity (low, medium, and high) to ChemX when species-specific toxicity data were not available; and
- A seven day exposure window based on the half-life of ChemX.

Refined Assessment Results for ChemX

The results of the refined assessment for ChemX are summarized in Tables E-1 through E-4. Table E-1 provides a quantitative summary of acute bird mortality for the exposed complex of species. Since the sensitivity of most of the focal species to ChemX is unknown, model simulations were run based on low, medium, and high sensitivity to ChemX in order to address the uncertainty this introduces into the refined assessment.

In contrast, Tables E-2, E-3 and E-4 provide a quantitative summary of acute bird mortality for specific species, the red-winged blackbird and the mallard duck. Toxicity data were available for both species and were thus used in model simulations.

Mean Avian Mortality Levels

Table E-1 provides a summary of the mean mortality levels of avian species that occur in and around fields treated with ChemX. They include the range of mortality, which is based on the mean percent mortality, and the percentage of species with predicted mortality to be greater than 0, 10, and 70%.

For example, under the scenario for aerial application to corn at the lowest application rate of 0.25 lb ai/acre, the range of mortality for the complex of avian species exposed, on average, is between 0 and 88%. That is, over the long term, some species are experiencing no mortality and other species may be experiencing an average mortality up to 88%. Further, on average, (1) 70% of the exposed complex of species will have some mortality due to ChemX exposure, with 30% of the species experiencing no mortality; (2) 35% of the species are expected to experience 10% mortality or greater; and (3) 10% are experiencing 70% mortality or greater, which may range up to 88%.

Table E-1. Range of Predicted Mean Mortality Results (Across Species, Application Scenarios, and Exposure Scenarios) and Percent of Species Above Selected Levels of Mortality

Use Scenario	Range of Mean Percent Mortality	Percentage of species with mean mortality X% or greater than:		
		>0 %	10%	70%
corn aerial 0.25 lb ai/acre (minimum rate)	0 to 88	70	35	10
corn aerial 0.75 lb ai/acre (typical rate)	0 to 98	85	65	15
corn aerial 1 lb ai/acre (maximum rate)	0 to 99	95	90	20
corn banded 1 lb ai/acre (only rate)	0 to 86	60	33	<5
corn in-furrow 1 lb ai/acre (only rate)	0 to 86	70	37	<5
alfalfa aerial 0.125 lb ai/acre (minimum rate)	0 to 50	55	27	0 (max. 50% mortality)
alfalfa aerial 0.5 lb ai/acre (typical rate)	0 to 89	70	57	17
alfalfa aerial 1 lb ai/acre (maximum rate)	0 to 92	95	62	23

An overview of Table E-1 suggests that the majority of avian species using ChemX-treated fields of corn and alfalfa, regardless of application rate and method, will experience, on average, some mortality. Approximately one-third or more of the exposed species expected to experience 10% mortality or greater. At typical aerial application rates for both corn and alfalfa crops, approximately 60% or more of the species are expected to experience mean mortality of 10% or greater and approximately 15% are expected to experience 70% or greater. Except for the lowest aerial application rate to alfalfa, very high average levels of mortality (70% or greater) will occur in some species. Even at the lowest application rate for alfalfa, some species are still predicted to experience nearly 50 percent mortality.

Predicted Mortality for Red-Winged Blackbirds and Mallard Ducks

Tables E-2 through E-4 provide summaries of predicted mortality for the red-winged blackbird and mallard duck. Both species have toxicity data for ChemX, which indicate they are fairly sensitive to this pesticide. Model runs were based on the toxicity of these species to ChemX, and therefore more quantitative conclusions could be made for these birds.

Table E-2 provides a range of predicted mortality for red-winged blackbirds. Even at the lowest rate of aerial application to corn, 24% mortality of the exposed red-winged blackbirds is expected to result, on average. Mortality is expected to be 10% or greater in the majority of cases (95% probability). However, in a few cases (5% probability), the mortality is expected to be between 45 and 50% at the lowest application rate. At higher application rates, the mortality is predicted to be even greater.

Table E-2. Range of Predicted Mortality for Red-Winged Blackbirds

Use Scenario	Mean Mortality Level	95% Probability of Mortality	5% Probability of Mortality
corn aerial 0.25 lb ai/acre (minimum rate)	24%	≥10%	45 - 50%
corn aerial 0.75 lb ai/acre (typical rate)	57%	≥40%	75 - 85%
corn aerial 1 lb ai/acre (maximum rate)	64%	≥45%	85 - 95%
corn banded 1 lb ai/acre (only rate)	30%	≥15%	45 - 64%
corn in-furrow 1 lb ai/acre (only rate)	30%	≥15%	50 - 60%

Predicted mortalities for mallard ducks exposed to ChemX are summarized in Table E-3 for zero days after application and in Table E-4 for 12 days after application. High mortality rates are predicted in alfalfa fields for both temporal application cases, with the exception of exposure at the lowest application rate approximately two weeks after pesticide application. If mallard ducks feed in a recently treated field at the lowest application rate zero days after application, the mean mortality level expected is 82%. There is a 95% probability that mortality will be 65% or greater, and in a very few cases (5% probability) mortality of 95% or greater is expected. At this same application rate, mortality is still expected 12 days later, but ChemX residues appear to decline to a level that does not induce high mortality.

Table E-3. Range of Predicted Mortality for Mallard Ducks Zero Days After Application

Use Scenario	Mean Mortality Level	95% Probability of Mortality	5% Probability of Mortality
alfalfa aerial 0.125 lb ai/acre (minimum rate)	82%	≥65%	≥95%
alfalfa aerial 0.5 lb ai/acre (typical rate)	99%	≥95%	≥100%
alfalfa aerial 1 lb ai/acre (maximum rate)	100%	≥100%	≥100%

Table E-4. Range of Predicted Mortality for Mallard Ducks 12 Days After Application

Use Scenario	Mean Mortality Level	95% Probability of Mortality	5% Probability of Mortality
alfalfa aerial 0.125 lb ai/acre (minimum rate)	3%	≥0%	≥10%
alfalfa aerial 0.5 lb ai/acre (typical rate)	28%	≥10%	≥45%
alfalfa aerial 1 lb ai/acre (maximum rate)	54%	≥35%	≥70%

Tables E-2 through E-4 provide species-specific predictions of mortality to the red-winged blackbird and mallard duck from ChemX application. Results for both species indicated significant mortality events were likely, depending upon application rate and method. Analysis of all mean mortality predictions across species and sensitivity assumptions suggests that significant mortality events are likely for a large number of species.

Conclusions

The results of the refined assessment quantify the conclusions reached in the lower level, screening assessment. Based on the construct of this probabilistic model, high mortality in at least some avian species will occur, regardless of the application rate and method, following the application of ChemX to corn and alfalfa using the application methods and rates examined in the refined assessment.

Specifically, results show that from 55% to 95% of the bird species using midwestern corn and alfalfa fields treated with ChemX will experience some mortality, on average. Twenty-seven to 90% of the species are likely to experience at least 10% or greater mortality, on average, while up to 23% of the species are likely to experience at least 70% mortality, again on average.

The relative risks of some application methods and application rates can be differentiated. Banded and in-furrow applications of ChemX to corn are predicted to result in lower levels of mortality to more species than aerial application of ChemX to corn at comparable and even lower rates. For both corn and alfalfa aerial applications, lower rates of application result in lower predicted levels of mortality for more species. However, even for those application rates and methods showing lower impacts, several species are still predicted to experience relatively high mortality levels.

In reference to red-winged blackbirds, mean mortality in corn is predicted to be from 24 to 64%. But for some groups of birds, mortality could go as high as 95%. The results for mallard ducks in alfalfa are even more striking. Depending on the application rate, the mean mortality is predicted to range from 57 to 99% 3 days after application, 39 to 95% 6 days after application, and from 3 to 54% 12 days post application.

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INTRODUCTION

The Environmental Fate and Effects Division (EFED) conducted a screening-level risk assessment for flowable ChemX under a variety of agricultural uses. This assessment evaluated risks to terrestrial wildlife and aquatic organisms through the application of the EFED risk quotient method. In addition, EFED analyzed wildlife effects fields studies, monitoring programs, publically available literature, and reports of incidents of adverse effects on aquatic and terrestrial organisms associated with field uses of ChemX. The risk quotient assessment and field study/incident analysis lead EFED to conclude that the risks to birds and other wildlife by flowable ChemX is extremely high. The screening assessment concluded that the weight of evidence for effects on birds is extensive, leading to a high level of certainty in concluding high risks to these organisms.

Although the risk quotients for flowable ChemX exposures in birds were demonstrated to be greatly above levels established by EFED as triggers for concern for significant risks of acute lethal effects and the review of incidents and field studies suggested that mortality events could be large, the assessment approach could not provide risk managers with a quantitative estimate of the probability and magnitude of wildlife mortality in treated fields.

As a consequence EFED conducted a refined avian risk assessment, using probabilistic techniques, for selected flowable ChemX uses in order to provide a quantitative estimate of the probability and magnitude of effects. The refined risk assessment presented herein follows, in general, the approaches outlined in EFED's implementation plan for conducting probabilistic terrestrial organism risk assessments.

The report includes the following:

- Problem Formulation: This section (1) reviews the current status of flowable ChemX registrations, (2) discusses the extent of each flowable use registration, (3) presents the application scenarios selected for risk assessment, (4) describes the selection process for identifying focal species for exposure and effects modeling, and (5) outlines the routes of exposure considered.

- Risk Assessment Model: This section (1) provides a general overview of the risk assessment model, (2) presents a detailed description of the exposure model, including descriptions of model variables, (3) discusses the effects model and applicable variable parameters, and (4) describes the methods for integrating the exposure and effects models for risk assessment output.

- Model Scenario Matrix: This section describes the full extent of combinations of crop, pesticide application method, application rate, and exposure model options.

- Results and Discussion: This section presents the results of application of the risk assessment model and provides interpretations of these results.

- Summary and Conclusions: This section summarizes the results and provides overall conclusions from the refined assessment.

PROBLEM FORMULATION

The screening level assessment for ChemX concluded that the pesticide presented a high acute risk to non-target wildlife. The high avian acute risks indicated from the deterministic assessment (risk quotient calculation), and supported by documentation (field studies and incident reports) of the occurrence of acute impacts to birds following operational use of ChemX formed the basis for the screening assessment conclusions. The screening assessment also raised significant concerns about potential chronic exposure impacts to birds from the use of the compound and there are concerns for possible impacts to non-avian wildlife as well. Owing to the existence of a comparatively more robust avian toxicological data set, the scope of the refined risk assessment efforts is confined to direct acute effects on birds (principally mortality).

The focus on direct acute effects to birds does not imply the other risks of ChemX, sub-lethal, indirect and chronic are not of concern. This focus on birds should not be interpreted to indicate that other taxonomic groups (e.g., reptiles, amphibians, and mammals) are not at risk from similar exposures to ChemX. However, given the past emphasis of the Agency on addressing pesticide risk to avian species, the relatively large databases of toxicity, field studies and incident reports on bird species, direct acute effects to avian species are believed to be more amenable for developing a refined assessment to better characterize the risk of ChemX to non-target wildlife species. Further, direct acute effects to avian species are more manageable for assessment (given the current state of science) than other more complex interactions(ECOFRAM 1999) . The focus on birds does not imply they are the most important taxonomic group. The larger databases of toxicity and life history information on avian species make them more tractable in refining the assessment. Therefore, this refined assessment has been restricted to addressing the magnitude and probability of direct acute effects (mortality levels) to selected avian species that represent species that occur in and around agro-ecosystems where ChemX is used.

Review of Flowable ChemX Registrations

ChemX is a restricted use broad spectrum insecticide, nematicide, and miticide registered in the United States in the 1960's. It is formulated into flowable and wettable powder formulations for use on alfalfa, clover, coffee, corn (field, pop, and sweet), cotton, forest trees (cottonwood and pine plantations, pine seed orchards), nonbearing fruit trees (apple cherry, nectarine, peach, and plum), ornamentals, peanuts, potatoes, pumpkins, rice, small grains (wheat, oats, and barley), sorghum (grain and forage), soybeans, strawberries, sugar beats, sugarcane, sunflowers, tobacco, and several minor use crops.

The Agency’s best available marketing information suggests that more than million pounds of ChemX are used annually on 1.5 to 3.8 million acres of the United States.

Approximately 85% of the ChemX used in the United States is the flowable formulation. Presently, most of the ChemX is used on alfalfa, field corn, potatoes, sorghum, tobacco, sunflower, and soybeans. In recent years, a large amount of ChemX has also been used as a foliar application to control sucking insects on cotton.

Review of Extent of Use for Each Registration

To further discriminate the ChemX uses of greatest concern, EFED consulted the Biological and Economic Assessment Division (BEAD) for an application overview report of ChemX uses. Corn and alfalfa uses account for the greatest acres treated with ChemX. In 1995, some 3.1 and 1.5 million acres of corn and alfalfa were treated. ChemX uses on these two crops in 1995 totaled 1.34 and 0.67 million pounds of active ingredient for corn and alfalfa, respectively. Corn use of ChemX, according to BEAD analysis, appears to be greatest within the mid-western United States and Texas.

Use Scenarios Selected for Probabilistic Assessment

On the basis of (1) the large volumes of ChemX used, (2) the extensive crop areas potentially treated, and (3) and the combination of high deterministic risk quotient results and reported incidents, this risk assessment focuses on the at-plant and foliar applications of flowable ChemX to corn and the foliar applications to alfalfa.

Regional aspects of ChemX use also served to focus the risk assessment use scenarios to certain areas within the United States. Based on the high use of ChemX in Midwest corn and alfalfa, this refinement to the risk assessment for flowable ChemX focuses on the Midwest region. Other regions of the United States may be as important when considering alfalfa (i.e., the western states). However, the results of the evaluation of Midwest alfalfa and bird species are believed applicable in general to western alfalfa and the associated bird species. This risk assessment focuses on a single application of ChemX in all cases. The following application scenarios for corn and alfalfa treatments are considered

Crop	Application Method	Application Rate	Rationale
corn	at plant in furrow	2.5 oz./1000 ft.	labeled rate
corn	at plant banded	2.5 oz/1000 ft, 7 in. band	labeled rate
corn	foliar	1 lb a.i./acre	max single label rate
corn	foliar	0.75 lb a.i./acre	most frequent rate*
corn	foliar	0.25 lb a.i./acre	24-c minimum rate
alfalfa	foliar	1 lb a.i./acre	maximum label rate
alfalfa	foliar	0.5 lb a.i./acre	most frequent rate*
alfalfa	foliar	0.125 lb a.i./acre	minimum label rate

* scenario falls within the range of application rates reported to encompass the largest percentage of treated acres according to BEAD application overview.

Foliar applications are assumed to be aerial applications. The EFED exposure models considered are not sensitive to whether the application is aerial or ground applied, with the exception of considerations of applications to fields with standing water. Ground applications, of any type, were not considered feasible for saturated crop fields where standing puddles are present because of limitations in operating farm machinery under such conditions.

In all cases, the refined risk assessment considers avian risks associated with a single application of ChemX.

Focal Species Selection

The goals for selection of bird species serving as the focus of the risk assessment were to (1) advance the assessment beyond consideration of "generic" bird types so as to consider appropriate biological conditions associated with the treated environments and (2) identify the types of species potentially at greatest risk from flowable ChemX exposure at the corn and alfalfa use sites identified above. Under the current EFED state of probabilistic risk assessment development, the use of focal species in an assessment is limited. The likely lack of species-specific toxicity data engenders considerable uncertainty regarding predicting the magnitude of mortality in any single bird species. Rather, the use of focal species is targeted to represent a myriad of potential species with similar biological/behavioral characteristics, yet retain some specificity as to the type of organisms using a treated area. The types of information that could serve to identify such species could include direct toxicological evidence from laboratory studies, information on known occurrence in the treated crops, incident and field study information on known mortalities, and information on life history characteristics such as feeding habits.

In selecting focal bird species for conducting this probabilistic risk assessment, EFED considered census data from field studies identifying avian species in and around corn and alfalfa fields where ChemX was being applied (Field Study A) and the reported species found dead (Field Studies B and C). In addition, available open literature concerning studies of birds in corn and alfalfa fields and surrounding habitats as well as information on the feeding and nesting habits of birds associated with these crops was considered (Best et al. 1995, 1990, Bryan and Best 1991, Frawley and Best 1991, and Patterson and Best 1996).

Midwest Corn

Field Study A includes avian survey data for bird populations in corn fields in Illinois. A total of 87 bird species were observed during census efforts. Observations were categorized as being in the field or in the edge habitat (50 m orthogonal to field edge). The most abundant species observed in corn fields of Illinois included: red-winged blackbird, common grackle, American robin, horned lark, mourning dove, common yellow throat, song sparrow, field sparrow, European starling, and eastern meadowlark.

Best et al. (1990) categorized birds with respect to frequency of observation within corn fields in Illinois and Iowa. Species observed included: American goldfinch, American robin, American crow, common yellowthroat, dickcissel, European starling, field sparrow, grasshopper sparrow, horned lark, killdeer, mourning dove, northern cardinal, red-winged blackbird, Savannah sparrow, song sparrow and the vesper sparrow.

EFED also investigated the results of ChemX field studies of avian effects to determine the species of birds found dead in and around corn fields treated with flowable formulations (Field Study B). Species found dead included: American robin, Cassin's sparrow, barn swallow, black-capped chickadee, blue jay, brown-headed cowbird, chipping sparrow, common grackle, horned lark, and house sparrow.

On the basis of this information, EFED selected seven bird species that were known to occur with high frequency in Midwest corn agricultural areas, are frequently observed within corn fields, and have been observed as mortalities in flowable ChemX field tests or are similar in terms of size as well as feeding and nesting characteristics to species found dead. These species include the following:

Species	Diet Preferences*	Feeding Sites*	Nesting Sites*
meadow lark (eastern and western)	insectivore	ground	ground
horned lark	omnivore	ground	ground
vesper sparrow	omnivore	ground**	ground
red-winged blackbird	omnivore	ground	shrubs
mourning dove	granivore	ground	tree
killdeer	insectivore	ground**	ground

* life history information from Best et al. (1990)
**observed nesting in corn fields (Best et al. 1990)

Midwestern Alfalfa

In comparison to available information regarding birds in corn fields, data for alfalfa-associated birds is less comprehensive. In a two year study of breeding birds in Iowa alfalfa fields, Frawley and Best (1991) reported on eight species common to alfalfa. The most common birds observed were: dickcissel, red-winged blackbirds, western meadow lark, common yellowthroat, sedge wren, grasshopper sparrow, morning dove, and vesper sparrow.

Patterson and Best (1996) conducted three years of observations of bird abundance in Iowa rowcrop and Conservation Reserve Program (CRP) fields. The CRP fields were predominately alfalfa. A total of 33 species of birds were observed in these CRP fields. The most abundant species reported were: red-winged blackbird, dickcissel, grasshopper sparrow, bobolink, common yellowthroat, brown-headed cowbird, Savannah sparrow, ring-necked pheasant, and western meadowlark.

EFED also investigated the results of ChemX field studies of avian effects (Field Study C) to determine the species of birds found dead in and around alfalfa fields treated with flowable formulations. Species found dead in Kansas and Oklahoma included: American robin, Savannah sparrow, grasshopper sparrow, house sparrow, meadowlark sp., northern cardinal, red-winged blackbird, sparrow sp., and vesper sparrow.

On the basis of this information, EFED selected a number of bird species that were frequently observed within alfalfa fields, and have been observed as mortalities in flowable ChemX field tests or are similar to mortality species in terms of size, and feeding characteristics. These species include the following:

Species	Diet Preferences*	Feeding Sites*	Nesting Sites*
dickcissel	omnivore	ground	ground
western meadowlark	insectivore	ground	ground
grasshopper sparrow	omnivore	ground	ground
mourning dove	granivore	ground	tree
vesper sparrow	omnivore	ground	ground

* life history information from Best et al. (1990)

Waterfowl were also included in this refined assessment due to the relatively large number of poisoning incidents reported for these species in association with the use of ChemX on alfalfa. The mallard duck was selected as the focal species to evaluate. Due to these species' relatively large range and the special challenges to modeling the probability of a flock of ducks feeding in a recently treated alfalfa field, the scenario used was limited to a single feeding of flocks of twenty birds at varying times after application.

Exposure Pathways

In order to determine the scope of exposure routes to be quantitatively evaluated in this risk assessment, EFED considered the toxicological and physical/chemical properties of ChemX as well as the availability of exposure assessment methods for the potential routes. EFED believes that the principal routes of exposure related to acute lethal risks of ChemX are associated with oral ingestion of pesticide residues associated with dietary items and drinking water. EFED eliminated inhalation of vapor phase ChemX from the possible dominant exposure routes because its low vapor pressure suggests that ChemX volatility is not likely to be a major route of dissipation or movement. There is a potential for inhalation immediately following application, but EFED currently does not have a method to estimate exposure from this route. There is also a potential for oral ingestion exposure as a result of preening behavior. However, EFED currently does not have a method to estimate exposure via the preening route. Similarly, dermal exposure was eliminated from quantitative consideration because of a lack of acceptable methods to quantify exposure and a lack of avian dermal toxicity data for ChemX to compare with exposures. The importance of future consideration of dermal exposure to flowable ChemX is uncertain. Also, incident ingestion of soil was not addressed because the absence of a developed sub-model to estimate this exposure route.

PROBABILISTIC RISK ASSESSMENT MODEL

General Model Overview

The basic structure of the model developed for this refined assessment to estimate the magnitude and probability of ChemX acute effects to non-target avian species can be expressed by the general equation:

$$Risk = f\left(exposure, toxicity\right).$$

Therefore, the model is based on the characterization of exposure and effects through developing distributions of the major exposure and effects variables and combines these distributions to estimate the probability and magnitude of effects.

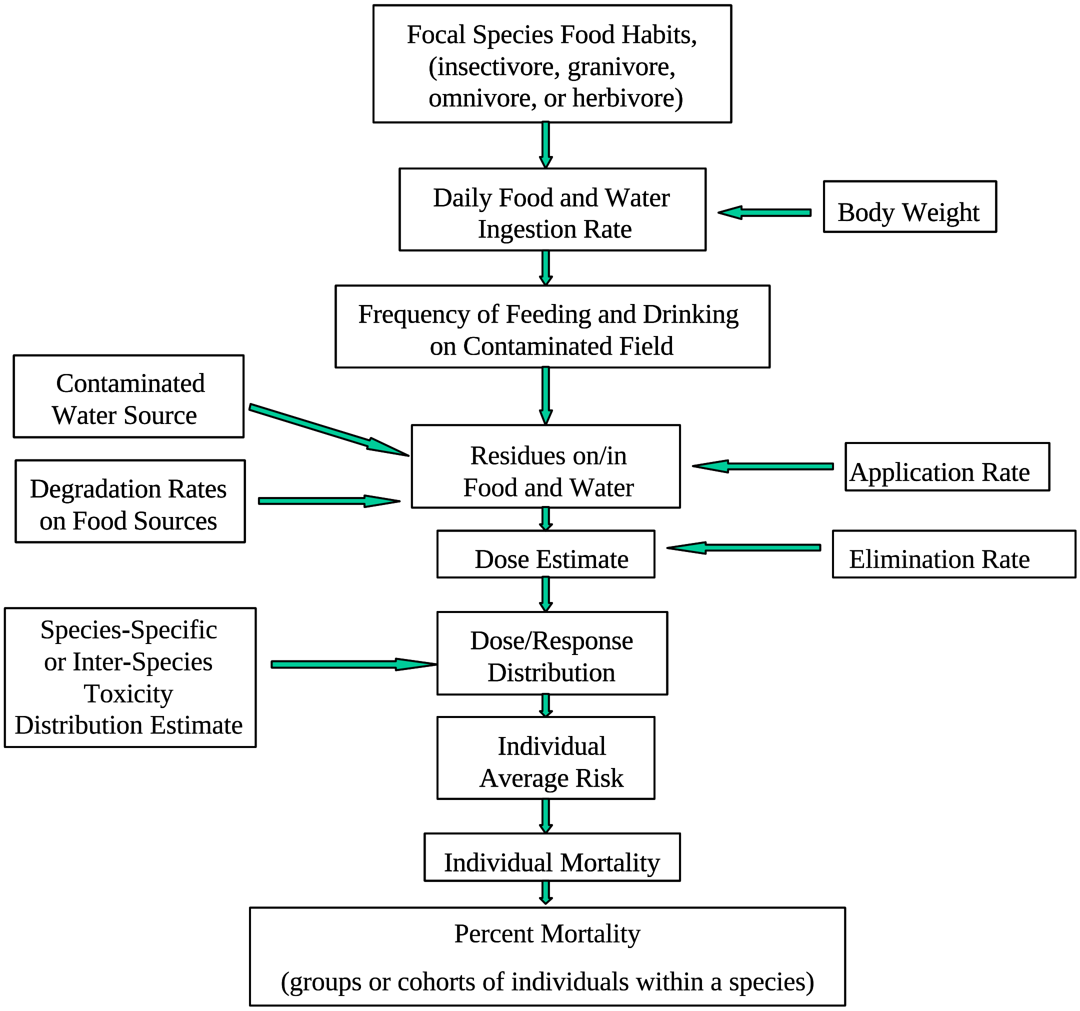
The risk model developed for this refined assessment can be characterized as a species specific model which addresses acute mortality levels over a defined exposure window (7 days). The spatial scale is at the single treated field level, such that the field and surrounding area is assumed to meet habitat requirements for each focal species. As an overall simplifying assumption, contamination of edge or adjacent habitat from drift is assumed zero. As stated in the *Problem Formulation* section, the temporal scale for the assessment is for exposures immediate to and following a single application of ChemX

The major parameters addressed in the model are:

- Food habits of selected focal species proportioned for each food type consumed by the specific focal species,
- Daily ingestion rate of food and water as a function of body weight randomly assigned from species specific body weight distributions,
- Frequency of feeding and drinking on the sprayed field,
- Distribution of residues on focal species food and water sources (including dew, puddles, and ponds) as a function of application rate,
- Degradation rates of food residues estimates, and
- Inter-species distribution based estimates of dose-response acute toxicity curves for focal species for which laboratory derived toxicity estimates aren't available or the dose-response curve (toxicity distribution) derived from laboratory toxicity test for the focal species, if available.

For each individual run of the model, a random selection of values is made for the major exposure input parameters to estimate a dose to an individual of a focal species. The estimated average risk of mortality from this individual's estimated dose is calculated from the dose response curve. The survival of this individual (dead or not dead) at this dose is assigned by comparing the estimated average risk to a random selected number from a uniform distribution (0-1). If the random number is less than the average risk estimate, the individual is scored 'dead', and if the random number is greater than or equal to the average risk the individual is scored 'not dead'. This procedure is repeated using Monte Carlo sampling for a set of individuals to generate a percent affected estimate. After multiple iterations of sets of individuals a probability density function of percent mortality is generated. Figure 1 provides a simple diagram of the model used in this refined assessment. The following sections discuss the various exposure and effects input parameters and their integration to estimate the magnitude and probability of acute effects to the selected focal species.

Figure 1. Conceptual Model Flow Diagram



Exposure Modeling

As was discussed in the *Exposure Pathways* section of this document EFED considered ChemX exposure in birds from the dietary and drinking water routes. For the purposes of this risk assessment, EFED divided daily exposure into two equal daily periods or time steps. At the onset of each time step, a binomial probability function was used to determine if an individual modeled bird uses the treated field as a source of food and water (see *Frequency of Birds in Treated Fields* (T_f) section of document for determination of weights for binomial function). Once a bird is determined to be in the treated area for a particular time step, the general model for calculating ChemX exposure to a given bird (normalized to body weight as a total dose) is as follows:

$$NIR_{total}(t) = \frac{CI_{total}(t)}{BW}$$

where: $NIR_{total}(t)$ is the body weight normalized ChemX burden on time step t after application (µg ChemX/g body weight/time step)
$CI_{total}(t)$ is the total body burden of ChemX on time step t after application (µg ChemX/day)
BW is the individual bird body weight (g)

Total time step ChemX body burden for an individual bird is calculated as:

$$CI_{total}(t) = CI_{food}(t) + CI_{water}(t) + CI_{total}(t-1) \times f_{retained}$$

where: $CI_{food}(t)$ is the total intake of ChemX on time t after application (µg ChemX/time step)
$CI_{water}(t)$ is the intake of ChemX in drinking water on time t after application (µg ChemX/time step)
$CI_{total}(t-1)$ is the total intake of ChemX one time step before the current step after application (µg ChemX/time step)
$f_{retained}$ is the fraction of ChemX intake retained in the bird at the end of a time step (unitless)

ChemX intake from food ($CI_{food}(t)$) is calculated as follows:

$$CI_{food}(t) = \sum_k C_k(t) \times TDIR \times 0.5 \times DF_k \times FC_k$$

where: $C_k(t)$ is the concentration of ChemX in the *k*th food item on time t after application (µg ChemX/g)
TDIR is the total daily intake of diet in a bird (g/bird/day), see *Total Daily Intake Rate* section for an explanation of calculation

DF_k is the fraction of the diet attributed to the *k*th food source (unitless)
O.5 is the fraction of the TDIR consumed in each of the two time steps models for each day (unitless)
FC_k is the fraction of the kth food source that is actually contaminated with ChemX (unitless). Used to account for in-furrow or banded treatments.

ChemX intake from water ($CI_{water}(t)$) is calculated as follows:

$$CI_{water} = C_w \times DWIR \times 0.5$$

where: C_w is the concentration of ChemX in drinking water sources (µg/mL), see *Drinking Water Residues* section for an explanation of scenarios
DWIR is a bird's daily drinking water intake rate (mL/day), see *Drink Water Intake Rate* section for an explanation of calculation
0.5 is the fraction of the DWIR consumed in each of the two time steps modeled for each day (unitless)

Biological Parameters For Exposure Modeling

Body Weight (BW)

The body weight of an individual is critical to the exposure and effects characterization aspects of the risk assessment. For exposure estimation purposes, individual body weight is used to calculate the daily energy requirements of the individual and so the mass of diet consumed. In addition, body weight is also used to estimate individual daily drinking water requirements. On the effects side, mean body weight is also used to normalize available toxicological data. For this refined assessment only adult birds were addressed and therefore only distributions of adult body weights were used.

Body weights for each focal species, as used in exposure estimates, were treated as random variables drawn for each individual from empirically established distributions. For the purposes of this risk assessment, the source of distribution parameters for each species is Dunning (1984). For this assessment, separate distributions for females and males were not used. This decision was made to simplify modeling and it is believed that consideration of separate body weight distributions for males and females would have limited if any effect of on results. For species for which body weights were reported separately for males and females, a pooled mean (pooled mean BW) and pooled standard deviation (pooled BW SD) were calculated assuming a population of 50% males and 50% females. The calculations used were:

$$Pooled\ mean\ BW = \frac{Mean\ male\ BW + Mean\ female\ BW}{2}$$

and

$$Pooled\ BW\ SD = \sqrt{Pooled\ BWV} = \sqrt{\overline{V} + V_M}$$

Where: V = variance

$\overline{V}$ = mean of variances

V_M = variance of means

In situations where a standard deviation of body weights was not reported for a species, a standard deviation was estimated from the coefficient of variation which was calculated from the mean standard deviation of the species with reported standard deviations. The upper and lower limit of body weights were estimated as ± 2.6 standard deviations assuming a normal distribution. Table 1 gives the mean pooled body weights and the pooled body weight standard deviation for the focal species used in this assessment.

Table 1. Focal Species Weights in Grams

Species	Pooled Mean	Pooled S.D.
killdeer	96.55	9.84
mourning dove	119.00	4.39
horned lark	31.35	2.17
dickcissel	26.95	2.97
vesper sparrow	25.70	1.90
grasshopper sparrow	17.00	2.75
red-winged blackbird	52.55	11.65
eastern meadowlark	90.00	14.85
western meadowlark	97.70	10.59
mallard duck	1082.00	129.00

Total Daily Intake Rate for Food (TDIR)

Focal species-specific food ingestion rates are based on the allometric equation of Nagy (1987) relating body weight (see *Body Weight* section of this document) to bird field metabolic rate (FMR):

$$\text{FMR(kcal/day)} = 2.123\ (\text{body weight g})^{0.749} \qquad \text{(Passerine birds)}$$

$$\text{FMR(kcal/day)} = 1.146\ (\text{body weight g})^{0.749} \qquad \text{(Non-Passerine birds)}$$

EFED used the approach summarized in USEPA (1993) for considering the gross energy content, assimilation efficiency, and proportion of total dietary matrix and the above energy requirement allometric relationship to estimate daily food requirements for each food type in an organism's diet. This process is as follows:

Step 1. Estimate field metabolic rate (FMR)

$$\mathrm{FMR(kcal/day)} = 2.123\ (\mathrm{bodyweight\ g})^{0.749} \quad \text{(Passerines)}$$
$$\mathrm{FMR(kcal/day)} = 1.146\ (\mathrm{bodyweight\ g})^{0.749} \quad \text{(Non-Passerines)}$$

Step 2. Estimate Average Metabolizable Energy (ME_{avg})of Diet

$$ME_{avg}\ \text{(kcal/wet weight)} = \sum[(DF_k)(ME_k)]$$

where: DF_k is the fraction of the bird diet attributed to the *k*th food source (see corresponding section of the document)

ME_k is the metabolizable energy in fresh food item k calulated as:

ME_k = (Gross Energy (GE) for food type k)(Assimilation Efficiency (AE) for food type k)

(An explanation of GE and AE parameters follows the equations)

Step 3. Estimate Total Daily Intake Rate (TDIR)

$$\mathrm{TDIR\ (g/g)} = \mathrm{FMR}/ME_{avg}$$

In order to estimate the total daily intake rate EFED employed estimate values for the gross energy (GE) and assimilation efficiency (AE) for each food type considered in the risk assessment. Gross energy (GE) of fresh food items were from USEPA (1993) and were assumed to be from lognormal distributions with the following parameters described in Table 2. The lower and upper bounds of the sampled portions of these distributions were set at 0.1 and 99.9 percentiles in an attempt to avoid implausibly small and large values.

Table 2. Gross Energy Content of Fresh Avian Food Items (USEPA 1993)

Food Item Lognormal Distributions	Mean	SD	GM	GSD	Percentile Minimium 0.001	Maximim 0.999
Insects	1.6000	0.2600	1.5793	1.1752	0.9589	2.6009
Seeds	4.6260	0.9980	4.5220	1.2377	2.3393	8.7413
Fruit	1.1000	0.3000	1.0612	1.3072	0.4638	2.4282
Forage, grass	1.3000	0.1300	1.2935	1.1049	0.9504	1.7606
Forage, broadleaf	0.6300	0.0740	0.6257	1.1242	0.4358	0.8984

Assimilation efficiency (AE) of fresh food items is that portion of gross energy that can be assimilated by the consuming organism. EFED used information from USEPA (1993) and assumed beta distributions for these variables with the following parameters summarized in Table 3. EFED scaled the assimilation efficiency variable to avoid implausibly small and large values and to avoid generation of AE values equal to 0.

Table 3. Assimilation Efficiency of Fresh Avian Food Items (USEPA 1993)

Food Item Beta Distributions					Shape Parameters		Minimum	Maximum	
	Mean	**SD**	**Min**	**Max**	**Parm 3**	**Parm 4**	**0.0001**	**0.9999**	**range**
Insects	0.720	0.051	0.000	1.000	55.086	21.422	0.5128	0.8801	0.3672
Seeds	0.750	0.090	0.000	1.000	16.611	5.537	0.3655	0.9695	0.6040
Fruit	0.640	0.150	0.000	1.000	5.914	3.326	0.1177	0.9822	0.8646
Forage, Grass	0.470	0.096	0.000	1.000	12.234	13.795	0.1560	0.8014	0.6454
Forage, Broadleaf	0.470	0.096	0.000	1.000	12.234	13.795	0.1560	0.8014	0.6454

The fraction of the diet (DF_k) attributed to the *k*th food source was evaluated for each focal species selected. The input data is from Martin et al. (1951), which reports proportions of the diet for spring and summer seasons. Within each crop scenario (corn and alfalfa) the proportions of food items were held constant for a species. However, spring dietary proportions were selected for corn and alfalfa application scenarios, owing to the likelihood that first applications of ChemX will occur in the spring months. Table 4 describes the parameters for food preferences used in the risk assessment.

Table 4. Dietary Preferences (% of total diet) for Focal Bird Species (Martin et al. 1951)

	% insects	**% seeds**	**% vegetation**
Species	**Spring**		
killdeer	100	0	0
mourning dove	0	100	0
horned lark	34	66	0
dickcissel	62	38	0
vesper sparrow	41	59	0
Savannah sparrow	27	73	0
grasshopper sparrow	60	40	0
red-winged blackbird	40	60	0
eastern meadowlark	84	16	0
western meadowlark	81	19	0

Drinking Water Intake Rate (DWIR)

The drinking water ingestion rate was derived from work performed by Nagy and Peterson (1988), who developed allometric relationships between avian body weight and daily water flux rate. The daily water flux rate or turnover rate for birds in the field is estimated as follows:

$$daily\ water\ flux\ rate(mL)\ =\ 1.180 \times BW^{0.874}$$

where: BW (units g) is a randomly selected parameter from the distribution established for each focal species (see *Body Weight* section of this document) and is the same body weight value selected for calculation for daily dietary intake rate (see *Food Ingestion Rate* section of this document)

The daily water flux rate is assumed for a bird in water equilibrium, such that water balance is maintained each day. EFED assumes that a proportion of this daily water flux is fulfilled by water obtained through the consumption of each day's dietary items, with the remainder satisfied through daily drinking water intake. The calculation of water from dietary items is made by multiplying the daily fresh mass of each food item consumed by the focal species by the corresponding fractional water content of that food item as follows:

$$food\ water\ g = \sum_{k} TDIR \times DF_{k} \times FW_{k}$$

where: TDIR is the total daily intake rate for food items (g/day)
DF_k is the constant fraction of TDIR attributed to the *k*th food item
FW_k is the unitless and constant fraction of water in a fresh food item as cited in USEPA (1993) and summarized as follows:

Food Item	Fractional Water Content
Insects	0.69
Grasses (young)	0.79
Broadleaf forage	0.85
Seeds	0.093
Fruit	0.77

EFED assumes a standard density of water of 1 g per 1 mL. Therefore, the actual daily drinking water intake rate (DWIR) is calculated as follows:

$$DWIR\ mL/day = water\ flux\ rate - food\ water$$

The daily drinking water requirement is evenly distributed across each daily set of time steps.

Frequency of Birds in Treated Fields (T_f)

For the purposes of this risk assessment, only food and water resources on the treated field were considered to be contaminated with ChemX. It is therefore critical to the assessment to model the probability of an individual bird using the treated field as a source of drinking water and food in a given time step exposure period. EFED does not have empirical information on the actual proportions of daily diet and drinking water that are obtained from treated fields for each individual of a focal species. Such information would require specialized individual bird behavior monitoring studies beyond the scope of the current level of assessment refinement. However, EFED does have access to bird census information from various field studies and published literature that can be used to provide crude frequencies of bird occurrence in crop fields (T_f) as compared to birds in agro-environments, but not in the treated field itself. Such frequency information is used to weight a binomial distribution that is in-turn used to predict if an individual bird is in a treated area during an exposure time step. If a bird is predicted to be in a treated area during a time step of exposure, all food and water is assumed to originate from the treated area during the time step (the daily intake rate is partitioned equally among the number of daily exposure time steps modeled). If a bird is predicted to be out of the treated area, no exposure to ChemX is assumed for that particular exposure time-step.

It should be noted that, for this risk assessment, a prediction of bird occurrence in a treated field for a particular exposure time step is assumed to be independent of predictions for other time steps.

T_f Values for Midwest Corn Focal Species

The available data for focal species use of mid-western corn fields includes summaries of census data taken from a variety of fields within the geographic region. These data are summarized in Table 5. As can be seen from the data, there appears to be a wide range of proportions of total observations that were collected in corn fields (ranging from 0% to 100%). The sources of variability include temporal fluctuations, geography, and adjacent habitat types, factors for which too little data exist to develop definitive relationships. Because of this variability in terms of use of treated fields, EFED elected to use a minimally biased distribution that reproduces the specified means from the census data (i.e., the widest distribution consistent with the specified mean). EFED assumed a truncated exponential distribution for this parameter and set the mean equivalent to the mean value from the available data and limited the distribution to lower and upper limits of 0% and 100%.

It is notable that the highest proportions of observations within fields were with the horned lark (mean 69%) and the killdeer (mean 76.3%). These two species were listed by Best et al. (1990) as being resident nesters in corn. Horned larks are known to prefer tilled fields (Castrale 1985) and have been reported at high densities in disced cropland (Beason 1970).

Table 5. Summary of Available Avian Census Data for Focal Species Observations in Corn Fields (Percent of Observations)*

Study	Red-Winged Blackbird	Horned Lark	Vesper Sparrow	Eastern Meadowlark	Western Meadowlark	Mourning Dove	Killdeer
Field Study A IL	58.00	82.30	--	89.5	--	32.5	97
Best et al. 1990 IA	16.7	100	28.8	--	9.3	30.6	76.3
Best et al. 1990 IL	7.5	86.4	12.5	7.7	7.5	14.1	--
Camp and Best 1993 (IA, 1990 survey fields vs. roadsides)	0.7	55.6	4.8	--	1.1	0	81.1
Camp and Best 1993 (IA, 1991 survey fields vs. roadsides)	0.3	100	3.6	--	0.8	0	100
Field Study D TX	62	--	--	23.6	--	61.2	43.8
Bryan and Best 1991 (IA, 1987 survey fields vs.waterways)	13.7	44.4	54.7	--	26.2	--	78.6
Bryan and Best 1991 (IA, 1988 survey fields vs. waterways)	47.3	14.2	8.5	--	20.7	--	57.5
Mean	25.8	69.0	18.8	40.3	10.9	23.1	76.3

* percentages are a mixture of actual count percentages [(observations on-field/observations on and off field)(100)] and density percentages [(observations per unit area on-field/observations per unit area on and off-field)(100)]

T_f Values for Midwest Alfalfa Focal Species

In contrast to bird use of corn, there is comparatively little data to assess focal species use of alfalfa fields in a quantitative manner. Field Study C presented the results of bird census studies conducted within the alfalfa field, along the outer perimeter of the fields, and in edge habitat for alfalfa agro-environment in Kansas and Oklahoma. These census samples were conducted on fixed treatment plots/transects of the course of multiple weeks. This sampling scheme gives some indication of temporal variability (multiple sampling periods) and geographic variability (multiple plots and two states) in the proportion birds observed within the alfalfa field (mid-field and perimeter). Table 6 summarizes the focal species proportions of total census results from this study for 5 of the six focal species selected for this risk assessment.

Table 6. Percentages of In-Field Bird Observations in Alfalfa (Kansas and Oklahoma, Field Study C)

Parameter	Dickcissel	Grasshopper sparrow	Meadowlarks (Eastern and Western Combined)	Mourning Dove	Vesper Sparrow
mean	24.0	53.9	52.6	8.5	40.0
maximum	100	100	100	85.6	100
minimum	0	0	0	0	0

The maximum and minimum observations of 0 and 100% for many of the focal species suggests that any assumed distributions for alfalfa field use by these organisms (as approximated by the census data) must be large enough to account for the extreme variability of the observed upper and lower finite values. For the purposes of this risk assessment, EFED chose minimally biased distributions capable of reproducing the mean values from the census data. Exponential functions were assumed for the field use parameter in alfalfa, with mean values of the distributions assumed equivalent to the mean values from Field Study C and extreme values of 0 and 100 %.

Special Considerations for Drinking Water Source Selection

EFED has assumed two sources for drinking water for birds predicted to occupy the treated area for a particular exposure time step: puddles on the treated field, and dew on food items on the treated field. Off site water sources are assumed to be uncontaminated with ChemX. Expert opinion (pers. comm. Louis Best, 2000)[1] on drinking water strategies for crop-associated birds indicates that the behavior for selection of water sources is not well characterized in the scientific literature and that the most likely strategy is one of opportunistic exploitation of whatever water source is immediately available. EFED has assumed that daily drinking water is equally divided between the daily exposure time steps and originates entirely from the treated site for time steps when the bird is predicted to occupy the treated area and drinking water sources are available in that area.

EFED has constructed three scenarios for characterizing the on-field drinking water source. One scenario assumes that no rain falls on the treated area over the course of the entire exposure period modeled. In this scenario, dew is the source of drinking water from on-field sources for the first time step in a 24-hour period that the bird occupies the treated field. A second scenario assumes, for foliar applications only, that puddles are present on the field from a precipitation event before ChemX treatment and to the extent that these puddles remain on the field, drinking water is from puddles to which ChemX has been directly applied. This puddle is assumed to last only for the duration of the first exposure time step for the day of application, so subsequent exposure time steps involve a return to dew as the on-field drinking water source. A third scenario assumes, for foliar application, that a rainfall event one day after application occurs, leaving puddled water on the field. Birds are assumed to get drinking water from dew on the first half of day of application, shift to an on-field puddle on the second day (duration of puddle is only for the first exposure time step), and shift back to dew on subsequent exposure time steps of the modeled exposure period.

In all cases of drinking water exposure, the model used in this risk assessment assumes that exposure via the consumption of dew occurs only in the first (morning) time step of any day where dew is assumed to be a drinking water source. The second time step of each exposure day does not include dew as a drinking water source. Therefore, when puddles are not on the field, drinking water for this time step is assumed to be from un-contaminated off-field sources. It should be noted that the exposure model for this risk assessment does not consider plant guttation in the second daily time step of exposure as a source of on-field drinking water.

Fraction of ChemX Intake Retained in the Bird at the End of a Time Step (f_{retained})

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[1] Personal communication between Louis Best, Iowa State University and Edward Fite, EFED/OPP/USEPA, July 5, 2000.

The elimination rate of ChemX was estimated from a carbon-14 laying hen study. Carbon-14 labeled ChemX was administered orally in gelatin capsules to laying hens once a day for seven days. The test material was dosed at levels equivalent to dietary concentrations of 25 ppm. The test showed that ChemX was extensively metabolized and readily eliminated following oral administration to the laying hens. The majority of each days dose was excreted within 24 hours of administration, with an average of 82.8 excreted within 24 hours for the three groups treated. Based on these results the refined assessments assumed a constant rate of elimination of 83% per day to estimate total body burden following the initial exposure period. Therefore the amount of ChemX retained at the end of a 24-hour period was assumed to be a constant 17%. This retention constant was then increased for the shorter duration time steps assumed in the model (i.e., 41 % for a 12-hour period). It should be noted that the applicability of the results of the carbon-14 laying hen study to the focal species selected for this refined assessment may be questionable due to differences in metabolism between species. However, given it's the only data available that estimates elimination rates in avian species, it provides at least a first approximation of the process in other birds.

Chemical Parameters

ChemX Concentrations in Food Items (C_k) on Day of Application

C_k in Vegetation Food Items (Day of Application)

EFED relied on the summary statistical information provided by Fletcher et al. (1994) for establishing ChemX residues in vegetative food items for those focal species consuming such dietary material (Table 7). Maximum, minimum, mean and standard deviation values for these data are normalized to an application rate of 1 lb a.i./acre. For this risk assessment, the food item residue parameters were adjusted linearly to the application rate selected for each modeling scenario.

Table 7. Vegetative Food Item ChemX Residue Summary Statistics Normalized to mg/kg/1 lb a.i./acre (Fletcher et al. 1994)

Group	# Records	Low	High	Mean	SD
short range grass	18	15.3	194	84.8	60.3
forage (legumes)	96	0.05	350	45	56.7
pods and seeds (legumes)	26	0.05	24.6	4	5.9
fruit	108	0	40.7	5.4	9.8

EFED used the above residue statistics to establish log normal distributions for C_k for each vegetative food item. The mean and standard deviation from Fletcher et al. (1994) served as the basis for establishing the distributions. The sampled portions of these distributions were defined with a minimum value set to 0 mg/kg and the maximum value was set to correspond with the 99.9 percentile of the distribution. The Fletcher et al. (1994) statistics describe data that encompass a variety of applied pesticides, application conditions, geographic areas, and environmental conditions. It is possible that the distribution of ChemX residues across a given treated field are more uniform than those that could be assumed from Fletcher et al. (1994). However, the available data for ChemX field treatments are limited, and EFED elected to rely on Fletcher et al. (1994) for this level of assessment.

C_k in Insectivorous Food Items (Day of Application)

For residues in insects potentially consumed by birds, EFED relied on the data of Fischer and Bowers (1997). Like the data developed for vegetative food items, these data cover a variety of application methods, pesticides, and crop areas. Table 8 presents the results of these data. For this risk assessment, the food item residue parameters were adjusted linearly to the application rate selected for each modeling scenario.

Table 8. Summary Statistics Pesticide Residues in Terrestrial Invertebrates Normalized to mg/kg/1 lb a.i./acre (Fischer and Bowers 1997)

Application Method	Mean	SD	Geometric Mean	Median	Maximum	Minimum
foliar spray	5.716	9.213	2.139	1.65	54	0.04
soil incorporated	0.600	3.362	0.036	0.03	25.2	0

EFED used the above residue statistics to establish log normal distributions for ChemX residues in the insect dietary component of focal bird species.

It is important to note that the methods for sampling insects in Fischer and Bowers (1997) result in the collection of insects that are not confined to a treated portion the field. The implications of such collections methods in the risk assessment are discussed later in the *Fraction of the Food Source Contaminated with ChemX* (FC_k) section of this document.

ChemX Residues In Food Items Time Steps After Application (C_k (t>0)).

In modeling exposures over multiple days, EFED recognized the importance of accounting for dissipation of ChemX residues from the food sources. To derive the ChemX residue dissipation half life values for various vegetative food items, EFED turned to available ChemX field studies (Field Study A, Field Study E, Field Study F, and Field Study G). These studies provided time series concentration measurements of ChemX in wildlife food items for one or more applications of the pesticide. Assuming first-order dissipation, the residue concentrations were log transformed and linear regression was applied to estimate slope and corresponding half-life values following each pesticide application. Table 9 lists half-life values derived from the time series data from these studies.

Table 9. Calculate mean ChemX Dissipation Half-Life Values

Grasses (t1/2 days)	Broadleaf Forage (t1/2 days)	Insects (alive or dead) (t1/2 days)
Field Study G		
1.42	--	--
Field Study A		
3.52	3.52	--
1.58	1.58	--
0.98	0.98	--
13.41	13.41	--
--	1.66	--
--	1.62	--
--	0.80	--
--	1.73	--
Field Study F		
--	2.26	--
--	2.19	--
--	0.15	--
Field Study E		
1.02	--	6.77
1.93	--	2.05
--	--	0.46
Mean Values		
3.41	2.72	3.09

The mean half-life values ($t_{1/2}$)for each food item were used to calculate a mean dissipation rate using the following equation:

$$r = -\ln(0.5) / t_{1/2}$$

Table 10 presents the dissipation rates for wildlife food items calculated from the mean half-life values. The reader should note that residues in seeds were not included in the data set. Therefore, EFED assumed for the purposes of this risk assessment that seed residue dissipation was equivalent to the residues for broadleaf forage, an assumption warranting future investigation.

Table 10. Residue Dissipation Constants (r) Derived from Mean Residue Half-Life Values

Grasses (dissipation r)	**Broadleaf Forage (dissipation r)**	**Insects (alive or dead) (dissipation r)**
.203269	.254834	.224319

To calculate residues in wildlife food items ($C_k(t>0)$) on one or more time steps after application of ChemX to the field, the exposure model randomly selects a Day 0 residue concentration from the distributions described in sections above and dissipates this residue using the following formula:

$$C_k(t) = C_k(t_0)e^{-rt}$$

where: $C_k(t)$ is the residue concentration in the *k*th food item on the time step t after treatment (mg/kg), with time step t expressed in terms of half-day increments

$C_k(t_0)$ is a randomly selected starting residue concentration on the day of application

r is the dissipation rate constant for ChemX in the *k*th food item

t is the time in half-day increments after ChemX treatment

Owing to the lack of fruit and seed residue half-life data, fruits and seed half-life estimates were assumed to be equivalent to broadleaf values.

ChemX Residues in Drinking Water (C_w)

As was discussed in the *Special Considerations for Drinking Water Source Selection* section of this risk assessment, EFED considered on-field and off-field drinking water sources for birds for the broadcast application to corn and alfalfa. Contaminated water sources were not addressed for the banded and in-furrow corn application. Banded and in-furrow applications present specific modeling challenges to estimate drinking water contamination which applicable models are not presently available. It is possible that concentrations of water in puddles forming in treated furrow and banded areas could be higher than modeled for aerial sprays. This potential for increased exposure magnitude warrants future field investigation and model refinements to account for these application methods.

For the broadcast applications, off-field drinking water sources were assumed not to be contaminated with ChemX. Drinking water sources located on the treated field were assumed to be contaminated by ChemX in three ways. First, puddles from potential precipitation events preceding ChemX foliar applications were assumed to be contaminated with ChemX by direct application at the time of field treatment. Second, puddles created by a precipitation event following ChemX treatment were assumed to be contaminated by runoff water. Finally, drinking water consisting of dew on plant sources was assumed to be contaminated with ChemX partitioning between the water and the organic carbon fraction of plant mass.

C_w in Puddles Directly Treated with ChemX

Predictions of ChemX concentrations in puddles on fields directly treated with the pesticide originate from available field data presented in Field Studies B and C. In this study, surrogate puddles consisted of water-filled 5-gallon buckets buried in fields treated with flowable ChemX. The buckets were periodically sampled over the course of the field study. Although the study documentation does not provide information on the starting volume or depth of water in these buckets, EFED has assumed a starting volume of 5 gallons or 12 inches depth based on the volumes of water for chemical analysis withdrawn from the buckets during the study period and general dimensions of a 5 gallon bucket.

The ChemX concentrations reported for these surrogate puddles immediately after treatment form the basis for directly treated puddle residue predictions in the risk assessment. Recognizing that puddles on treated fields were likely to vary in depth, EFED assumed four depth categories for puddles (0.5, 1, 2, and 3 inches). The measured results for the 12-inch deep buckets from the field were linearly adjusted to reflect the reduced volume associated with shallower depths (e.g., a one inch deep puddle would have 1/twelfth the volume of a 12-inch deep puddle with similar surface area and therefore a ChemX concentration 12 times that of the deeper measured puddle.) The results of all four puddle depth categories were then used to fit a distribution reflecting the variability across a treated field observed in the field study as well as the variability associated with differing puddle depths (Table 11).

Table 11. Distribution Parameters for ChemX Concentration in Day-Of Application Puddles Normalized to 1 lb ai/acre*

log Normal distribution	Mean (mg/L)	SD	Maximum (mg/L)	Minimum (mg/L)
corn and alfalfa	3.73	15.70*	31.40	0.004

* derived from all puddle depths.

C_w in Puddles Contaminated by Field Runoff

The second category of drinking water (puddles contaminated by field runoff) was modeled using the results of PRZM modeling. The PRZM model provides a mass of pesticide and a volume of runoff for each day modeled over a 36-year period. EFED used these outputs (mass pesticide/total runoff volume) to estimate the field wide average runoff concentration of pesticide. EFED assumed that puddles on a field surface would, on average, be approximated by concentrations of pesticide in runoff water.

For each precipitation event in the PRZM run that resulted in runoff on the day after aerial pesticide application, the field-wide average runoff concentration (assumed to be equivalent to average puddle concentration) was calculated. The mean value of these daily measurements (only for days where runoff was predicted to occur) was calculated and served as the mean puddle concentration on the day after application. The coefficient of variance from the data on residues measured for simulated puddles (see previous section) was then applied to the day after puddle mean to establish a log normal distribution with the parameters summarized in Table 12. These are scaled in the risk assessment by application rate.

Table 12. Distribution Parameters for ChemX Concentration in Day-After Application Puddles Normalized to 1 lb ai/acre

log Normal distribution	Mean (mg/L)	SD
corn	0.25	0.43*
alfalfa	1.1	1.925*

* Coefficient of variation = 1.75 from 12 inch simulated puddles (buckets) residue data.

C_w in Dew from Contaminated Forage

ChemX concentrations in dew can be estimated through the use of a simple equilibrium partition model. This model assumes two compartments, water and leaf organic carbon into which the pesticide may associate. The basic equation for partitioning of pesticide between these compartments is as follows:

$$C_w(dew) = C_k \,/\, (K_{oc} \times f_{oc})$$

where: C_w(dew) is the concentration of dissolved pesticide in dew (mg/L)

C_k is the concentration of pesticide in broadleaf forage leaves (mg/kg-fw) at time t after application, effectively establishing a distribution on dew concentrations that is perfectly correlated with random selection of broadleaf forage pesticide concentration.

K_{oc} is the organic carbon:water partition coefficient. The value used in the risk assessment is the mean of the 12 values available for ChemX summarized in Table 13.

f_{oc} is the fraction of organic carbon in leaves. Donahue et al. (1983) have estimated this fraction to be 0.40 for alfalfa, clover, bluegrass, corn stalk, and small grain straw. Further discussion of alternate assumptions for this variable is included in the results discussion of this document.

Table 13. K_{oc} (organic carbon:water partition coefficient) Summary Statistics

K_{OC} Data	Statistic	Value
62.5	Mean	37.7750
61.7	SE	4.8963
51.9	Median	36.2500
36.5	SD	16.9612
39.7	Variance	287.6839
29.6	Range	52.8
52	Minimum	9.7
9.7	Maximum	62.5
31.1	Count	12
13.3		
29.3		
36		

The uncertainties and assumptions associated with this simple model include:

- Relative compartment volumes are assumed unimportant, such that the mass of pesticide initially on the leaf compartment is sufficient to reach maximum equilibrium concentrations in water.

- Organic carbon used as the basis for empirically establishing K_{oc} values is of comparable adsorption affinity to carbon incorporated in undecayed plant material.

- Surface characteristics of the vegetation are not accounted for in determining the potential for modifying solubilization of vegetation/associated pesticide residues.

- Equilibrium is established quickly between the two compartments.

- The contribution of pesticide material suspended in dew from exfoliated plant material or dislodged pesticide solids is not accounted for in this model, only dissolved pesticide is considered.

Application Associated Parameters

Fraction of the Food Source Contaminated with ChemX (FC_k)

For foliar applications of flowable ChemX, the entire treated field is assumed to be exposed to ChemX and therefore each of the avian food items found on such fields are judged to be contaminated with the pesticide. However, for in-furrow or banded spray applications, the pesticide application is assumed to be limited to the portion of the treated field constituting the furrows or bands.

Insects found on the in-furrow or treated field are assumed to be mobile across the entire field, and so the application of pesticide to only furrow or bands is not assumed to affect the fraction of the food item assumed to be contaminated. This is in keeping with the pitfall trap sampling design of the studies used to establish insect ChemX residues (Fischer and Bowers 1997). FC_k for insects is therefore held to a constant value of 1.0.

In contrast to insects, seeds were assumed to essentially occupy fixed locations on a treated field. Therefore the FC_k for seeds was set at a fixed value representing the area proportion of the treated field to which pesticide is directly applied. For in-furrow treatments this fraction of the treated field was estimated to be 0.05 for in-furrow applications with assumptions of 40 inch row spacing and 2-inch wide furrows. For banded treatments the fraction of field receiving treatment was estimated to be 0.17 with assumptions of 40 inch row spacing and 7-inch wide bands of treatment per row.

It should be noted that for this fraction of available seeds in the treated area, the effective application rate of ChemX is much higher than an average treatment rate across the field. In-furrow application at 2.5 oz/1000 row ft equates to an effective application rate of 20.42 lbs per actual treated acre, assuming a labeled 4 lbs ai/gallon and a 2 inch row width. Banded application at 2.5 oz/1000 row ft equates to a 5.8 lbs ai per actual treated acre, assuming 7 inch row width.

Effects Modeling

The basic element of the effects sub-model to estimate the magnitude and probability of direct short-term toxicological effects to avian species is the dose-response relationship derived from laboratory toxicity tests. The dose-response curve describes the relationship of measurable effects (mortality) to exposure to a pesticide for the duration of the test and provides an estimate of the variability of individuals. Each test provides a quantitative description of the dose-response relationship for one species under the conditions of the test. For any given dose, the dose response for an acute study gives the probability that an individual will be killed at that dose, or a probabilistic estimate of effects. The parameters derived from the dose-response study, the median lethal dose and the slope, are statistical estimates with associated error usually reported as standard errors and confidence intervals.

Uncertainty is introduced into the assessment from the major variables that influence the acute response of individual animals. These include: intra- and inter-species variability, age and sex, nutritional status, breeding status, environmental conditions, chemical formulation, routes of exposure and duration and extent of exposure. For the majority of these variables, while data has been developed that indicates they contribute to the variability of the response of an individual to exposure to a toxicant, limited information is available to quantify their influence on the numerous wildlife species exposures under the countless environmental conditions that occur under field conditions.

Of these variables inter- and intra-species variability have been identified to contribute substantially to the intensity of the response of non-target wildlife species exposed to pesticides and are addressed in this refined assessment (ECOFRAM 1999). Also, as previously discussed in the exposure section, duration and extent of exposure are accounted for in the assessment. Not accounted for in this assessment are routes of exposure other than oral ingestion (e.g., transdermal and inhalation), age and sex, breeding and nutritional status, environmental conditions and chemical formulation and their influence on the sensitivity of individuals response to exposure to ChemX. In general these factors, if accounted for, would intensify the response of individuals to exposure under field conditions in comparison to the laboratory toxicity tests used for a basis to estimate the dose response distribution.

Toxicological Standard

As indicated the basic element of the effects model to estimate the magnitude and probability of short-term direct toxicological effects to avian species is the dose-response relationship derived from laboratory toxicity tests. The two basic studies which have been used to estimate the short term dose-response of non-target avian species are the acute oral and subacute dietary toxicity study. The avian acute oral test provides a measurement of acute toxicity to the test population from a single oral dose administered after a fasting period to groups of individuals at geometrically spaced doses. The number responding at each dosage level is recorded over time (usually fourteen days). Probit analysis or another appropriate statistical method is used to estimate the dose response curve and other descriptive statistics including the LD50, the slope and confidence limits around the estimates.

The avian dietary toxicity test provides a measurement of subacute toxicity to the test population from a quantity of toxicant mixed in the diet and fed to young birds for a period of days (usually five) followed by a recovery period (usually 3-days) during which the birds are fed a clean diet. The same observations are recorded for the dietary test as the acute oral test and the same statistical methods are used to estimate the dose response curve and the descriptive statistics. However, the toxicity estimates are based on the quantity of toxicant in the diet (bio-availability) in comparison to the amount of toxicant introduced into the bird as in the acute oral study.

Both these studies have limitations for estimating the risk to wild avian species exposed to pesticides in the environment. Both studies have a fixed exposure period, not allowing for the differences in response of individuals to different duration of exposure. Further, for the acute oral study, the dose administered in a single dose all at one time does not mimic wild birds' exposure. Also, for exposure through different environmental matrices, it does not account for the effect of the matrices on the absorption rate of the chemical into the animal. This latter criticism also applies to the dietary test for other food matrices consumed in the wild.

For the dietary test, as it is currently designed, there are several other aspects of this test that limits its utility for refining an assessment and in particular for ChemX (Mineau et al. 1994, ECOFRAM 1999). The endpoint of this test is reported as the concentration mixed with food that produces a response rather than as the dose ingested. Although food consumption is sometimes measured allowing for the estimate of a dose, calculations of the mg/kg/day are confounded by undocumented spillage of feed and how often consumption is measured over the duration of the test. Usually, if measured at all, food consumption is estimated once at the end of the five-day exposure period. Further, the group housing of birds only allows for a measure of the average consumption per day for a group and can be further confounded if birds die within a treatment group. Also complicating the estimate of the dose, is the observation that young birds undergo rapid growth at an exponential rate, often with controls nearly doubling in size over the duration of the test. With weights only taken at the initiation of the exposure period and end, the dose per body weight (mg/kg) is difficult to estimate with any precision. The interpretation of this test is also confounded because the response of birds is not only a function of the intrinsic toxicity of the pesticide, but also the willingness of the birds to consume treated food.

More importantly, there is evidence that the laboratory derived LC_{50} ChemX values are poor predictors of effects. The average LC_{50} value for ChemX is 96.7 ppm (geometric mean = 68.1 ppm) for mallards and an estimated LC_5 ranging from 27 to 45 ppm depending on the slope. However several incidents of mortality have been reported at significantly lower exposure levels.

Therefore, given the number of questions with the reliability of the LC_{50} test results for ChemX, the results from the actual oral LD_{50} tests were used in this refined assessment to estimate the acute risk to non-target avian species.

However, the acute oral LD_{50} study is not without its limitations. Its failure to mimic exposure duration and account for differences in absorption rates in the gut from different environmental matrices introduce uncertainty into the estimates of risk based on the results of this test. Further analysis of the uncertainties these variables introduce into the refined assessment is limited by the inability to determine the effects of duration of exposure and estimate absorption constants from the current standard toxicity tests. A battery of tests would be needed to address these issues on several species, varying the duration of exposure and matrices, with appropriate physiological and pharmacokinetic measurements taken. In the absence of this information, the acute oral LD_{50} test provides the best estimate of acute effects for chemicals where exposure can be considered to occur over relative short feeding periods, such as the diurnal feeding peaks common to avian species (ECOFRAM 1999).

The uncertainties with the acute oral test are further confounded because exposure occurs over several days, introducing the need to consider cumulative dose and elimination of the chemical from the body for the duration of the exposure. To account for this a simple chemical in, chemical out approach was adopted. The assumption is made that there is no cumulative effect of repeated doses that reduce the tolerance of an individual to successive doses, and that the peak cumulative dose per day, taking into account the elimination rate of the chemical per day, is equivalent to the single bolus exposure in the acute oral toxicity test. In essence, the foundation of the approach is the toxic response of the individual is a function of the body burden of the compound, and the body burden is a function of the ingestion rate plus the residual from previous exposure periods using a defined time step.

Inter-species Toxicity Variability

One of the largest sources of uncertainty associated with predicting effects of pesticides to non-target species comes from the large variability in the sensitivity of species to toxic chemicals. A review of toxicity studies for 53 carbamate and organophosphate insecticides, showed the range between LD_{50}'s among birds is from 5 to more than 100 (ECOFRAM 1999). For 70% of the products, this range extends between 10 and 100. For ChemX, 24 acute oral toxicity tests have been conducted with15 different species. LD_{50} values range from 0.238 for the most sensitive species to an average of 7.85 for the least sensitive species, a 33 fold difference in tested species sensitivity to ChemX.

If the focal species of the assessment is the same as the species tested in a toxicity study, the effects profile may be the same as the dose-response relationship derived from the study. More often the assessment is focused on species that have not been tested. Therefore, the effects profile needs to account for the uncertainty introduced by the high variability in sensitivity among species. In the absence of toxicity data on the focal species it is unknown where on the sensitivity distribution it lies, introducing large uncertainty into the assessment of risk to individual species depending on the level of exposure. That is, significantly different estimates of risk can result, depending on where the individual focal species lies on the sensitivity distribution, particularly at the extremes, i.e., opposite tails. To account for this uncertainty in this refined risk assessment, an inter-species distribution-based method was used to bound the risk estimates and predict the most likely or average risk.

The inter-species distribution based model generates a distribution of species sensitivity from the results of available acute oral toxicity tests (ECOFRAM 1999, Baril et al. 1994, Baril and Mineau 1996, Van Straalen and Denneman 1989, Aldenberg and Slob 1993). This approach is based on the concept that the sensitivity of species is a stochastic variable that can be characterized by fitting a probability density function to the results of the toxicity tests. This assumes that the distribution of wild species sensitivity closely approximates the estimated distribution from laboratory tests and the sensitivity of species used in laboratory tests is an unbiased measure of the variance and mean of the distribution of sensitivity of wild species.

The distribution-based approach estimates inter-species sensitivity variability by directly fitting the available toxicity values to a log-logistic distribution. The parameters of the distribution are determined directly from the available toxicity values, applying correction factors for the bias introduced by small sample sizes and body size (Baril et al. 1994, Baril and Mineau 1996, Luttik and Aldenberg 1995, Mineau et al. 1996, Aldenberg and Slob 1993). Only studies which reported exact toxicity values were used to define the inter-species toxicity distribution (Table14). Studies which reported ranges were not used. Species with more than one reported LD_{50} value, the geometric mean of the values reported was used in developing the distribution to avoid weighting the distribution to any one species.

Table 14. Acute oral toxicity of technical-grade ChemX to avian species

Species	Age	LD$_{50}$ mg/kg	95% C.L.
Fulvous Whistling Duck (*Dendrocygna bicolor*	3-6 mo	.238	0.20-0.28
Mallard (*Anas platyrhynchos)*	33-39 h 6-8 d 27-33 d 3-4 mo 6 mo 12 mo 12 mo	0.370 0.628 0.510 0.397 0.415 0.480 0.510 G.M.$^{\#}$=0.466	0.28-0.48 0.53-0.74 0.41-0.64 0.32-0.50 0.33-0.51 0.38-0.60 0.41-0.64
Red-winged Blackbird (*Agolaius phoericous*)	adult	0.422	
Red-billed Quelea (*Quelea quelea*)	adult	0.422-0.562*	
American Kestrel (*Falco sparverius*)	1-4 yr	0.60	0.50-1.0
House Finch (*Carpodacus mexicanus*)	adult	0.750	
House Sparrow (*Passer domesticus*)	adult	1.33	
Brown-headed Cowbird (*Molothrus ater*)	adult	1.33	
Rock Dove (*Columbia livia*)	adult	1.33	
Common Grackle (*Quiscalus quiscula*)	adult	1.33-3.16*	
Japanese Quail (*Coturnix coturnix*)	14 d ♂ 14 d ♀	1.9 1.7 G.M.$^{\#}$=1.79	1.7-2.1 1.3-1.9
Eastern Screech Owl (*Otus asio*)	2-5 yr	1.9	1.4-2.7
Ring-necked Pheasant (*Phasianus colchicus*)	3 mo	4.15	2.38-7.22
Northern Bobwhite (*Colinus virginianus*)	3 mo 16-20 wk 1-2 yr	5.04 12 8.0 G.M.$^{\#}$=7.85	3.64-6.99 7.0-19.0 6.0-10.0
European Starling (*Sturnus vulgaris*)	adult	5.62	

Geometric mean of reported values for species

The following steps were used in deriving the toxicity estimates for the focal species:

Step 1. Each LD$_{50}$ value was corrected with a scaling factor. For ChemX the body weight scaling factor was 0.89 ($r^2 = 0.54$.), the opposite trend in scaling factor observed for the majority of chemicals. That is larger bodied birds were more sensitive than smaller bodied birds. The reported fit ($r^2 = 0.54$) suggests that further exploration and analysis of this scaling factor is warranted.

$$LD50_{corrected} = LD50_{tested} / W^{(0.89-1)}$$

Step 2. The log 10 of each scaled LD$_{50}$ was taken and the mean and standard deviation of the log transformed LD_{50} values were calculated.

Step 3. The 5^{th} , 50^{th} and 95^{th} percentile of the log transformed distribution were calculated using a small sample size extrapolation constant (EC) for the nth percentile from Aldenberg and Slob (1993). The EC value corresponding to the available number of toxicity values was 1.71.

$$5th\ percentile\ toxcity\ value = \overline{x} - (EC * SD)$$

$$50th\ percentile\ toxicity\ value = \overline{x}$$

$$95th\ percentile\ toxicity\ value = \overline{x} + (EC * SD)$$

Step 4. The antilog of the 5^{th}, 50^{th} and 95^{th} percentiles and the 95^{th} percent confidence limits of the 5^{th} and 95^{th} percentile were calculated.

Step 5. Scale the parameter to the body weight of the focal species:

$$focal\ species\ LD_{50} = nth\ percentile\ LD_{50}\ /\ focal\ species\ weight^{1-0.89}$$

Using the distribution-based approach, for each focal species three estimates of its LD_{50} were made; the 5^{th} , 50^{th} and 95^{th} percentile. This was used in the refined assessment to bound the estimates of risk and provide an average or most likely estimate of risk. Table 15 gives the results of these calculations for the 8 focal species for which toxicity data are not available.

Table 15. Estimated oral LD_{50} values for focal species, 5^{th}, 50^{th}, 95^{th} percentile.

	LD_{50} mg/kg		
Species[1]	**5th %tile**	**50th %tile**	**95th %tile**
Killdeer	0.23	1.36	8.24
Morning Dove	0.22	1.34	8.09
Vesper Sparrow	0.26	1.58	9.58
Horned Lark	0.26	1.55	9.37
Meadow Lark	0.23	1.38	8.32
Dickcissel	0.26	1.58	9.53
Grasshopper Sparrow	0.27	1.66	10.03
Savannah Sparrow	0.26	1.58	9.59

[1] Red-wing Black Bird and Mallard Duck not listed because toxicity data are available.

Slope of the Dose Response Curve

The dose-response curve generated from the basic toxicity tests required to support the registration of ChemX provides an estimate of intra-species variability for the species tested under the conditions of that test. The dose response curve provides an estimation of the probability of mortality at a given dose for the tested sample of the population and the slope provides an estimate of the variation of the individual tolerance in the tested sample. Steep slopes indicate a low variance among individuals and shallow slopes indicate a greater variance among individuals.

The slope of the dose-response curve is an estimate of the population's variability in individual tolerances and therefore has inherent statistical uncertainty. Also, the slope of the dose-response curve is thought to differ among species due to the differences in morphology, and biochemical and physiological processes which interact with the inherent pharmacokinetic characteristics of the compound. However, information on the extent of the variability of the slope between species is lacking and limits, at this point, predictions about the slope based on taxonomic relationships. Therefore few species, other than the standard species used for laboratory tests, are tested in such a way that slopes can be determined, which prevents a more thorough evaluation of the species differences in slopes at this time (ECOFRAM 1999).

In the absence of these data and considering the stage of model development and level of refinement of this assessment, estimates of slopes for all focal species were based on the geometric mean of all the tests which reported a slope or provided adequate data from which a slope was calculated. The geometric mean slope is equal to 5.7.

Integration of Exposure and Effects -Mean Mortality Estimate

To estimate the mortality distribution for the focal species selected for this refined assessment, the average risk for the maximum estimated body burden based on the external dose for the duration of the exposure duration for each individual is calculate from the dose- response curve derived for the particular focal species. The individual's fate (dead, not dead) at the estimated dose is assigned by comparing the estimated average risk to a random selected number from a uniform distribution (0-1). If the random number is less than the average risk estimate, the individual is scored 'dead', and if the random number is greater than or equal to the average risk the individual is scored 'not dead'. Using a random number selected from a uniform distribution(0-1) and comparing it to the average risk for a given dose in essence establishes a binomial distribution with a probability of mortality equal to the average risk for a given dose generated from the dose-response curve. This procedure is repeated for a set of individuals (Cohorts of 20) to generate a percent affected estimate. With multiple runs of cohorts of 20 (1000 runs of 20) a probability density function of percent mortality is generated or a probability density function of risk for cohort of 20 individuals and statistics generated. For this refined assessment the average risk and 5th and 95th percentiles of the distribution as well as the CDF for each scenario for each focal species is reported.

The average mortality risk estimate for a given dose is based on the probit model which assumes the quantal dose response phenomena are usually log-normally distributed and the general formula for the Z statistic:

$$z = \frac{x - m}{s}$$

Where,

z = z score for the standard normal distribution, mean =0, standard deviation =1,

x = the dose estimate for an individual of a focal species
μ = the estimated LD_{50} of the focal species, and
σ = standard deviation of the focal species dose response curve, *1/slope*.

Normalizing the dose curve gives:

$$z = (\log x - \log \mathrm{m}) \times slope \text{, or}$$
$$z_i = \left(\log D_i - \log LD_{50}\right) \times slope$$

Where,
D_i = the estimated dose for individual *i* in µg/g, and
LD_{50} = Median lethal dose for the focal species in µg/g.

The average risk of dose D_i to individual *i* is

$$P(z)_i$$

Where,
$P(z)_i$ = Probability of z_i from the standard normal distibution.

The fate(dead, not dead) of individual *i* at dose *i* is determined by:

$$\text{rand } (y) = \text{ (uniform distribution, 0,1) and if}$$

$$y < P(z)_i\text{, dead,}$$

$$\text{or, if}$$

$$y \geq P(z)_i\text{, not dead.}$$

Where,
y = a random number selected form the uniform distribution between 0 and 1.

The distribution of mortality of cohorts of 20 individuals is determined through 1000 iterations using Monte Carlo sampling techniques. Cohorts of 20 were selected as a reasonable estimate of the number of individuals of a given focal species that could occur in and around fields in the agro-ecosystems selected for this refined assessment. While additional literature review, as well as conducting field census surveys is warranted to provide better estimates of avian densities in agro-ecosystems, the size of the cohort used to estimate percent mortality is only relative to the variability in the distribution, with smaller cohorts having larger variability and larger cohorts having smaller variability. The means, or average effect levels are not altered by the size of the cohort selected.

SCENARIOS EXAMINED

As mentioned previously, several different scenarios were examined to provide insight into the level of effects under various conditions and provide estimates of uncertainty introduced in the assessment from inter-species variability of toxicity. In total, 360 different scenarios were examined for ChemX's corn and alfalfa uses. For broadcast application to corn and alfalfa, for each focal species, 27 separate scenarios were examined as outlined in Table 16. The influence of sources of contaminated drinking water on treated fields was appraised for three conditions: no puddles present for the simulation duration, puddles present at application, and puddles forming from a rain fall event the day following application. For each of these three conditions, three application rates were examined : low, typical, and high use rates, and for each use rate three species sensitivity assumptions were explored: low, medium and high sensitivity. The one exception to running three sensitivity assumptions for corn broadcast applications was the red-winged blackbird. Only one sensitivity scenario was run for this species since species-specific toxicity data are available.

For in-furrow and banded applications to corn, contaminated water sources were not explored. For these application methods, three scenarios were appraised as outlined in Table 15. One application rate for each application method was explored and for each application method three sensitivity assumptions for each focal species were examined. Again, for the red-winged blackbird only one sensitivity assumption was run because species specific toxicity data are available.

Also, three scenarios were explored for waterfowl feeding in treated alfalfa fields using the mallard duck as the focal species. These scenarios were limited to one feeding period at varying times (0 to 12 days) after application for each of three application rates. Contaminated water was not considered and each individual was assumed to ingest half of its daily food requirement of contaminated alfalfa. Only one sensitivity assumption was run because species specific toxicity data are available for the mallard duck.

Table 16. Scenarios Examined for Refined Assessment of ChemX

<table>
<tr><th colspan="12">Scenarios Examined for Broadcast Corn and Alfalfa for Each Focal Species</th></tr>
<tr><td colspan="12">No Puddles</td></tr>
<tr><td colspan="4">Low Application Rate</td><td colspan="4">Typical Application Rate</td><td colspan="4">High Application Rate</td></tr>
<tr><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td></tr>
<tr><td colspan="12"></td></tr>
<tr><td colspan="12">Puddles Day of Application</td></tr>
<tr><td colspan="4">Low Application Rate</td><td colspan="4">Typical Application Rate</td><td colspan="4">High Application Rate</td></tr>
<tr><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td></tr>
<tr><td colspan="12"></td></tr>
<tr><td colspan="12">Puddles Day after Application</td></tr>
<tr><td colspan="4">Low Application Rate</td><td colspan="4">Typical Application Rate</td><td colspan="4">High Application Rate</td></tr>
<tr><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td><td>High Sensitivity</td><td>Medium Sensitivity</td><td colspan="2">Low Sensitivity</td></tr>
<tr><td colspan="12"></td></tr>
<tr><th colspan="12">Scenarios Examined for Each Focal Species For Corn Banded and In-furrow Applications at 1 lb ai/A</th></tr>
<tr><td colspan="4">High Sensitivity</td><td colspan="4">Medium Sensitivity</td><td colspan="4">Low Sensitivity</td></tr>
<tr><td colspan="12"></td></tr>
<tr><th colspan="12">Scenarios Examined for Waterfowl (Mallard Ducks) For Broadcast Alfalfa</th></tr>
<tr><td colspan="4">Low Application Rate</td><td colspan="4">Medium Application Rate</td><td colspan="4">High Application Rate</td></tr>
<tr><td>0 days</td><td>3 days</td><td>6 days</td><td>12 days</td><td>0 days</td><td>3 days</td><td>6 days</td><td>12 days</td><td>0 days</td><td>3 days</td><td>6 days</td><td>12 days</td></tr>
</table>

RESULTS AND DISCUSSION

EFED conducted 360 risk assessment model simulations for aerial applications of ChemX to Midwest corn and alfalfa, as well as in-furrow and banded applications to Midwest corn. Application scenarios included a variety of application rates and considered applications to fields with existing on-field puddles (aerial applications only), rain events on the day following application, and application in the absence of precipitation events. For each application scenario, risk assessment simulations were run using three assumptions of bird sensitivity to ChemX: high sensitivity (expressed as the 5th percentile point on the distribution of bird sensitivity), medium sensitivity (expressed as the 50th percentile point), and low sensitivity (expressed as the 95th percentile point).

The output of each risk assessment run is expressed in two ways in the following sections. First, tables provide a mean mortality prediction (mean of 1000 runs of 20-bird cohorts) for each combination of species, sensitivity assumption, target crop, drinking water assumption, application method, and rate of application. In addition, a maximum value and a minimum value for percent mortality are provided with each mean, which represent the 95th and 5th percentiles of the distribution of all 1000 20-bird cohort mortality predictions simulated for a particular scenario.

The second model presentation method graphically depicts the reverse cumulative distribution of mortality frequencies (number of dead out of 20 birds). These curves are based on binomial probabilities of cohorts of 20 individuals providing the cumulative probability of mortality, from zero to twenty, for each scenario examined. The binomial probabilities are based on the risk assessment model predictions of mean mortality.

Two immediate observations were made regarding the model output. First, comparison of no-puddle, day of application puddles, and day after application puddle drinking water scenarios within each corn and alfalfa application rate category reveals that the choice of drinking water source does not influence the model predictions to any great degree. For example, the mean, 95th, and 5th percentile values for killdeer mortality in corn with 0.25 lb ai/acre ChemX applied with no puddles are predicted to be 87 percent, 100 percent and 75 percent, while the same predictions with day of application puddles are 86 percent,95 percent, and 75 percent and with puddles present on the day after application the predictions are 88 percent, 100 percent and 75 percent (Table 17) . This is primarily due to the construct of the exposure model that considers puddles as a drinking water source for a single time step over the coarse of the exposure period modeled, and thereafter reverts to dew as the drinking water source. The potential for significant contribution of puddles to overall exposure is limited by the single time step allotted for exposure to these drinking water sources. Consequently, discussions of mortality predictions for each scenario will be limited in this document to consideration of the no-puddle drinking water assumption.

Secondly, with the exception of assessment predictions for the red-winged blackbird and mallard duck (for which actual toxicity data are available), the impact of the uncertainty regarding a species' true position on the distribution of individual species lethal sensitivity to ChemX appears to be great. For example, under the lowest aerial application of ChemX to corn, the range of mean mortality predictions can as large as 0 to 87 percent for an individual species (Table 17).
This uncertainty as to individual species sensitivity precludes definitive statements regarding actual

mortality levels on any single focal species, but rather represents the range of possible mortality outcomes for multiple species with biological and behavioral characteristics similar to the species modeled for exposure. In order to get a better understanding of the distribution of possible unspecified species mortality outcomes, EFED compiled the mean mortality predictions for each of the species modeled within an application scenario (including the low, medium, and high sensitivity-based outcomes) and interpolated percentile predictions of mortality using the PERCENTILE function in EXCEL. These predicted values were then graphed to provide a visual representation of the cumulative distribution of outcomes for all focal species. These graphs estimate the fraction of species that are being impacted and the magnitude and probability of these impacts. This assumes that the selected focal species constitute a representative sample of all species potentially exposed.

Acute Avian Risks Associated with Aerial ChemX Applications to Corn

Four species define the extremes of risk assessment results for applications of ChemX to corn. The mourning dove and/or western meadowlark are the modeled species with the lowest risks. The killdeer and/or horned lark are the modeled species at highest risk. Consequently, the discussion of results for individual species can be simplified by focusing on these extremes of species results. The following discussions of individual application rates and methods will therefore focus on mourning dove and killdeer for aerial applications and western meadowlark and horned lark for banded and in-furrow applications.

Aerial Application to Corn (0.25 lb ai /acre)

Table 17 presents the mortality predictions for ChemX applied to corn at a rate of 0.25 lb ai/acre. For each species, results are presented for each assumption of species sensitivity to the pesticide. As was discussed earlier, mean, 5th, and 95th percentile predictions of mortality are presented for each species within a sensitivity assumption. The mean value most closely represents a population average based on a sample size of 1000 individual 20-bird cohorts. The 5th percentile represents the low prediction of mortality; one that suggests a level of mortality for which 5 percent of the possible 20-bird cohort mortality outcomes were at or below. The 95th percentile value represents a high predicted mortality level at which the upper 5 percent of 20-bird cohorts equaled or exceeded. Figure 2 graphically presents the distributions of possible mortalities for 20-bird cohorts (number of dead out of 20) for each species and each sensitivity assumption. These values are based on the mean mortality predictions.

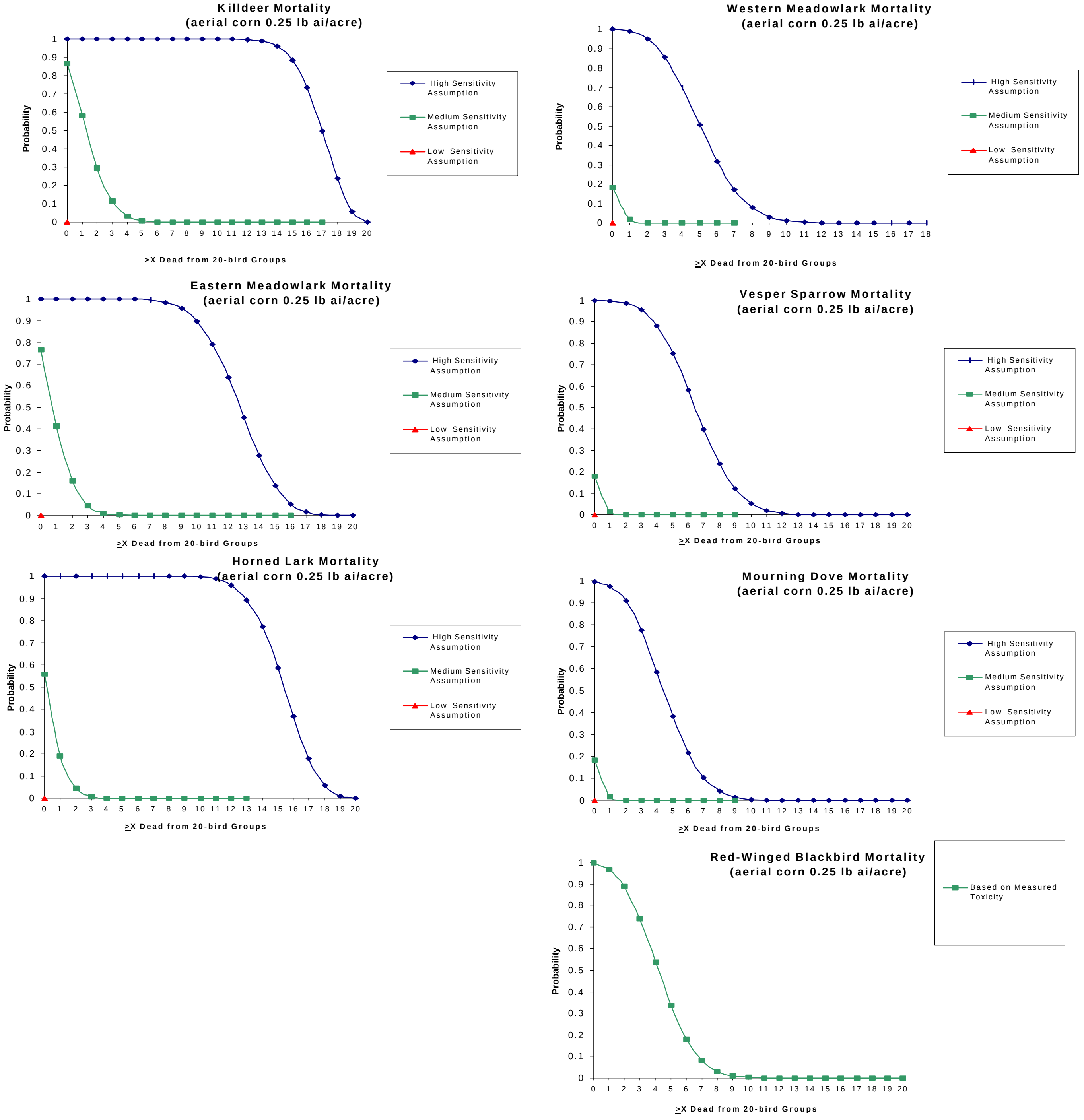
From this table and figure it can be seen, based on mean population mortality predictions, that the granivorous morning dove is the least impacted species modeled. If this species is assumed to be relatively insensitive to ChemX (i.e., a 95th percentile assumption on the toxicity distribution), there is no predicted mortality and if the species is assumed to be of average sensitivity to ChemX, there is a low probability (approximately 1 percent) that mortalities will be greater than 1 bird in 20. However, if the mourning dove is assumed to be a highly sensitive species (a 5th percentile assumption on the toxicity distribution), impacts to mourning doves are predicted to be more pronounced with average mortality estimated to be 5 of 20 birds with cohorts of birds showing 2 or less dead in about 5 percent of the cases and about 5 percent of simulated cohorts of 20 showing 8 or more dead birds. Complete mortality of 20-bird cohorts was not predicted for mourning doves.

Table 17. ChemX Aerial Application to Midwest Corn (0.25 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Drinking Water from Dew (no puddles on the field)									
K	87	100	75	10	20	0	0	0	0
HL	79	95	65	4	15	0	0	0	0
VS	35	50	20	1	5	0	0	0	0
MD	25	40	10	1	5	0	0	0	0
RWB				24	40	10			
EM	66	85	50	7	15	0	0	0	0
WM	28	45	10	1	5	0	0	0	0
Drinking Water from Puddles on the Day of Application									
K	86	95	75	11	25	0	0	0	0
HL	77	90	60	6	15	0	0	0	0
VS	34	50	15	2	5	0	0	0	0
MD	24	40	10	1	5	0	0	0	0
RWB				22	40	10			
EM	65	80	50	7	15	0	0	0	0
WM	27	45	15	2	5	0	0	0	0
Drinking Water from Puddles on the Day After Application									
K	88	100	75	10	20	0	0	0	0
HL	80	95	65	5	15	0	0	0	0
VS	36	55	20	1	5	0	0	0	0
MD	28	45	15	1	5	0	0	0	0
RWB				24	40	10			
EM	66	80	50	7	15	0	0	0	0
WM	28	45	10	1	5	0	0	0	0

K	killdeer
HL	horned lark
VS	vesper sparrow
MD	mourning dove
RWB	red-winged blackbird
EM	eastern meadowlark
WM	western meadowlark

Figure 2. Aerial Corn 0.25 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



In contrast to mourning doves, the killdeer appears to be more susceptible to ChemX-induced mortality in treated corn fields. Mortality was not predicted if a low sensitivity assumption was made. However, mortality was frequent and extreme under the medium and high sensitivity assumptions. Medium sensitivity assumptions regarding ChemX toxicity in killdeer, led to an average predicted mortality of about 2 dead birds in 20-bird cohorts, with mortality ranging from a low of 0 to a high of 20 percent. However, the high sensitivity assumption resulted in predicted mortalities of at least 15 out of 20 birds in 95 percent of the cases simulated, average mortality was 17 out of 20 and with complete mortalities (20 out of 20) were predicted in about 5 percent of cases simulated.

The other species modeled without species-specific toxicity data (horned lark, vesper sparrow, eastern/western meadowlarks) show predicted mortality levels intermediate to the mourning dove and killdeer, with low sensitivity assumptions yielding no mortality and high sensitivity showing 35 to 80 percent fatality rates.

As discussed earlier in the document, the wide variation in mortality predictions for different sensitivity assumptions can be traced to the uncertainty regarding a particular species' true sensitivity to ChemX. However, toxicity data are available for the red-winged blackbird, which reduces the uncertainty of the risk assessment model mortality predictions for this species. The predicted mean mortality for this species is 24 percent (5 dead in a 20 bird cohort). At least 2 birds are predicted to die in 95 percent of the 20-bird cohorts modeled. Five percent of the cohorts were predicted to experience at least 8 deaths.

Figure 3 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 70 percent of species have a predicted mean mortality greater than 0. Approximately 35 percent of the species have a predicted mortality of at least 10 percent (2 of 20) and 10 percent of the species are exhibiting 70 percent mortality or more. Regarding the red-winged blackbird (the species with least sensitivity uncertainty), the mean mortality prediction lies approximately at the 70th percentile of the distribution (i.e., 30 percent of the species are likely to be more severely impacted than the red-winged blackbird).

These results suggest that, at the lowest application rate for aerial ChemX use on corn, less than a third of the species have minimal impacts (mortality ca. 0 percent). The majority of species are experiencing some mortality and these mortalities may be quite severe (70 percent or greater) for the more sensitive species.

Aerial Application to Corn (0.75 lb ai /acre)

Table 18 and Figure 4 present the mortality predictions for ChemX applied to corn at a rate of 0.75 lb ai/acre. As for applications to corn at the lower rate, mourning doves are predicted to exhibit the lowest lethal response to ChemX treatment. An assumption of low sensitivity

Figure 3. Distribution of Predicted Mortality Outcomes
(aerial application to corn 0.25 lb/ai/acre)

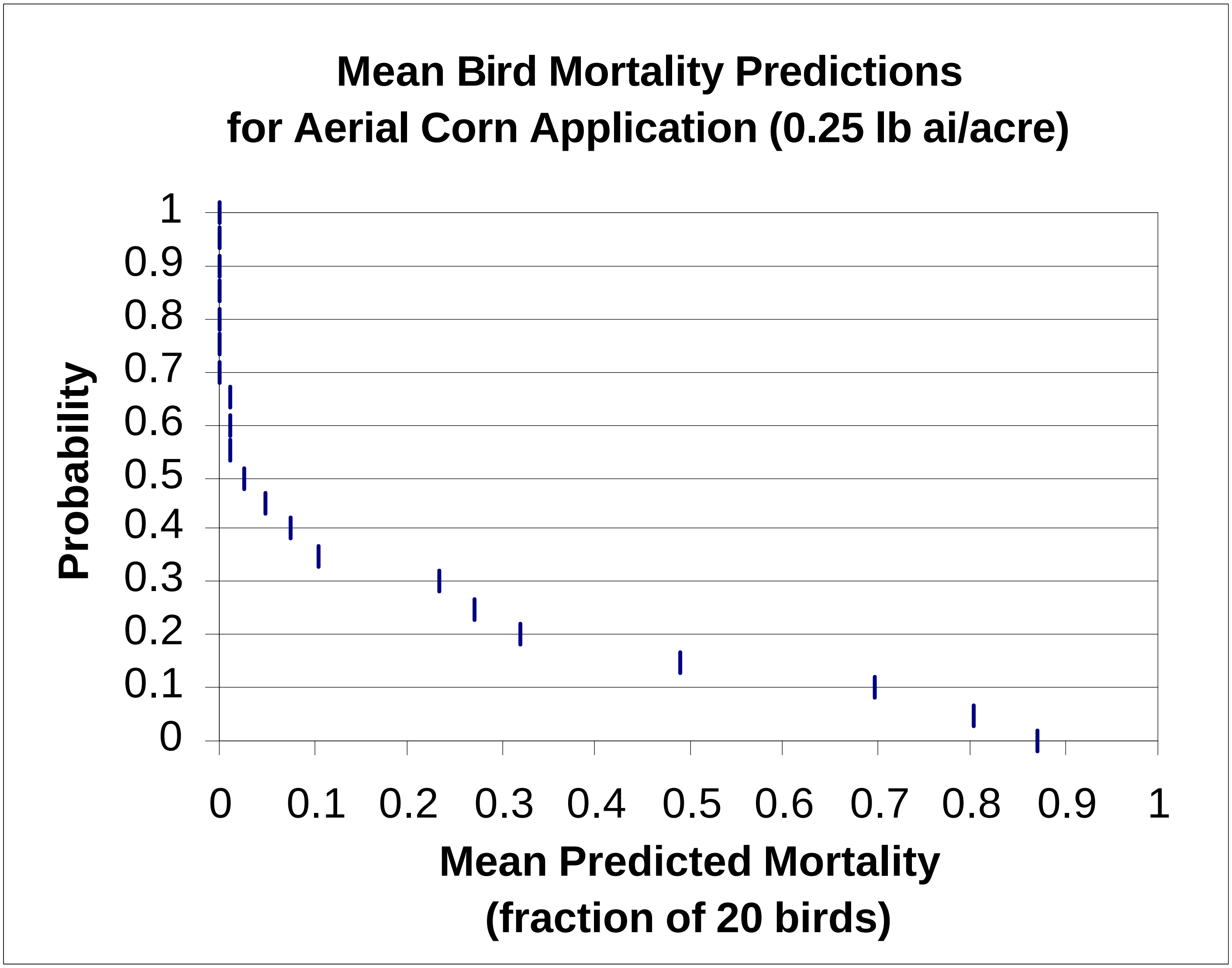
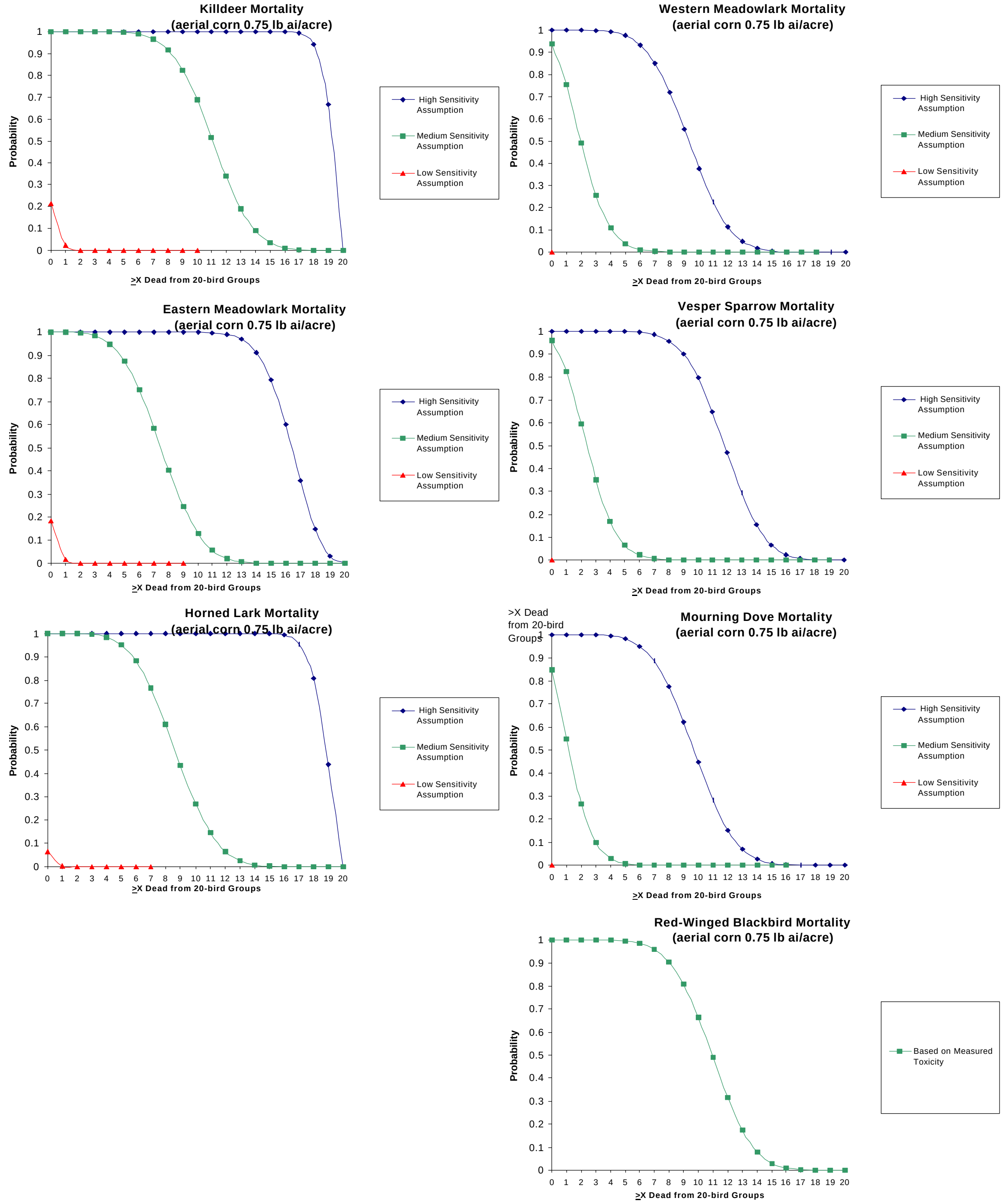


Table 18. ChemX Aerial Application to Midwest Corn (0.75 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Drinking Water from Dew (no puddles on the field)									
K	98	100	90	58	75	40	1	5	0
HL	96	100	90	46	65	25	0	5	0
VS	62	80	45	15	30	5	0	0	0
MD	51	70	30	9	20	0	0	0	0
RWB				57	75	40			
EM	84	95	70	40	60	25	1	5	0
WM	49	65	30	13	25	0	0	0	0
Drinking Water from Puddles on the Day of Application									
K	98	100	90	58	75	40	2	10	0
HL	96	100	85	44	60	25	1	5	0
VS	61	80	45	15	30	5	0	5	0
MD	50	70	30	10	20	0	0	0	0
RWB				57	75	55			
EM	84	95	70	41	60	25	0	0	0
WM	49	65	30	12	25	0	0	5	0
Drinking Water from Puddles on the Day After Application									
K	98	100	95	59	75	40	1	5	0
HL	96	100	90	47	65	30	0	5	0
VS	62	80	45	16	30	5	0	0	0
MD	54	75	35	11	25	0	0	0	0
RWB				58	75	40			
EM	84	95	70	41	60	25	0	0	0
WM	49	65	30	12	25	0	0	0	0

K	killdeer
HL	horned lark
VS	vesper sparrow
MD	mourning dove
RWB	red-winged blackbird
EM	eastern meadowlark
WM	western meadowlark

Figure 4. Aerial Corn 0.75 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



to ChemX (i.e., a 95th percentile assumption on the toxicity distribution) results in no predicted mortality. Contrasting the lower application rate scenario, if the species is assumed to be of average sensitivity to ChemX, approximately 54 percent of all 20-bird cohorts will have at least 1 death, mean mortality rates are predicted to be approximately 2 out of 20 birds and approximately 5 percent of 20-bird cohorts will have greater than 4 dead birds with an upper limit of predicted mortality of 15 birds out of 20. However, if the mourning dove is assumed to be a highly sensitive species (a 5th percentile assumption on the toxicity distribution), mortality impacts to mourning doves are predicted to be great with average mortality estimated to be 10 of 20 birds with cohorts of birds showing 6 or less dead in about 5 percent of the cases and 5 percent of the cohorts predicted to exhibit 14 or more dead birds. Complete mortality of 20-bird cohorts was not predicted for mourning doves.

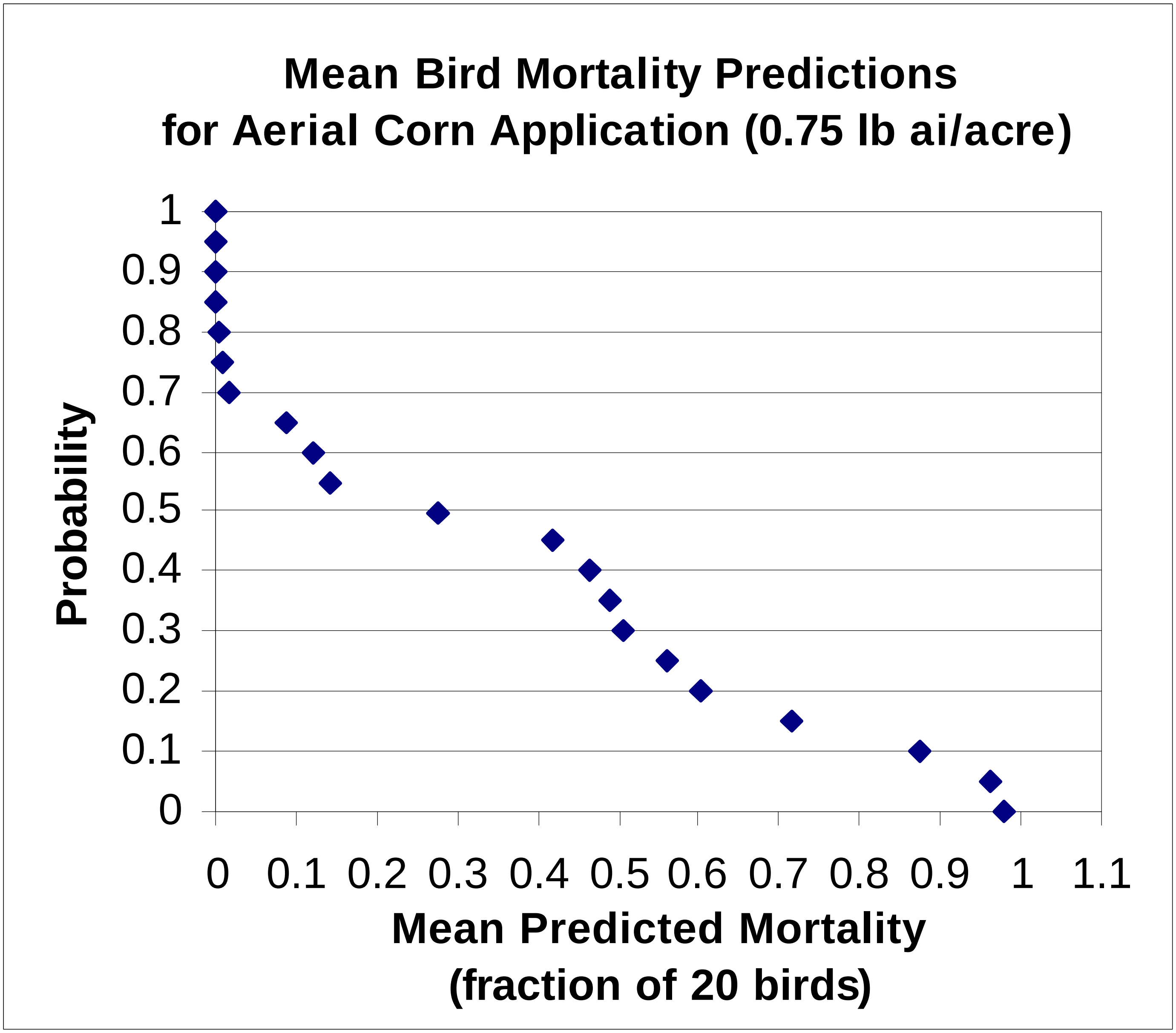
Killdeer mortalities under this scenario were also greater than predicted for the lower application scenario. Only low mortality (1 of 20) was predicted if a low sensitivity assumption was made, and this for approximately 20 percent of cases simulated. Mortality was frequent and extreme under the medium and high sensitivity assumptions. Medium sensitivity assumptions regarding ChemX toxicity in killdeer led to an average predicted mortality of about 11 dead birds in 20-bird cohorts, with approximately 95 percent of the cohorts having at least 8 dead birds and the upper 5 percent of the cases having at least 15 out of 20 dead birds. The high sensitivity assumption resulted in predicted mortalities of at least 18 out of 20 birds in 95 percent of the cases simulated, average mortality was 20 out of 20.

The other species modeled without species-specific toxicity data (horned lark, vesper sparrow, eastern/western meadowlarks) show predicted mortality levels intermediate to the mourning dove and killdeer, with low sensitivity assumptions yielding little if any mortality (maximum of 5 percent) and high sensitivity showing 49 to 96 percent fatality rates.

As discussed earlier in the document, the wide variation in mortality predictions for different sensitivity assumptions can be traced to the uncertainty regarding a particular species' true sensitivity to ChemX. However, toxicity data are available for the red-winged blackbird, which reduces the uncertainty of the risk assessment model mortality predictions for this species. The predicted mean mortality for this species is 57 percent (11 dead in a 20 bird cohort). At least 8 birds are predicted to die in 95 percent of the 20-bird cohorts modeled. Five percent of the cohorts were predicted to experience at least 15 deaths.

Figure 5 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 85 percent of species have a predicted mean mortality greater than 0. Approximately 65 percent of the species have a predicted mortality of at least 10 percent (2 of 20), with 15 percent of the species exhibiting 70 percent mortality or more. Regarding the red-winged blackbird (the species with least sensitivity uncertainty), the mean mortality prediction lies approximately at the 70th percentile of the distribution (i.e., 30 percent of the species are likely to be more severely impacted than the red-winged blackbird).

Figure 5. Distribution of Predicted Mortality Outcomes (aerial application to corn 0.75 lb/ai/acre)



These results suggest that, at the typical application rate for aerial ChemX use on corn, less than a sixth of the species have minimal impacts (mortality *ca.* 0 percent). The majority of species are experiencing some mortality and these mortalities may be quite severe (70 percent or greater) for the more sensitive species.

Aerial Application to Corn (1 lb ai /acre)

As can be expected, application of ChemX at the highest rate modeled, results in higher predicted mortality impacts on birds than lower application rates (Table 19 and Figure 6). Assumption of a low toxic sensitivity results in no predicted mortality for the mourning dove. An assumption of medium toxic sensitivity results in 82 percent of simulations of 20-bird cohorts having at least one mortality, mean mortality risk is 3 of 20, and 5 percent of 20-bird cohorts will have 6 or more dead birds with an upper limit (very rare occurrence) of predicted mortality of 18 out of 20. A high sensitivity assumption leads to almost 100 percent prediction of at least one death in each 20-bird group; mean mortality of 12 out of 20; and 5 percent of all simulations with 15 or more deaths.

Killdeer mortalities under this scenario were also greater than predicted for the lower two application scenarios. Low mortality (up to 2 of 20) was predicted if a low sensitivity assumption was made, and this for approximately 62 percent of cases simulated. Mortality was frequent and extreme under the medium and high sensitivity assumptions. Medium sensitivity assumptions regarding ChemX toxicity in killdeer, led to an average predicted mortality of about 15 dead birds in 20-bird cohorts, with approximately 95 percent of the cohorts having at least 11 dead birds and the upper 5 percent of the cases having at least 15 out of 20 dead birds. The high sensitivity assumption resulted in predicted mortalities of at least 19 out of 20 birds in 95 percent of the cases simulated, average mortality was 20 out of 20.

The other species modeled without species-specific toxicity data (horned lark, vesper sparrow, eastern/western meadowlarks) show predicted mortality levels intermediate to the mourning dove and killdeer, with low sensitivity assumptions yielding little if any mortality (maximum of 10 percent) and high sensitivity showing 52 to 97 percent fatality rates.

As discussed earlier in the document, the wide variation in mortality predictions for different sensitivity assumptions can be traced to the uncertainty regarding a particular species' true sensitivity to ChemX. However, toxicity data are available for the red-winged blackbird, which reduces the uncertainty of the risk assessment model mortality predictions for this species. The predicted mean mortality for this species is 64 percent (13 dead in a 20 bird cohort). At least 9 birds are predicted to die in 95 percent of the 20-bird cohorts modeled. Five percent of the cohorts were predicted to experience at least 16 deaths.

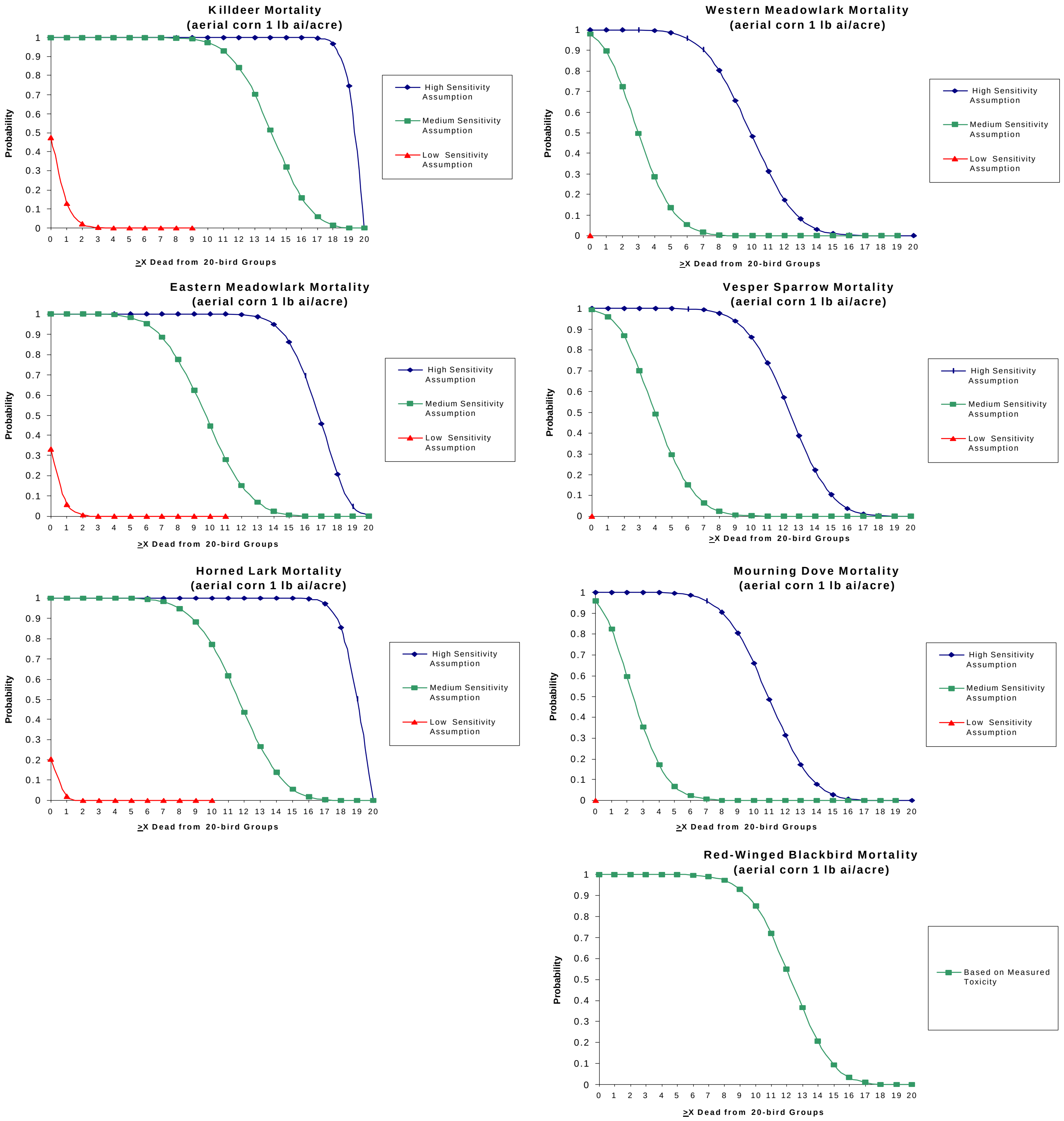
Figure 7 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 95 percent of species have a predicted mean mortality greater

Table 17. ChemX Aerial Application to Midwest Corn (1 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Drinking Water from Dew (no puddles on the field)									
K	99	100	95	72	90	55	3	10	0
HL	97	100	90	61	75	45	1	5	0
VS	64	80	45	23	40	10	0	0	0
MD	57	75	40	15	30	5	0	0	0
RWB				64	80	45			
EM	86	95	70	51	70	30	2	1	0
WM	52	70	35	18	35	5	0	5	0
Drinking Water from Puddles on the Day of Application									
K	98	100	95	71	85	55	4	10	0
HL	97	100	90	60	80	40	3	10	0
VS	65	80	45	22	40	10	1	5	0
MD	57	75	40	14	30	5	0	0	0
RWB				63	80	45			
EM	86	100	70	52	70	35	3	10	0
WM	52	70	35	19	35	5	1	5	0
Drinking Water from Puddles on the Day After Application									
K	99	100	95	73	90	55	3	10	0
HL	97	100	90	62	80	45	1	5	0
VS	65	85	45	23	40	5	0	5	0
MD	59	75	40	17	30	5	1	5	0
RWB				63	80	45			
EM	86	95	70	53	70	35	2	10	0
WM	53	70	35	19	35	5	0	5	0

K	killdeer
HL	horned lark
VS	vesper sparrow
MD	mourning dove
RWB	red-winged blackbird
EM	eastern meadowlark
WM	western meadowlark

Figure 6. Aerial Corn 1 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



Killdeer Mortality (aerial corn 1 lb ai/acre)

Western Meadowlark Mortality (aerial corn 1 lb ai/acre)

Eastern Meadowlark Mortality (aerial corn 1 lb ai/acre)

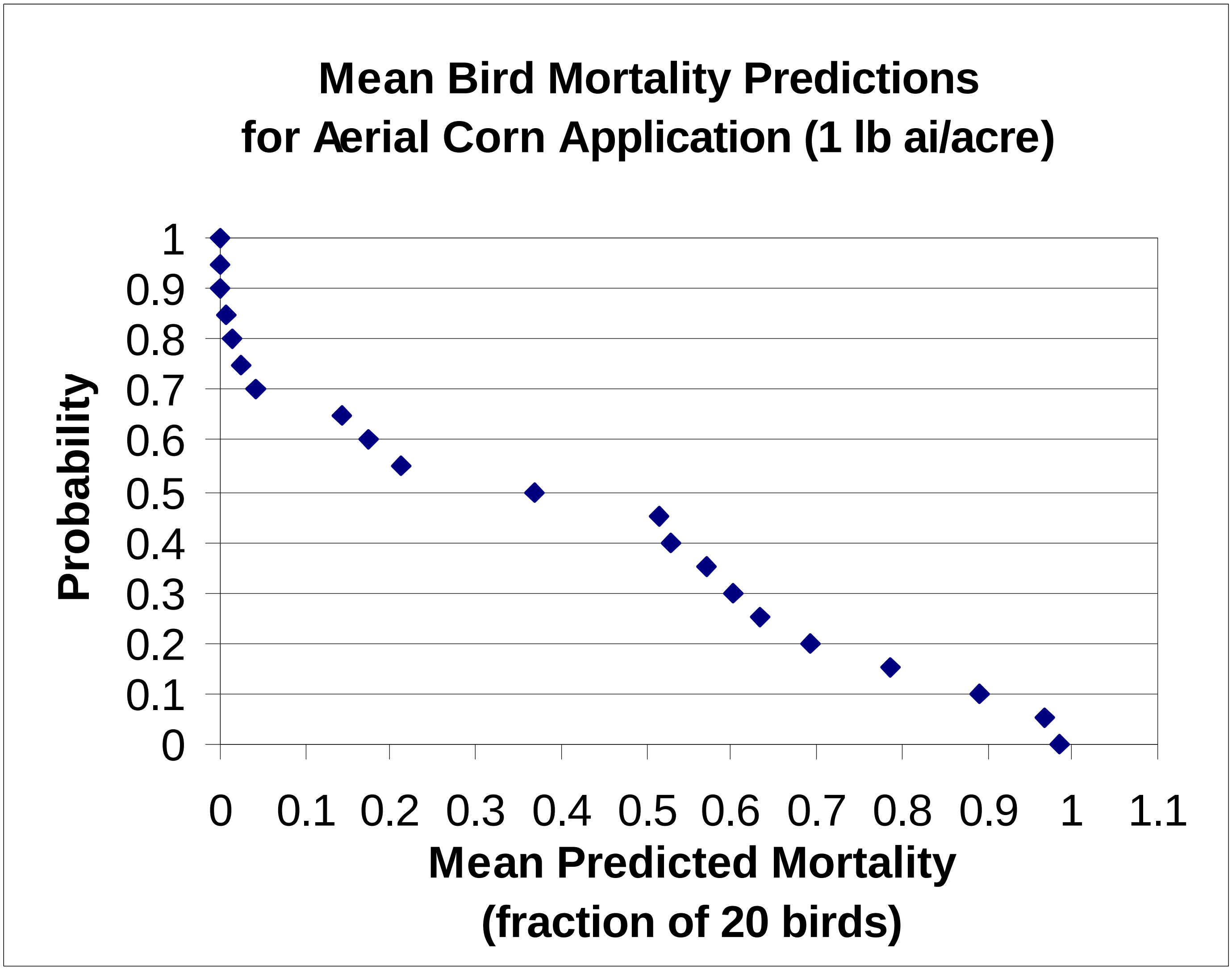
Vesper Sparrow Mortality (aerial corn 1 lb ai/acre)

Horned Lark Mortality (aerial corn 1 lb ai/acre)

Mourning Dove Mortality (aerial corn 1 lb ai/acre)

Red-Winged Blackbird Mortality (aerial corn 1 lb ai/acre)

Figure 7. Distribution of Predicted Mortality Outcomes
(aerial application to corn 1 lb/ai/acre)



than 0. Approximately 90 percent of the species have a predicted mortality of at least 10 percent (2 of 20), with 20 percent of the species exhibiting 70 percent mortality or more. Regarding the red-winged blackbird (the species with least sensitivity uncertainty), the mean mortality prediction lies approximately at the 75th percentile of the distribution (i.e., 25 percent of the species are likely to be more severely impacted than the red-winged blackbird).

These results suggest that, at the maximum labeled application rate for aerial ChemX use on corn, less than a twentieth of the species have minimal impacts (mortality *ca.* 0 percent).   The majority of species are experiencing some mortality and these mortalities may be quite severe (70 percent or greater) for the more sensitive species.

Banded Application to Corn (1 lb ai/acre)

The results of avian mortality simulations with banded ChemX treatment of corn (Table 20 and Figure 8) are lower than aerial treatments at comparable application rates.   The least impacted species, western meadowlark, shows low risk of mortality. Assumption of a low toxic sensitivity results in no predicted mortality. An assumption of medium toxic sensitivity results in 82 percent of simulations of 20-bird cohorts having zero to one mortality, mean mortality risk is 1 of 20, and 5 percent of 20-bird cohorts will have 1 or more dead birds with an upper limit (very rare occurrence) of predicted mortality of 8 out of 20. A high sensitivity assumption leads to mean predicted mortality of 17 percent (4 out of 20 dead), with 95 percent of the cohorts exhibiting at least 1 dead and 5 percent of the cohorts with at least 6 dead.

For horned larks, a low sensitivity assumption yields no predicted mortality. Medium sensitivity assumptions regarding ChemX toxicity in horned lark, led to an average predicted mortality of about 3 dead birds in 20-bird cohorts, with approximately 95 percent of the cohorts having at least 1 dead bird and the upper 5 percent of the cases having at least 6 out of 20 dead birds. The high sensitivity assumption resulted in predicted mortalities of at least 14 out of 20 birds in 95 percent of the cases simulated, average mortality was 17 out of 20 and complete mortality predicted in about 95 percent of the simulations.

The other species modeled without species-specific toxicity data (killdeer, vesper sparrow, eastern meadowlark, and mourning dove) show predicted mortality levels intermediate to the western meadowlark and horned lark, with low sensitivity assumptions yielding no mortality and high sensitivity showing 27 to 47 percent fatality rates.

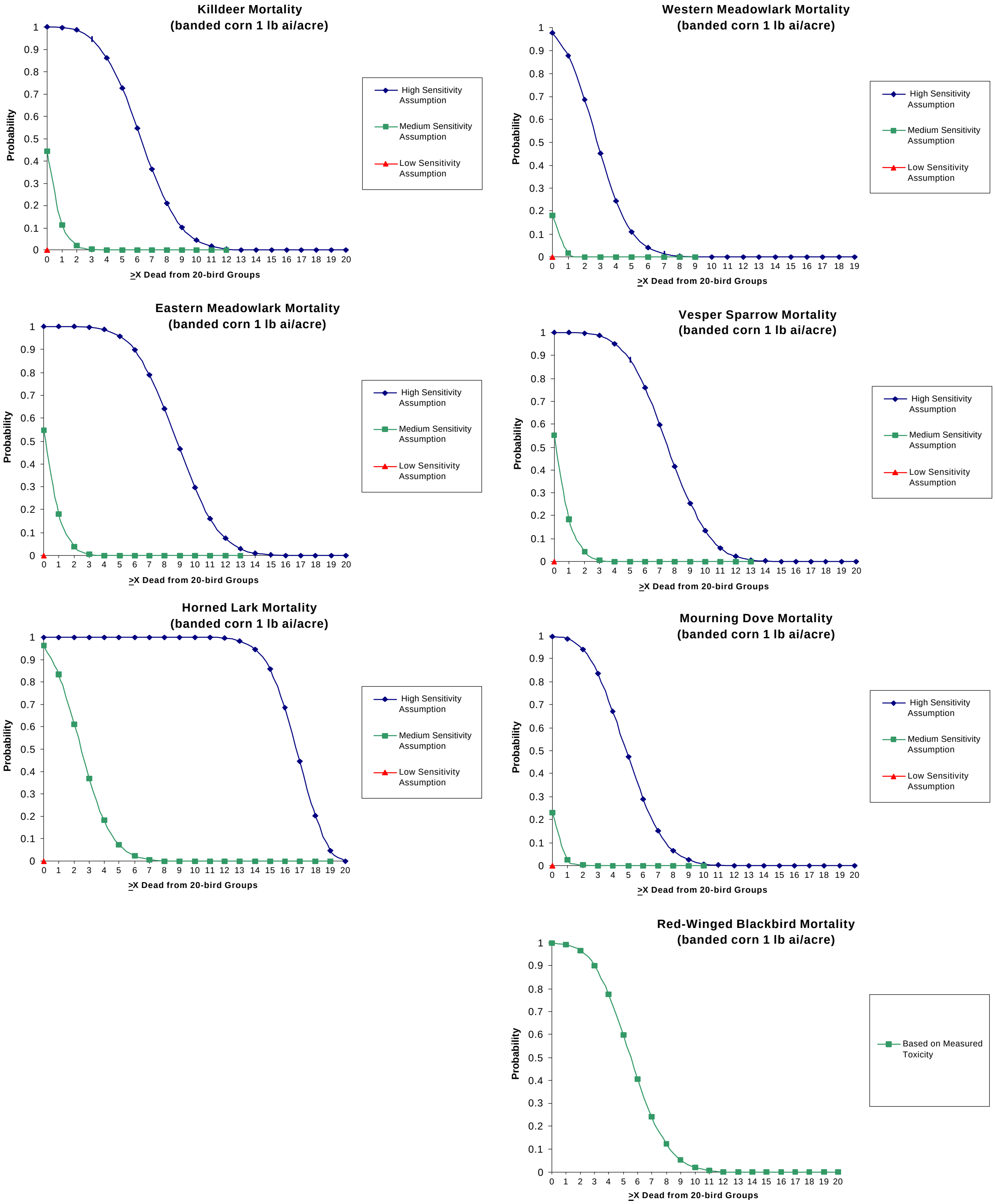
As discussed earlier in the document, the wide variation in mortality predictions for different sensitivity assumptions can be traced to the uncertainty regarding a particular species' true sensitivity to ChemX. However, toxicity data are available for the red-winged blackbird, which reduces the uncertainty of the risk assessment model mortality predictions for this species.

Table 20. ChemX Banded Application to Midwest Corn (1 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
K	34	45	10	3	5	0	0	0	0
HL	86	100	70	15	30	5	0	0	0
VS	40	60	25	4	10	0	0	0	0
MD	27	45	10	1	5	0	0	0	0
RWB				30	45	15			
EM	47	65	30	4	10	0	0	0	0
WM	17	30	5	1	5	0	0	0	0

K	killdeer
HL	horned lark
VS	vesper sparrow
MD	mourning dove
RWB	red-winged blackbird
EM	eastern meadowlark
WM	western meadowlark

Figure 8. Banded Corn 1 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



The predicted mean mortality for this species is 30 percent (6 dead in a 20 bird cohort). At least 3 birds are predicted to die in 95 percent of the 20-bird cohorts modeled. Five percent of the cohorts were predicted to experience at least 9 deaths.

Figure 9 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 60 percent of species have a predicted mean mortality greater than 0. Approximately 33 percent of the species have a predicted mortality of at least 10 percent (2 of 20), with less than 5 percent of the species exhibiting 70 percent mortality or more. Regarding the red-winged blackbird (the species with least sensitivity uncertainty), the mean mortality prediction lies approximately at the 85th percentile of the distribution (i.e., 15 percent of the species are likely to be more severely impacted than the red-winged blackbird).

These results suggest that, at the labeled application rate for banded ChemX use on corn, less than half of the species have minimal impacts (mortality *ca.* 0 percent). The majority of species are experiencing some mortality and these mortalities may be quite severe (70 percent or greater) for only the most sensitive species.

In-Furrow Application to Corn (1 lb ai/acre)

In-furrow application risk assessment results (Table 21 and Figure 10) were comparable to the banded application results. The least impacted species, western meadowlark, shows low risks of mortality. An assumption of a low toxic sensitivity results in no predicted mortality. An assumption of medium toxic sensitivity results in 83 percent of simulations of 20-bird cohorts having zero to one mortality, mean mortality risk is less than 1 of 20, and 5 percent of 20-bird cohorts will have 1 or more dead birds with an upper limit (very rare occurrence) of predicted mortality of 8 out of 20. A high sensitivity assumption leads to a percent prediction of at least one death in each 20-bird group for about 90 percent of cohorts; mean mortality of 4 out of 20; and 5 percent of all simulations with 6 or more deaths.

Horned lark mortalities under this scenario were also comparable to banded treatments. No mortality was predicted if a low sensitivity assumption was made. Mortality was frequent and extreme under the medium and high sensitivity assumptions. Medium sensitivity assumptions regarding ChemX toxicity in horned larks, led to an average predicted mortality of about 4 dead birds in 20-bird cohorts, with approximately 95 percent of the cohorts having at least 1 dead bird and the upper 5 percent of the cases having at least 6 out of 20 dead birds. The high sensitivity assumption resulted in predicted mortalities of at least 14 out of 20 birds in 95 percent of the cases simulated, average mortality was17 out of 20 and 19 dead out of 20 predicted in about 5 percent of the simulations.

The other species modeled without species-specific toxicity data (killdeer, vesper sparrow, eastern meadowlark, and mourning dove) show predicted mortality levels intermediate to the western meadowlark and horned lark, with low sensitivity assumptions yielding no mortality and

Figure 9. Distribution of Predicted Mortality Outcomes
(banded application to corn 1 lb/ai/acre)

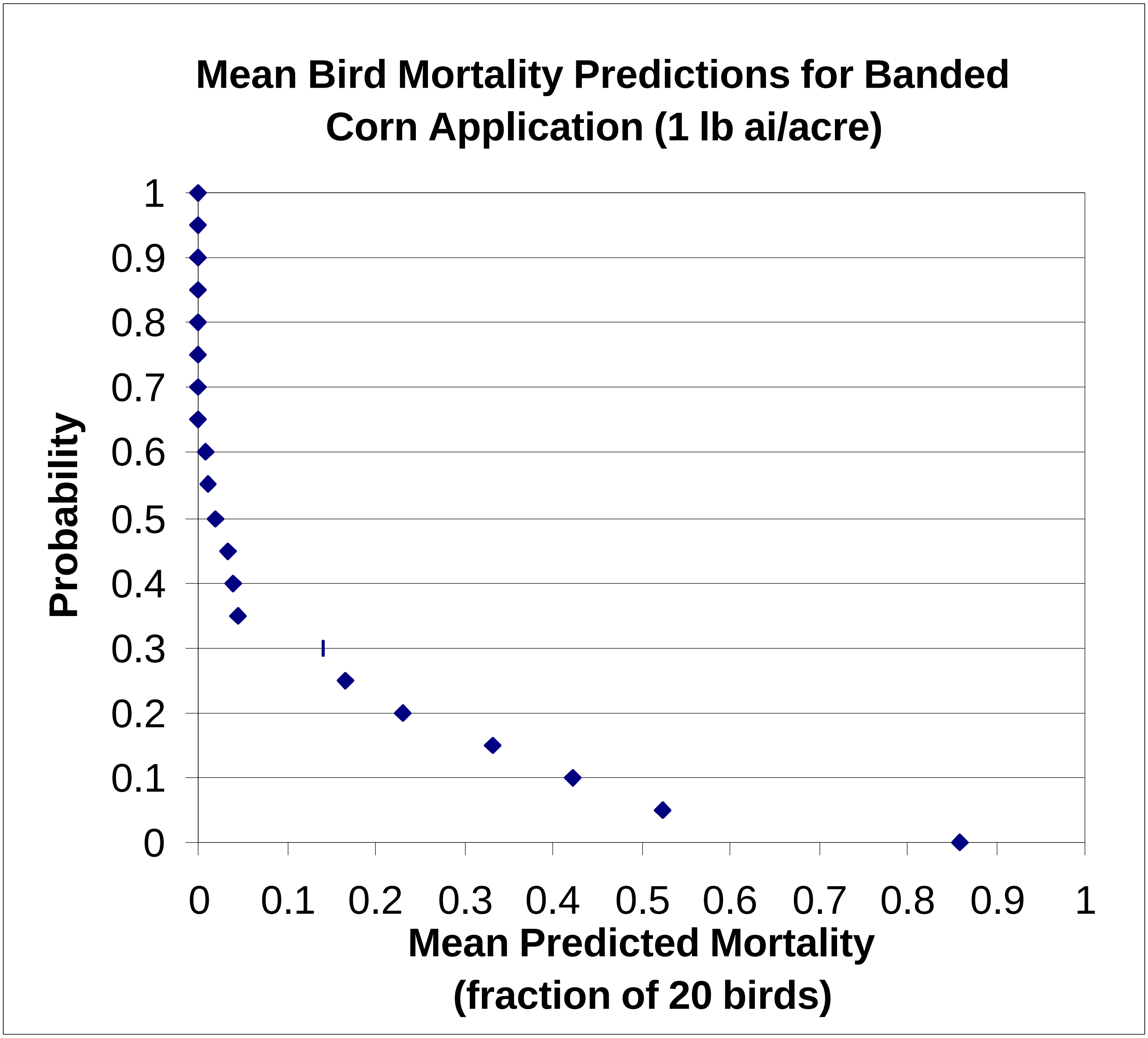
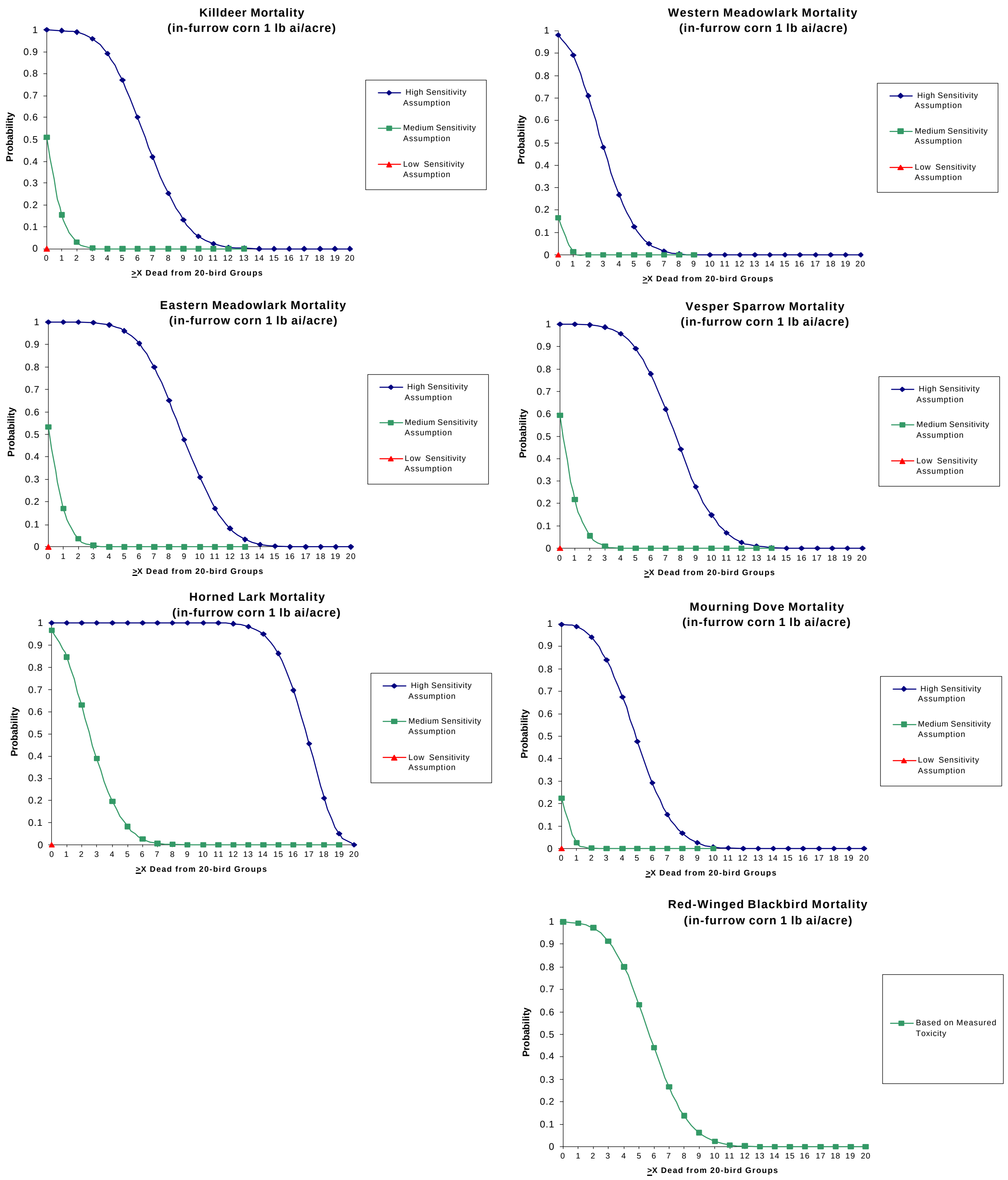


Table 21. ChemX In-Furrow Application to Midwest Corn (1 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
K	36	55	20	4	10	0	0	0	0
HL	86	95	70	16	30	5	0	0	0
VS	41	60	25	4	15	0	0	0	0
MD	27	45	10	1	0	5	0	0	0
RWB				31	50	15			
EM	47	65	30	4	10	0	0	0	0
WM	18	30	5	1	5	0	0	0	0

K	killdeer
HL	horned lark
VS	vesper sparrow
MD	mourning dove
RWB	red-winged blackbird
EM	eastern meadowlark
WM	western meadowlark

Figure 10. In-Furrow Corn 1 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



high sensitivity showing 27 to 47 percent fatality rates.

As discussed earlier in the document, the wide variation in mortality predictions for different sensitivity assumptions can be traced to the uncertainty regarding a particular species' true sensitivity to ChemX. However, toxicity data are available for the red-winged blackbird, which reduces the uncertainty of the risk assessment model mortality predictions for this species. The predicted mean mortality for this species is 31 percent (6 dead in a 20 bird cohort). At least 3 birds are predicted to die in 95 percent of the 20-bird cohorts modeled. Five percent of the cohorts were predicted to experience at least 10 deaths.

Figure 11 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 70 percent of species have a predicted mean mortality greater than 0. Approximately 37 percent of the species have a predicted mortality of at least 10 percent (2 of 20), with less than 5 percent of the species exhibiting 70 percent mortality or more. Regarding the red-winged blackbird (the species with least sensitivity uncertainty), the mean mortality prediction lies approximately at the 80th percentile of the distribution (i.e., 20 percent of the species are likely to be more severely impacted than the red-winged blackbird).

These results suggest that, at the labeled application rate for banded ChemX use on corn, less than half of the species have minimal impacts (mortality *ca.* 0 percent). The majority of species are experiencing some mortality and these mortalities may be quite severe (70 percent or greater) for the most sensitive species.

Acute Avian Risks Associated with Aerial ChemX Applications to Alfalfa

Applications of ChemX were modeled for five species and for three rates by aerial application methods. Two species define the extremes of risk assessment results. The granivorous mourning dove consistently proved to be the least impacted species modeled. The omnivorous grasshopper sparrow was consistently the species with highest predicted risks. To simplify the discussion of results, the following sections discuss the risk assessment results for mourning doves and grasshopper sparrows, with the understanding that results for other modeled species fall within the results for these two.

Aerial Application to Alfalfa (0.125 lb ai/acre)

Predicted mortalities in mourning doves are highly dependent upon assumption of relative sensitivity of the species to ChemX (Table 22 and Figure 12). For both an assumption of low sensitivity and medium sensitivity, no significant mortality is predicted. However, under an assumption of high sensitivity to ChemX, mean mortality in 20-bird cohorts is predicted to be approximately 1 bird. In approximately 5 percent of simulations of 20-bird cohorts, mortality is predicted to be 2 birds or more, with a maximum of 12 in 20 under extremely rare occasions.

Grasshopper sparrow mortality predictions are greater under some assessment assumptions than for mourning doves. However, there was no significant risk of mortality in 20-bird cohorts

Figure 11. Distribution of Predicted Mortality Outcomes (in-furrow application to corn 1 lb/ai/acre)

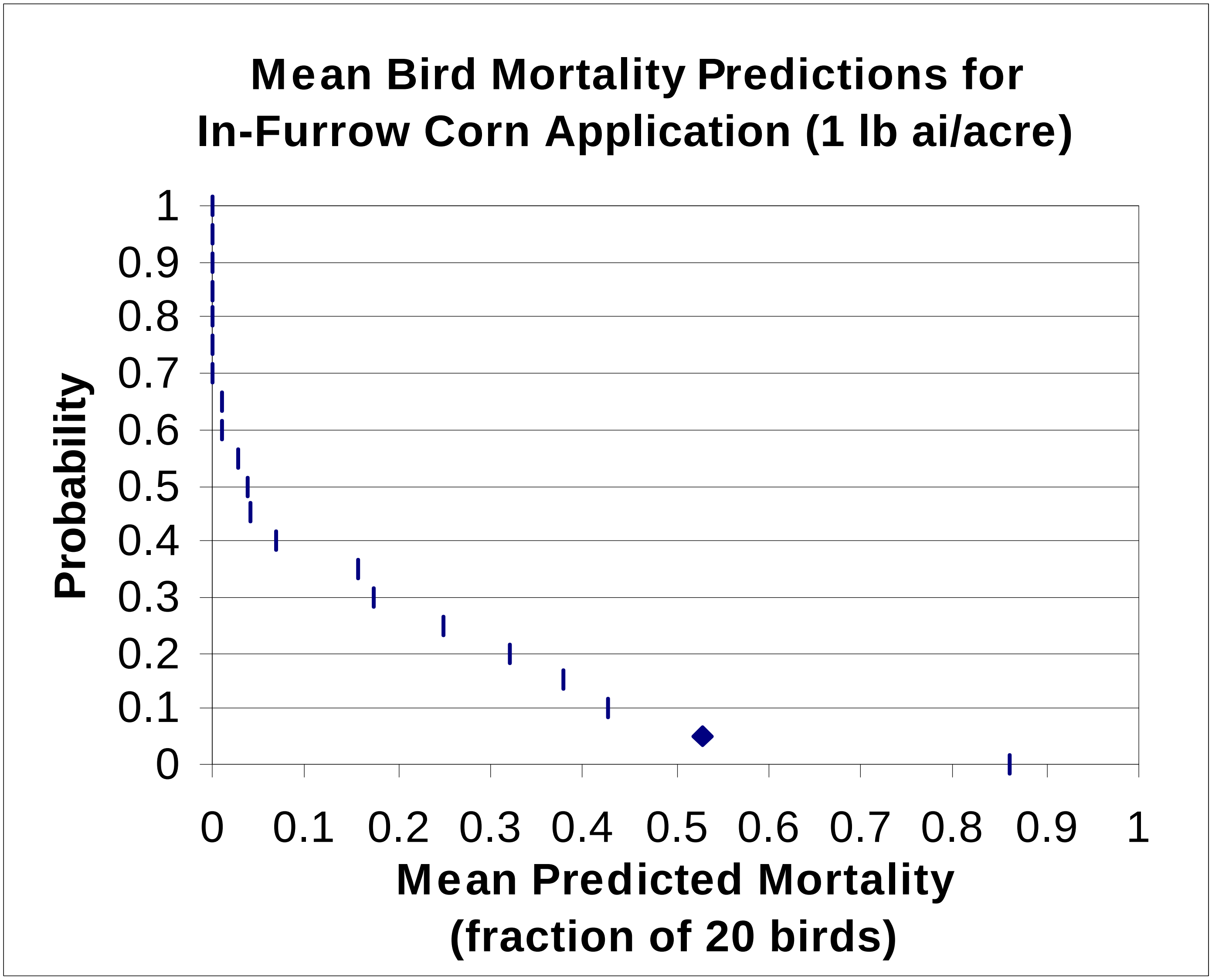
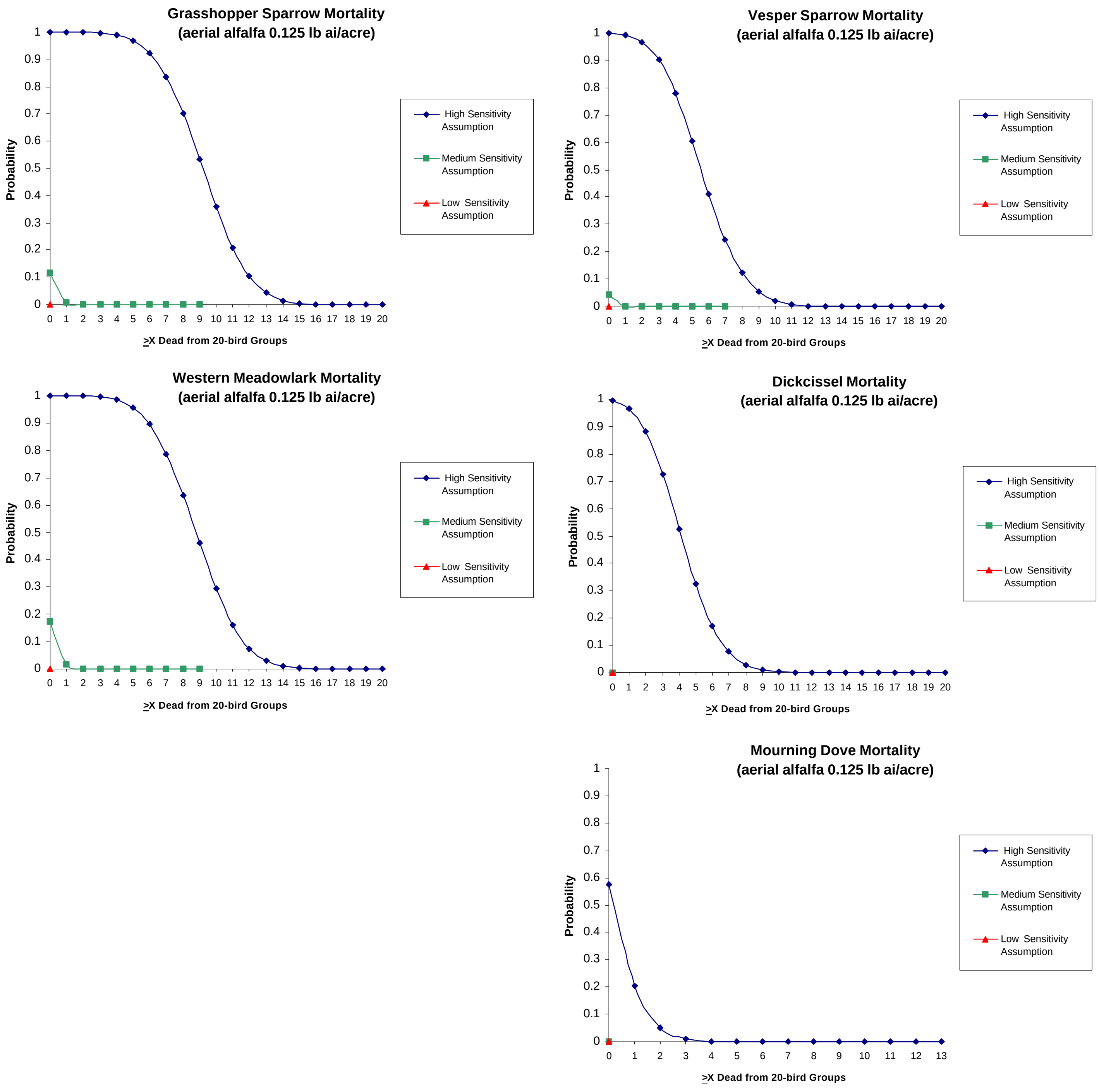


Table 22. ChemX Aerial Application to Midwest Alfalfa (0.125 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Drinking Water from Dew (no puddles on the field)									
D	24	40	10	0	0	0	0	0	0
WM	46	65	30	1	5	0	0	0	0
GS	48	65	30	1	5	0	0	0	0
MD	4	10	0	0	0	0	0	0	0
VS	31	45	15	0	0	0	0	0	0
Drinking Water from Puddles on the Day of Application									
D	23	40	10	1	5	0	0	0	0
WM	47	65	30	2	5	0	0	0	0
GS	47	65	30	1	5	0	0	0	0
MD	4	10	0	0	0	0	0	0	0
VS	30	45	15	1	5	0	0	0	0
Drinking Water from Puddles on the Day After Application									
D	25	40	10	0	5	0	0	0	0
WM	50	65	30	1	5	0	0	0	0
GS	49	65	30	1	5	0	0	0	0
MD	5	15	0	0	0	0	0	0	0
VS	34	50	15	0	5	0	0	0	0

D	dickcissel
WM	western meadowlark
GS	grasshopper sparrow
MD	mourning dove
VS	vesper sparrow

Figure 12. Aerial Alfalfa 0.125 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



predicted under an assumption of low bird sensitivity to ChemX. A medium sensitivity assumption led to predicted mortality greater than 0 in 20 for 11 percent of the sparrow cohorts, but only 5 percent of the cohorts had mortalities greater than 2. Mean mortality under an assumption of high sensitivity to ChemX was predicted to be 10 in 20 , with 95 percent of the cases involving 6 or more deaths and an upper 5 percent of the cases involving 13 deaths or more.

The other species modeled without species-specific toxicity data (dickcissel, vesper sparrow, and western meadowlark) show predicted mortality levels intermediate to the mourning dove and grasshopper sparrow, with low sensitivity assumptions yielding no mortality and high sensitivity showing 24 to 46 percent fatality rates.

Figure 13 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 55 percent of species have a predicted mean mortality risk greater than 0. Approximately 27 percent of the species have a predicted mortality of at least 10 percent (2 of 20) and mortality was never predicted to be greater than 50 percent (10 of 20) for any species.

These results suggest that, at the minimum application rate for aerial ChemX use on alfalfa, less than half of the species have minimal impacts (mortality *ca.* 0 percent). More than half of species are experiencing some mortality and these mortalities may be as severe as 48 percent.

Aerial Application to Alfalfa (0.5 lb ai/acre)

As can be expected, mortality risks with ChemX applied to alfalfa at 0.5 lb ai/acre (Table 23 and Figure 14) were predicted to be greater than at the 0.125 lb ai/acre rate. Nevertheless, mortality was not predicted in mourning doves under a low sensitivity assumption. An assumption of medium sensitivity resulted in only slight mortality, with a mean predicted death rate of 1 in 20 and only 5 percent of simulated cohorts having greater than 1 mortality. Assuming high sensitivity resulted in 95 percent of simulated cohorts showing at least 2 deaths, a mean mortality of 5 deaths, and 5 percent of the simulations having 8 or more deaths.

Grasshopper sparrow mortality was not predicted for simulations conducted under an assumption of low sensitivity to ChemX. Mortality predictions for a medium sensitivity assumption included at least 2 deaths in 95 percent of 20-bird cohorts, mean mortality predicted to be 3 birds per 20, and mortality equal to or greater than 9 birds in 20 for 5 percent of the simulations. A high sensitivity assumption led to predicted mortality of at least 9 dead birds for 95 percent of the 20-bird cohorts simulated. Mean mortality was predicted to be 17 of 20 birds and complete mortality was predicted for 5 percent of the cases simulated.

The other species modeled without species-specific toxicity data (dickcissel, vesper sparrow, and western meadowlark) show predicted mortality levels intermediate to the mourning dove and grasshopper sparrow, with low sensitivity assumptions yielding no mortality and high sensitivity showing 63 to 87 percent fatality rates.

Figure 13. Distribution of Predicted Mortality Outcomes (aerial application to alfalfa 0.125 lb/ai/acre)

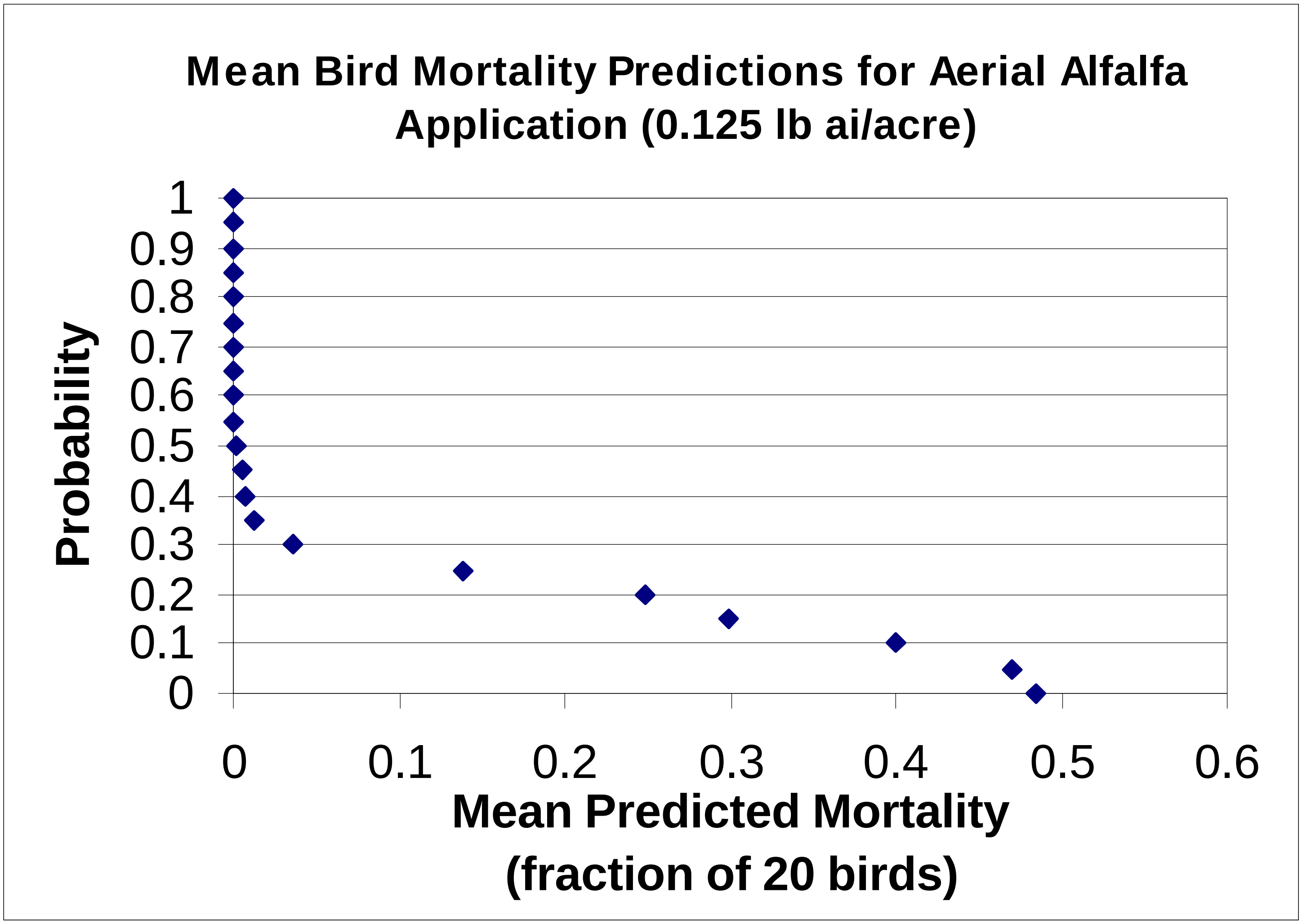
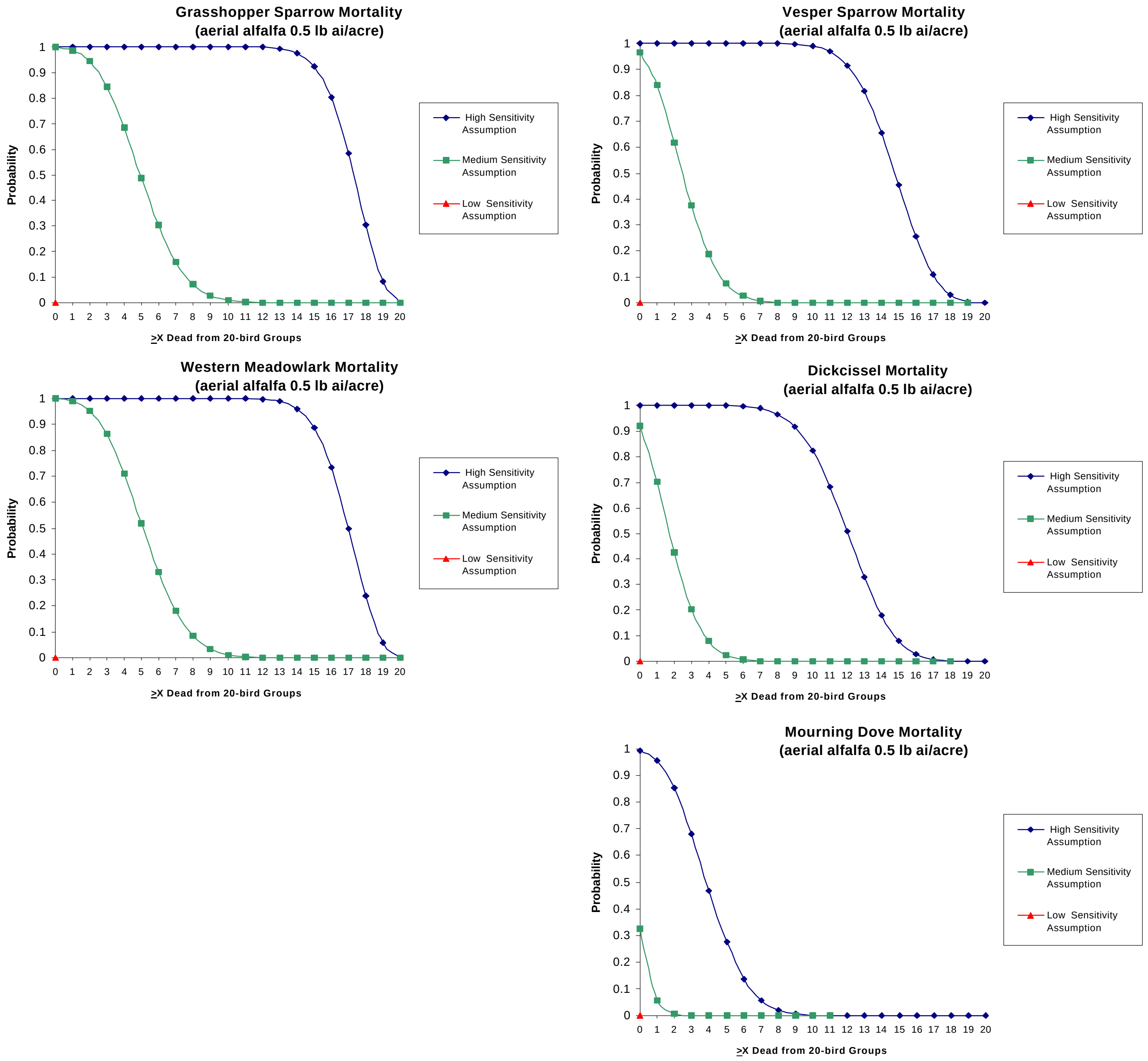


Table 23. ChemX Aerial Application to Midwest Alfalfa (0.5 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Drinking Water from Dew (no puddles on the field)									
D	63	80	45	12	25	0	0	0	0
WM	87	100	75	28	45	15	0	0	0
GS	88	100	75	28	45	10	0	0	0
MD	22	40	10	2	5	0	0	0	0
VS	76	90	60	15	30	5	0	0	0
Drinking Water from Puddles on the Day of Application									
D	63	80	45	12	25	0	0	0	0
WM	87	100	75	28	45	15	1	5	0
GS	88	100	75	28	45	10	0	5	0
MD	21	35	10	2	5	0	0	0	0
VS	76	90	60	16	30	5	0	5	0
Drinking Water from Puddles on the Day After Application									
D	64	80	45	14	25	0	0	0	0
WM	88	100	75	31	50	15	0	5	0
GS	89	100	75	30	45	15	0	0	0
MD	24	40	10	3	10	0	0	0	0
VS	77	90	70	18	30	5	0	0	0

D	dickcissel
WM	western meadowlark
GS	grasshopper sparrow
MD	mourning dove
VS	vesper sparrow

Figure 14. Aerial Alfalfa 0.5 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)



Grasshopper Sparrow Mortality (aerial alfalfa 0.5 lb ai/acre)

Vesper Sparrow Mortality (aerial alfalfa 0.5 lb ai/acre)

Western Meadowlark Mortality (aerial alfalfa 0.5 lb ai/acre)

Dickcissel Mortality (aerial alfalfa 0.5 lb ai/acre)

Mourning Dove Mortality (aerial alfalfa 0.5 lb ai/acre)

Figure 15 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 70 percent of species have a predicted mean mortality risk greater than 0. Approximately 57 percent of the species have a predicted mortality of at least 10 percent (2 of 20), with 17 percent of the cohorts exhibiting 70 percent mortality or greater.

These results suggest that, at the typical application rate for aerial ChemX use on alfalfa, less than a third of the species have minimal impacts (mortality *ca.* 0 percent). More than two thirds of species are experiencing some mortality and these mortalities may be quite severe (70 percent or greater) for the more sensitive species.

Aerial Application to Alfalfa (1 lb ai/acre)

ChemX application at 1 lb ai/acre results are summarized in Table 24 and Figure16. These results suggest that mortality in many bird species may be high under some sensitivity assumptions following ChemX application at this rate. As with other application scenarios, a low sensitivity assumption for mourning doves results in no predicted mortality in 20-bird cohorts. Assumption of medium sensitivity results in a mean mortality prediction of 2 dead in 20, with about 5 percent of all cohorts under the medium sensitivity assumption predicted to suffer at least 3 mortalities. An assumption of high sensitivity to ChemX resulted in mortality predictions in mourning doves where 95 percent of the 20-bird cohorts exhibit at least 3 dead birds, an average of 7 dead birds, and 5 percent of cohorts showing at least 10 dead birds.

Low grasshopper sparrow mortality was predicted for simulations conducted under an assumption of low sensitivity to ChemX with only 5 percent of the cohorts showing at least 1 dead bird out of 20. Mortality predictions for a medium sensitivity assumption included at least 8 deaths in 95 percent of 20-bird cohorts, mean mortality predicted to be 12 birds per 20, and mortality equal to or greater than 16 birds in 20 for 5 percent of the simulations. A high sensitivity assumption led to predicted mortality of at least 16 dead birds for 95 percent of the 20-bird cohorts simulated. Mean mortality was predicted to be 18 of 20 birds and complete mortality was predicted for 5 percent of the cases simulated.

The other species modeled without species-specific toxicity data (dickcissel, vesper sparrow, and western meadowlark) show predicted mortality levels intermediate to the mourning dove and grasshopper sparrow, with low sensitivity assumptions yielding minimal mortality (0 to 10 percent) and high sensitivity showing 73 to 92 percent fatality rates.

Figure 17 presents the distribution of mean population mortality rates derived from the focal species which are assumed to constitute a representative sample of all species potentially exposed. This figure indicates that 95 percent of species have a predicted mean mortality risk greater than 0. Approximately 62 percent of the species have a predicted mortality of at least 10 percent (2 of 20), with 23 percent of the cohorts exhibiting 70 percent mortality or greater.

Figure 15. Distribution of Predicted Mortality Outcomes
(aerial application to alfalfa 0.5 lb/ai/acre)

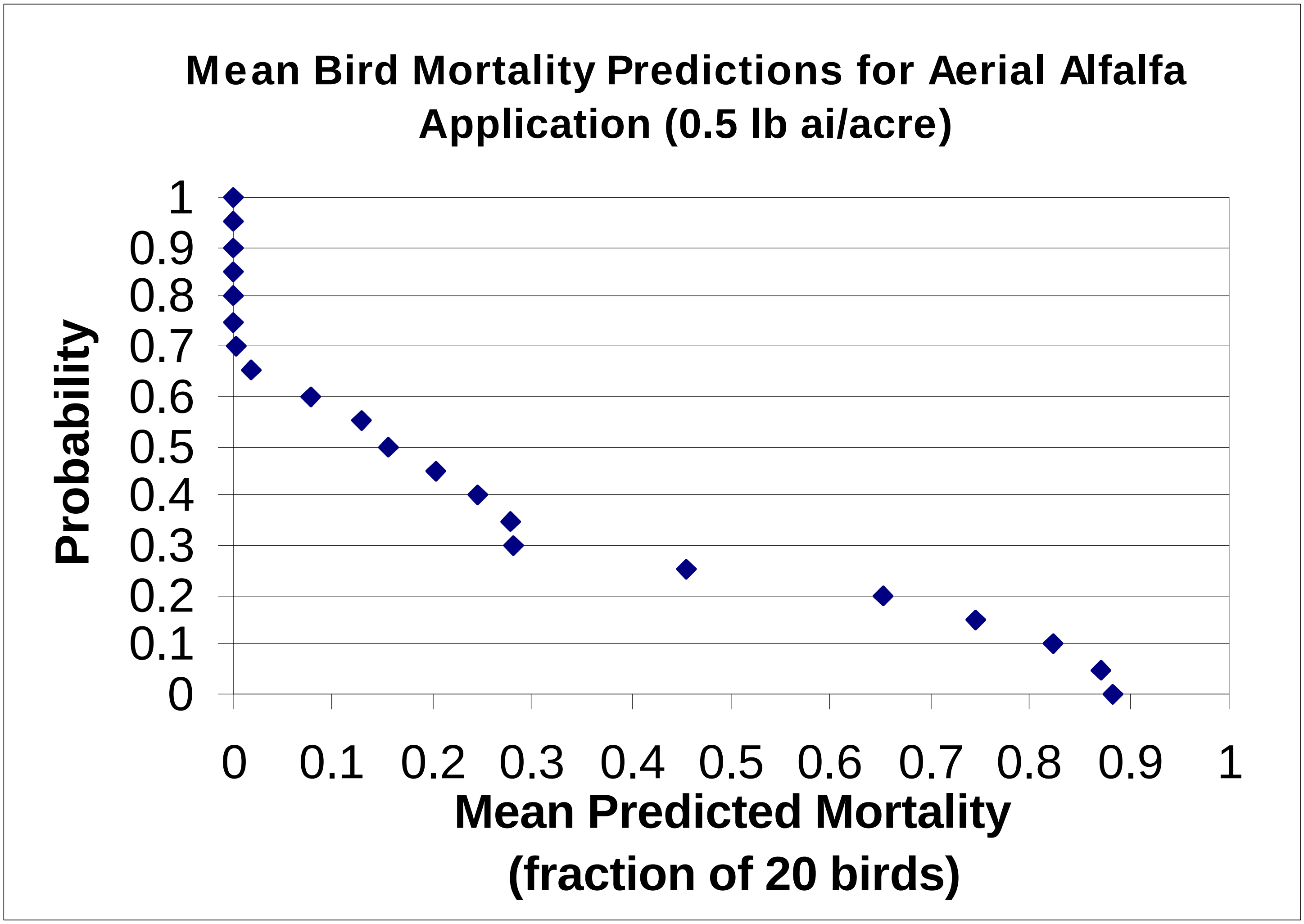


Table 24. ChemX Aerial Application to Midwest Alfalfa (1 lb/ai/acre)

	Population Mortality% (cohorts of 20 birds)								
	High sensitivity Assumption			Medium Sensitivity Assumption			Low Sensitivity Assumption		
Species	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Drinking Water from Dew (no puddles on the field)									
D	73	90	55	32	50	15	1	5	0
WM	92	100	80	60	75	40	2	10	0
GS	93	100	80	61	80	40	2	5	0
MD	33	50	15	7	15	0	0	0	0
VS	84	95	70	43	60	25	0	5	0
Drinking Water from Puddles on the Day of Application									
D	72	90	55	32	50	15	1	5	0
WM	92	100	80	60	80	40	3	10	0
GS	88	100	75	61	80	40	3	10	0
MD	32	50	15	6	15	0	0	0	5
VS	84	95	70	41	60	25	0	5	0
Drinking Water from Puddles on the Day After Application									
D	73	90	55	34	50	2	1	5	0
WM	92	100	80	62	80	45	3	10	0
GS	92	100	80	63	80	45	2	10	0
MD	34	50	15	8	20	0	1	5	0
VS	84	95	70	46	65	30	0	5	0

D	dickcissel
WM	western meadowlark
GS	grasshopper sparrow
MD	mourning dove
VS	vesper sparrow

Figure 16. Aerial Alfalfa 1 lb ai/acre Mortality Predictions (rounded to nearest bird of 20-bird groups)

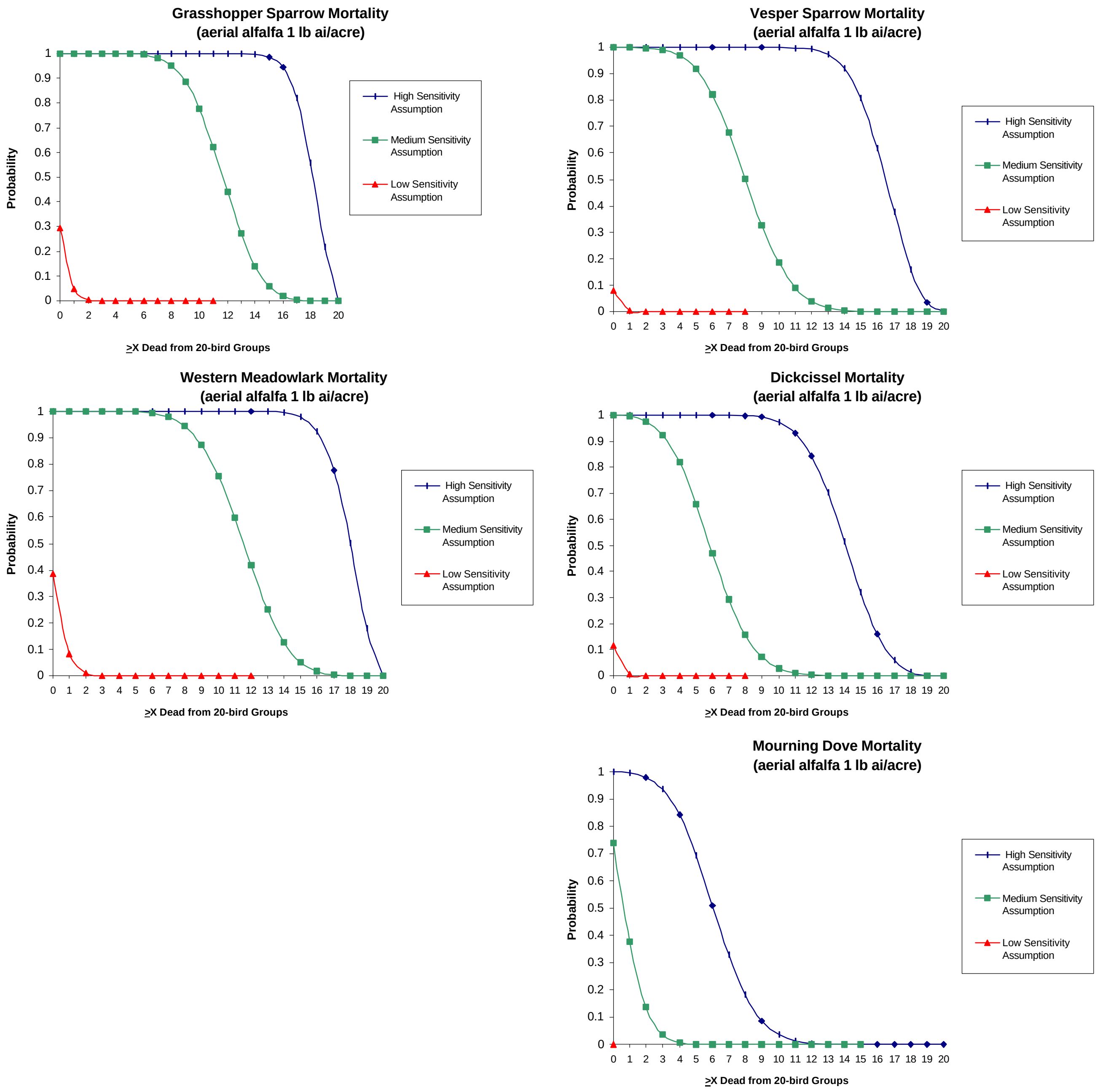
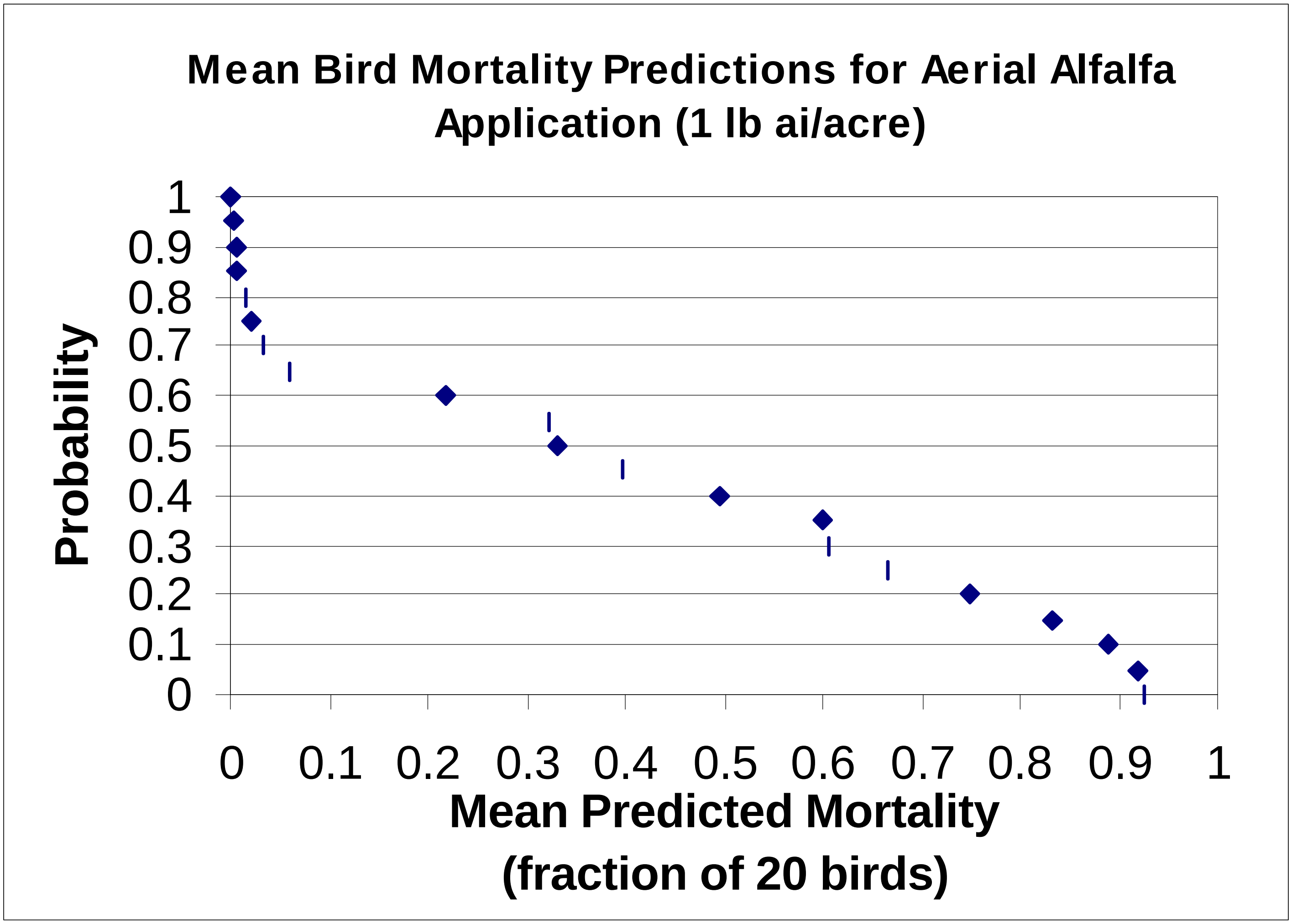


Figure 17. Distribution of Predicted Mortality Outcomes
(aerial application to alfalfa 1 lb/ai/acre)



These results suggest that, at the maximum labeled application rate for aerial ChemX use on alfalfa, less than a twentieth of the species have minimal impacts (mortality *ca.* 0 percent). More than 80 percent of species are experiencing some mortality and these mortalities may be frequently severe (70 percent or greater).

Modified Model Assessment: Risks to Mallard Duck Immediately Following ChemX Application to Alfalfa

As was discussed in the problem formulation section of this document, there a number of documented incidents of waterfowl mortality following treatment of alfalfa fields with ChemX. Because of an expected high degree of mobility for waterfowl, EFED has modeled exposure for the waterfowl focal species (mallard duck) as a short-term stochastic phenomenon. Therefore the model considered exposures for discrete time periods after pesticide application and did not include drinking water exposures. As for red-winged blackbirds, the availability of ChemX acute toxicity data for the mallard precluded the need to assume a range of sensitivity to the pesticide. Table 25 and Figure 18 present the results of the risk assessment for mallards at all three application rate scenarios employed elsewhere for alfalfa. Four time intervals after application were examined: immediately, 3 days, 6 days, and 12 days.

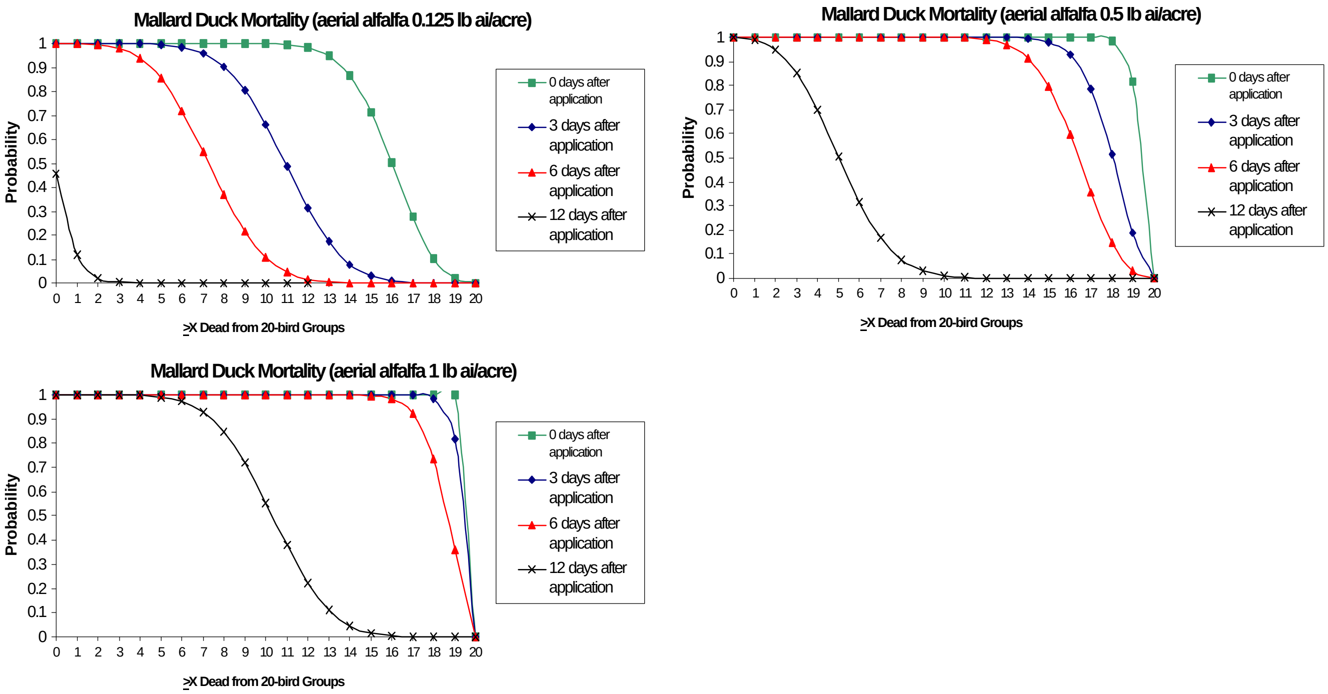
At all application rates, a high level of mean mortality for 20-bird cohorts was predicted. For birds immediately entering fields treated with ChemX, the low application rate yielded 82 percent mortality (approximately 17 dead out of 20). Complete mortality was predicted for the next two higher application rates. Ducks entering the field 3 days after application are predicted to exhibit a mean mortality rate of 57 percent (11 dead in 20), for the low rate of application. For higher application rates mean mortality was predicted to be 92 percent for the typical application rate and 99 percent at the maximum labeled rate. Entering the field 6 days after application resulted in a mean mortality rate of 39 percent at the low application rate, 84 percent at the typical application rate, and 95 percent at the labeled maximum rate. Mallards entering the field twelve days after ChemX application are predicted to exhibit low mortality (3%) at the lowest application rate, 28 percent mortality at the typical rate, and 54 percent at the labeled maximum application rate.

Although alfalfa fields are known to be used by waterfowl (e.g., incident data for waterfowl mortality in treated alfalfa), predicting the numerical probability of mallard flocks or other waterfowl flocks entering treated alfalfa fields is beyond the scope of this level of probabilistic risk assessment. However, should such events occur within a week of application of ChemX, there is no application rate employed that avoids high levels of mortality. Should mallards enter the field up to approximately two weeks after pesticide application, only the ChemX residues at the lowest application rate appear to have declined to a level that does not induce high mortality. Establishing the frequency of such events would require the generation and analysis of field data.

Table 25. Mallard Duck Mortality for ChemX Application to Alfalfa (no drinking water considered)

Days After Application	Population Mortality% (cohorts of 20 birds)								
	0.125 lb ai/acre			0.5 lb ai/acre			1 lb ai/acre		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
0	82	95	65	99	100	95	100	100	100
3	57	75	40	92	100	80	99	100	95
6	39	55	20	84	95	75	95	100	85
12	3	10	0	28	45	10	54	70	35

Figure 18. Modified Model Scenario:
Mallard Duck Mortality for Aerial ChemX Applications to Alfalfa



SENSITIVITY ANALYSIS

The construct of the model does not readily lend itself to sensitivity analysis using the packaged tools from the software employed to build the model. This is because of the aggregation of a number of the variables used to quantify the exposure estimates. Future model refinements will include a more focused effort to allow for a more complete sensitivity analysis. However, EFED did use multiple simulations to estimate the sensitivity of model output to some variables. These variables include: (1) interspecies sensitivity to ChemX, (2) time step assumptions for exposure analysis, (3) frequency of birds in treated fields T_f , and (4) contribution of drinking water exposures to species mortality predictions.

Interspecies Sensitivity to ChemX

As discussed earlier in the Effects Modeling and Results and Discussion sections of the document, this probabilistic risk assessment addresses uncertainty regarding the true species-specific sensitivity to ChemX by creating multiple assessment scenarios. The scenarios were conducted under assumptions of low, medium, and high ChemX sensitivity. As the results indicate, the relative position of a particular species on the distribution curve of sensitivity to ChemX has marked impact on the predicted mortality output of the model. The mortality predictions, in some cases, range as widely as no mortality to complete mortality. This high degree of uncertainty precludes, in the absence of actual species-specific toxicity data, definitive conclusions as to the impact of ChemX on a single discrete species. However, results for species with toxicity data indicated significant mortality events were likely, depending upon application rate and method. Furthermore, analysis of all mean mortality predictions across species and sensitivity assumptions suggests that significant mortality events are likely for a large number of species.

In order to establish more definitive estimates of potential mortality in a particular species, additional toxicological investigation for that species would be required. Modification of existing toxicity testing methods to better mimic exposure and environmental conditions in the field also appears warranted. The focus of this assessment on the acute single oral lethal dose study introduces uncertainty into establishing a dose response relationship for birds under field conditions as it does not consider of the impacts of dietary matrix and rate of ingestion on the sensitivity of a species to ChemX.

Time Step Assumptions for Exposure Analysis

The discussion of the exposure model has indicated that two daily time steps were incorporated into the exposure assessment. Under the model construct, ingestion and elimination of ChemX was evenly distributed across these two daily time steps. The net effect of this construct is that half of daily food and water requirements are fulfilled in each time step. This argues for a protracted exposure period in each time step (ca. 12 hours), and there is uncertainty as to the applicability of such protracted exposure to be compared with toxicity estimates derived from a oral dose study.

It is possible that some birds will feed over the course of an entire time step. These birds could be assumed to ingest food and ChemX residues at minute-by-minute rate that merely involves half the daily rate divided by 720 minutes. ChemX elimination is assumed in this model to be occurring at a rate similar to that reported for chickens, but expressed for the length of the time step. However, other species may actually limit their feeding period within a particular time step to a much shorter period than the entire twelve hours allotted. These later cases would therefore involve higher feeding rates over shorter periods (e.g., the half-day ingestion rate divided by a factor of less than the full 720 minutes in the time step), with elimination occurring over the whole time step.

EFED investigated the net effect of differing ingestion rates for a time step on the maximum body burden of ChemX within the time step. This was accomplished through the application of the following mass balance model.

$$BB = \left[\left(1 - e^{-(ER)(T_{avg})}\right)\left(IR_{effective}\right)\right] \div \left[ER\right]$$

Where: BB is the maximum body burden of ChemX in the bird over the time step (ug/bird)

ER is the ChemX elimination rate derived from the 24-hour elimination rate for chickens adjusted on a minute-by minute basis (0.000129 unitless)

T_{avg} is the ingestion period averaging time within a time step (minutes)

$IR_{effective}$ is the effective time step ingestion rate (total time step ingestion rate divided by the averaging time, ug/bird/minute)

For this exercise, EFED used the red-winged blackbird LD50 value of 0.422 ug/g-bw and a body weight of 52.55 g to yield a total time step ingestion rate target of 0.022176 ug/bird. This total time step ingestion rate is then averaged over different averaging times to yield a series of $IR_{effective}$ values. These are then used to calculate, with the above formula, the maximum body burden of ChemX on a minute-by-minute basis. Table 26 presents these results. For all feeding durations considered, the peak body burden calculated ranged from 0.02167 to 0.02218 ug/bird. Therefore, the actual averaging time assumed for birds feeding within a particular time step appears to be of limited importance for time steps of 12 hours or less. More importantly, the body burdens do not appear to be greatly different from the instantaneous dose assumed for a corresponding toxicity endpoint. That is, if the current exposure model predicted a time step ingestion rate equivalent to a bird LD50, the actual instantaneous body burden of ChemX, regardless of averaging time, is approximately equivalent to the dose assumed from the toxicity study.

Table 26. Predicted Maximum Body Burdens (BB) of ChemX for Different Ingestion Averaging Times (T_{avg}) and a Total Time Step Ingestion Rate ($IR_{effective}$) Equivalent to Red-Winged Blackbird LD50 (0.022176 ug/bird)

	T_{avg}= 720 min.	T_{avg} = 360 min.	T_{avg} = 180 min.	T_{avg} = 60 min.	T_{avg} = 30 min.	T_{avg} = 1 min.
$IR_{effective}$ (ug/bird/min.)	3.08 E-05	6.16 E-05	1.23 E-04	3.70 E-04	7.39 E-04	2.22 E-02
ER (unitless)	0.000129	0.000129	0.000129	0.000129	0.000129	0.000129
BB (ug/bird)	0.02177	0.02167	0.02192	0.02209	0.02213	0.02218

Frequency of Birds in Treated Fields T_f

EFED investigated the frequency of birds in treated fields (**T_f**) variable contributes to the observed differences between low impacted and high impacted focal species within a model scenario. One of the initial variables that appeared to affect model outcomes for biologically similar species was the reported distribution for frequency of birds in the treated field T_f.

EFED considered model scenarios for the lowest and highest impacted focal species on corn (mourning dove and killdeer). The mean T_f for these species in the risk assessment model represented distributions for this variable that were skewed to the right and left. In order to assess the extent to which alternative values for T_f could influence model outcomes, EFED conducted repeat assessment model runs for various ChemX application scenarios, varying the assumed mean for the T_f distribution. Table 27 presents the results of this investigation. The table suggests that model outcome is sensitive to T_f, with mean mortality predictions roughly proportional to the mean T_f selected. Differences in mortality outcomes between the two species, under constraint of a similar T_f assumption, are likely traceable to differences in dietary preferences. For example, the mourning dove (a granivore) has a lower food mass intake than the insectivorous killdeer, primarily due to the relative differences in assimilative energy of the two food sources.

Table 27. The Effects of T_f assumption on Predicted Mean Mortality Outcome

Species	**Mean T_f value**	**Mean Predicted Mortality (%)**
ChemX Aerial Application to Corn 0.75 lb ai/acre (medium sensitivity assumption)		
Mourning dove	0.231 (used in risk assessment)	9
	0.50	22
	0.75	32
Killdeer	0.762 (used in risk assessment)	58
	0.50	42
	0.25	22

Contribution of Drinking Water Exposures to Species Mortality Predictions

As was summarized in the results section of the document, the construct of the model resulted in drinking water source assumptions having minimal impact on predicted mortality. However, the results presented earlier do not provide information on the extent to which drinking water exposures to ChemX, regardless of the source, contribute to predicted mortality. In order to evaluate the contribution of drinking water to predicted mortality, EFED repeated risk assessment model runs for a number of application scenarios, but eliminating the drinking water source entirely from the exposure. These runs were conducted for the mourning dove and killdeer under assumptions of high sensitivity (both species) and medium sensitivity (killdeer only) to ChemX and typical application rate. The medium sensitivity assumption was included for killdeer because the risks from food were so high under the high sensitivity assumption that water contributions could not be assessed.

Recall from the results section that mean mourning dove mortality including water exposure was reported to be 51 percent under the model scenario discussed above. However, with drinking water not considered, mean mortality was 18 percent for the same model scenario; a reduction of 65 percent. For the killdeer, the predicted mortalities, including drinking water exposure were 98 and 58 percent for high and medium sensitivity assumptions, respectively. Without drinking water exposure, killdeer mean mortalities are reduced to 96 percent for the high sensitivity assumption and 42 percent for the medium assumption; respective reductions of 2 and 28 percent. The differences in the contribution of drinking water to overall mortality risk between the mourning dove and killdeer can be traced to dietary differences. The granivorous mourning dove gets little daily water requirement from dietary sources and consequently must consume more drinking water than the insectivorous killdeer.

Depending upon species and sensitivity assumption, drinking water can contribute significantly to the overall predicted mortality risk. Therefore, future refinement of the risk assessment model would benefit from, in some cases, further refinement to the drinking water residue estimation approaches used in this risk assessment.

Assumptions Contributing to Over- or Underestimation of Risk

Day of Application Puddle Drinking Water Scenario and Rainfall

The method used to establish the distribution of ChemX concentrations in puddles directly treated by aerial application of ChemX assumes that the rainfall event preceding the day of application was of sufficient intensity to create puddles up to 3 inches in depth. Such an assumption effectively shifts the distribution of concentrations to lower values because (1) ChemX concentration is inversely related to puddle depth and (2) deeper puddles are assumed to be as frequent on the field as any other lesser puddle depth modeled for the distribution.

Rainfall and Foliar Residues

It may be argued that strong rainfalls associated with puddle formation on a field may also contribute to residue wash-off from vegetation. EFED believes that the field study origins of foliar residue dissipation data used in the exposure model may, in part, account for foliar wash-off by rainfall. However, the meteorological conditions associated with these field studies are not correlated in the model with rainfall events causing puddle formation.

Dietary Intake Model Does Not Account for Gorging Behavior

The dietary intake model used to estimate daily food intake for birds is based on allometric equations for the average daily field metabolic rate. This model therefore predicts the average intake needed to achieve balance with daily caloric requirements. However, ECOFRAM documentation (Kirkwood 1983) indicates that under some situations, birds may consume food in excess of their daily caloric requirements. Such gorging behavior may result in dietary intakes as much as 3 times greater than the daily estimates based on energy requirements. Birds exhibiting gorging behavior would have greater daily ChemX residue intake, and so be at greater risk of mortality than predicted using the present model.

Drift Assumed to be Zero

The exposure model for this risk assessment assumes that environmental media not directly treated with ChemX, or in contact with such treated media, are not contamianted with ChemX. The model assumes zero drift from the treated area, such that if a bird is determined not to occupy the treated area of the field, exposure to ChemX is assumed to be zero. This serves to underestimate potential ChemX exposure and subsequent risk of mortality off the field and within the field in untreated areas. Drift is likely to occur in all spray applications and the amount of drift is a product of a variety of factors related to application method, droplet size spectrum, and environmental conditions. Future exposure models can be enhanced by incorporation of available drift modeling programs such as AgDrift.

Other Routes of Exposure Not Considered

As was stated in the problem formulation sections of this document, the exposure model was limited to certain routes of exposure. These included oral ingestion of ChemX residues via the diet and drinking water. Incidental ingestion of ChemX residues on soil and grit was not considered. Inhalation exposure both from vapor phase ChemX and from intake of respirable droplets/particles during and after treatment was not considered. Dermal exposure from impingement of directly applied material and from contact with treated surfaces was not considered. Oral exposure via preening was also not considered. EFED cannot predict, in the absence of empirical data or mechanistic models, the significance of exposures via these unaccounted for routes. However, it can be assumed that quantitative consideration of these routes, as future modeling capabilities come on line, will increase overall bird exposure and therefore predicted levels of risk.

Additive Damage from Multiple Exposures

The construct of the risk assessment model relies on the peak exposure over the course of a series of time steps. That is, the assessment of individual bird survivorship within a cohort of birds is based on the interpolation of a mortality risk for the highest exposure time step modeled. In this way, risk of mortality for the highest time step is evaluated independently from previous exposure history. Therefore, the model can not account for any potential increase or decrease in susceptibility to ChemX intoxication that occurs at lower dosages from earlier time steps.

Sublethal Effects

By relying on toxicity data derived under laboratory conditions, this risk assessment only considered mortality resulting from ChemX exposure under controlled environmental conditions. As a consequence, the assessment cannot evaluate the potential for additional reduced survivorship as a result of sublethal effects of ChemX. These types of sublethal effects may include increased susceptibility to temperature stress, reduced ability to obtain food, reduced ability to care for offspring, and impaired ability to avoid predation.

Indirect Effects

The problem formulation of this risk assessment indicated that the assessment was concenred with direct toxic effects. As a consequence, the assessment does not evaluate indirect effects of ChemX treatment upon survivorship of individual birds. Such indirect effects may include reduced availability of invertebrate food items and reduced availability of a variety of food items and drinking water as a result conditioned response to avoid chemical contamination.

Organic Carbon Fraction (F_{oc}) Assumption in Modeling Dew Concentrations

As was discussed in the Exposure Model documentation earlier in this report, there are a number of uncertainties associated with the modeling of ChemX water concentrations in dew. One of the parameters that was used for the partitioning model employed for these estimates was the organic carbon fraction for plants. The value selected for this variable was 0.40 (Donahue et al., 1993). This value was for the organic carbon fraction for dry-weight plant matter. Owing to the assumed high water content of fresh weight plant material assumed in other portions of the exposure model, it is likely that the fresh weight organic carbon content of plant material is lower than the 0.40 fraction assumed. If a lower fresh weight carbon fraction was used in the dew concentration partitioning model, the resultant ChemX concentrations in dew would be estimated to be considerably higher than those predicted in the present model runs. However, EFED elected to use the 0.40 value for two reasons:

1. EFED is uncertain of the role of the entire plant tissue mass in the partitioning of ChemX between dew and the plant surface. It is suspected that whatever ChemX adsorption that is taking place on plant surfaces is occurring at some thin boundary layer (eg. the plant cuticle), where the water content in the inner plant tissues is not a consideration. Therefore, adjustment of a dry weight organic carbon fraction for fresh weight water content may not be necessary.

2. Owing to the above uncertainty as to the exact nature of the adsorption process, EFED elected to use the published organic carbon fraction. This results in a higher sorption coefficient for plant surfaces and a corresponding lower modeled dew concentration of pesticide and so minimizes conservative bias in the model.

<u>Metabolism Differences Among Bird Species</u>

The exposure assessment model assigns a fixed estimate of ChemX clearance rate to every bird species evaluated. This rate is based on metabolism data for ChemX dosing in domesticated chickens. It is possible that other birds will exhibit different metabolic clearance rates for ChemX. Smaller birds, the subjects of much of this risk assessment, are likely to have overall higher metabolic rates than chickens. It is possible that ChemX clearance rates may be higher than those assumed in this risk assessment. If this is the case, higher clearance rates would mean less ChemX carryover from one time step to another and peak exposures for most individual birds modeled would be lower, corresponding to lower risks.

<u>Insect Residues are a Result of Pitfall Trap Samples</u>

A large proportion of the insect residue data used to predict ChemX residues in invertebrate prey of birds were the result of pitfall trap sampling efforts in treated plots. The use of pitfall traps has the potential to bias insecticide residues downward. This is because pitfall trapping is only effective on mobile insects. Insects receiving insecticide exposures high enough to immobilize them will not be sampled by pitfall traps. However, there also is uncertainty as to the extent that immobilized insects are a food source for birds.

<u>In-furrow /Banded Treatment Residues on Seeds and Incorporation Effects</u>

The exposure model does not account for incorporation of seeds as a result of in-furrow and banded treatment. In-furrow and banded treatments were assumed to result in ChemX residues on seeds in proportion to the application rate. Unlike risk screening methods employed in EFED, there has been no assumption of the proportion of treated seeds that are incorporated into the soil after the in-furrow or banded treatment. It is assumed that some seeds will remain on the surface and availability is proportional to the uncontaminated areas between rows. Data are not available to address the relative availability between the bands/in-furrow areas and between rows. If planting activities and incorporation make seeds less available, current model predictions may over estimate risk. However, it has also been speculated that disturbed areas can attract some avian species (e.g., horned larks are known to prefer tilled fields, Castrale 1985) which could counter the availability question. If seed availability was assumed to be equivalent between furrow, band and between row areas and birds are assumed to be attracted to the tilled portions of the field, model predications may underestimate risk. Nevertheless EFED did consider the untreated portions of the field and assumed that the seed component of the diet is distributed between furrow or band and the untreated areas in proportion to the fraction of field actually receiving chemical treatment.

SUMMARY AND CONCLUSIONS

Based on the results of this refined assessment, high mortality in avian species will occur following ChemX applications to corn and alfalfa fields from all application rates. Due to the uncertainty introduced into the assessment from the absence of species specific toxicity data, limited quantitative conclusions can be made about specific mortality levels for many focal species. However, based on the species sensitivity distribution of the complex of exposed species, estimates of the number of species being impacted and the magnitude and probability of these effects can be made.

For the aerial application to corn at .25 lbs ai/A, the lowest labeled use rate, 70 percent of the species have mortality greater than 0 percent on average. Approximately 35 percent of the species have at least 10 percent mortality on average and 10 percent of the species have 70 percent mortality or greater with a maximum of 86 percent. For corn at .75 lbs ai/A, the typical application rate, a higher percentage of species are experiencing mortality and on average higher levels of mortality. Eighty-five percent of the species have mortality of greater than 0 percent on average. Approximately 65 percent of the species have at least 10 percent mortality on average and 15 percent of the species have 70 percent mortality or greater with a maximum average mortality of 98 percent. At the highest labeled use rate considered,1 lb ai/A, 95 percent of the species have a mortality greater than 0 percent on average. Approximately 95 percent of the species have at least 10 percent mortality on average and 15 percent of the species have 70 percent mortality or greater with a maximum mean mortality of 98 percent.

For red-winged blackbirds, for which species specific toxicity data are available, the refined assessment indicates that at the lowest application rate there is a 95 percent probability that mortality will be greater than 10 percent, with a mean mortality level of 24 percent, with mortality levels as high as 40 to 50 percent 5 percent of the time. At .75 lbs ai/A, these estimates increase to a 95 percent probability of mortality greater than 40 percent, with a mean mortality level of 57 percent, with mortality levels as high as 75 to 85 percent, 5 percent of the time. At the highest use rate, 1 lb ai/A, there is a 95 percent probability that mortality will be greater than 45 percent, with a mean mortality level of 64 percent, with mortality levels as high as 85 to 95 percent, 5 percent of the time.

For the banded application to corn at 1 lbs ai/A, some what lower mortality levels are predicted than for corn aerial applications. Sixty percent of the species have mortality greater than 0 percent on average. Approximately 33 percent of the species have at least 10 percent mortality on average and with approximately 1 percent of the species exhibiting 70 percent mortality or greater. The maximum mean mortality for the most sensitive species is estimated to be 86 percent.

For in-furrow application to corn, at 1 lbs ai/A, showed similar results to the banded application results for corn. Seventy percent of the species have mortality greater than 0 percent on average. Approximately 37 percent of the species have at least 10 percent mortality on average and with approximately 1 percent of the species exhibiting 70 percent mortality or greater. The maximum mean mortality for the most sensitive species is estimated to be 86 percent.

For red-winged blackbirds, for which species specific toxicity data are available, the refined assessment indicates that for banded applications to corn there is a 95 percent probability that mortality will be greater than 15 percent, with a mean mortality level of 30 percent, with mortality levels as high as 45 to 60 percent, 5 percent of the time. For, in-furrow applications, at 1 lb ai/A, to corn there is a 95 percent probability that mortality will be greater than 15 percent for the red-winged blackbird, with a mean mortality level of 30 percent. Five percent of the time, mortality levels are predicted to range from 50 to 60 percent.

For the aerial application to alfalfa at .125 lbs ai/A, the lowest labeled use rate, 55 percent of the species have mortality greater than 0 percent on average. Approximately 27 percent of the species have at least 10 percent mortality on average and mortality was never greater than 50 percent on average. Maximum average mortality predicted was 48 percent. For alfalfa at .5 lbs ai/A, the typical application rate, a higher percentage of species are experiencing mortality and on average higher levels of mortality. Seventy percent of the species have mortality of greater than 0 percent on average. Approximately 57 percent of the species have at least 10 percent mortality on average and 17 percent of the species have 70 percent mortality or greater with a maximum of 88 percent. At the highest labeled use rate considered,1 lb ai/A, 95 percent of the species have a mortality greater than 0 percent on average. Approximately 62 percent of the species have at least 10 percent mortality on average and 23 percent of the species having 70 percent mortality or greater with a maximum of 93 percent.

Also for alfalfa, under a modified model that investigated the level of mortality, if a cohort of waterfowl were to feed in a recently treated field, indicated that immediately after application at the lowest application rate, there is a 95 percent probability that mortality would be grater than 65 percent, with a mean of 82 percent. At typical rates, .5 lbs ai/A, there is a 95 percent probability that mortality will be greater than 95 percent, with a mean of 99 percent. At the highest use rate, 1 lbs ai/A, the model predicted 100 percent mortality. Up to 12 days after treatment, residues in alfalfa fields were still at levels toxic to waterfowl. At the lowest application rate,12 days after application, mean predicted mortality was 3 percent, and at the two higher rates average mortality were 28 and 54 percent, respectively.

Based on these results EFED concludes that potentially high mortality in at least some avian species was predicted in all scenarios modeled, but the relative risks of some application methods and application rates can be differentiated. Banded and in-furrow applications of ChemX to corn are predicted to result in lower levels of mortality to more species than aerial application of ChemX to corn. However, even with these banded and in-furrow applications, some species are still experiencing severe impacts, although less than the predicted impacts for aerial applications. For both corn and alfalfa aerial applications, lower rates of application result in lower predicted levels of mortality for more species. For the special case of waterfowl stochastic use of treated alfalfa fields, modeling shows that there is a high probability of high levels of mortality in waterfowl if a single feeding event occurred within a week following an application at all labeled rates and for at least two weeks for the higher labeled use rates. For waterfowl under the scenario modeled, labeled application rate is not as important as the lag time between application of the pesticide and use of the treated field by waterfowl. Reductions in predicted mortality are directly related to protracted time periods between application and waterfowl presence. However, considering the predicted risks, residue reductions are of insufficient magnitude over a two week period following application to preclude concern for waterfowl mortality.

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