# Preliminary Report on the Potential Ecological Risks from Paraquat Exposure

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**California Department of Pesticide Regulation**

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## Executive Summary

In November 2022, as a part of the annual pesticide registration renewal cycle the Center for Biological Diversity (CBD) submitted a letter of concern regarding the continued registration of paraquat products, citing significant adverse impacts to human health and the environment from use of these products. The submission included 80 citations, 19 of which were related to ecological risk. In November 2023, an additional 25 studies related to human health were submitted for additional consideration. The Department of Pesticide Regulation (DPR) Ecotoxicology Program (Ecotox) reviewed the submitted citations relevant to ecological concern, as well as the data on file with DPR, and found that paraquat may adversely affect non-target organisms, particularly birds, mammals, and sediment-dwelling aquatic (benthic) organisms. Ecotox used the U.S. EPA risk assessment models Pesticide in Water Calculator (PWC, v. 2.001) to assess risks to aquatic organisms, Terrestrial Residue Exposure model (TREX, v. 1.5.2) to assess risks to terrestrial vertebrates, and Bee Residue Exposure model (BeeREX, v. 1.0) to assess the risks to bees and other pollinators. Ecotox used these models combined with the currently registered labels and data on file to assess the risks to non-target organisms from the highest registered application rates of paraquat products, according to program standard modelling practices. Additional scenarios were modeled for terrestrial vertebrates, representing various registered uses, to further refine the risk assessment. The highest risk quotients (RQs) identified for each taxa are summarized in Table 1, below, along with the relevant Level of Concern (LOC) threshold. Full modelling results are presented in Appendix I. The magnitude of risk for birds and mammals is higher than that for benthic organisms and is the primary concern. These risks are present for all but one currently-registered use. The only use that did not result in significant risks to non-target organisms was a single, low-application rate application as a cotton defoliant.

**Table 1. Highest risk quotients identified for each taxa from registered uses of paraquat.**

| Taxa | Highest RQ | Relevant LOC |
|---|---|---|
| Mammals | 80.43 (chronic) | 1.0 |
| Birds | 54.63 (acute) | 0.5 |
| Fish | <0.01 (acute and chronic) | 0.5/1.0 |
| Aquatic invertebrates | 1.35 (acute and chronic) | 0.5/1.0 |
| Bees and pollinators | 0.42 (acute)* | 0.4 |

* Chronic and larval data not available

**Background:**

The herbicide paraquat dichloride is a California restricted material intended for control of broadleaf weeds on agricultural, forestry, residential, commercial, and nursery use sites. This fast-acting contact herbicide suppresses or eradicates a wide spectrum of post-emergent weeds and is quickly absorbed by living plant tissue (U.S. EPA, 2019). It is generally applied as a flowable solution and readily dissociates into its cation, paraquat. Paraquat dichloride (hereafter referred to as paraquat) is currently registered for use in California on a wide variety of agricultural and non-agricultural use sites. It is primarily applied in the Central Valley and in 2018 was one of the top five herbicides applied in California (DPR, 2020). However, use has declined significantly in recent years from 1,301,935 lbs and 1,240,012 acres in 2018 to 426,104 lbs and 399,445 acres in 2021 (DPR, 2023).

Seven paraquat products are currently registered for use in California. All seven have comparable uses, application rates, and restrictions. All registered products are listed as Restricted Use Pesticides and must only be used by certified applicators. They also have comparable environmental risk profiles. The products are:

- Devour
- Drexel Quick-Quat
- Gramoxone SL 3.0
- Helmquat 3SL
- Para-Shot 3.0
- Paraquat Concentrate
  Willowwood Paraquat 3SL

Review of Data Submitted by the Center for Biological Diversity

The references cited in the CBD letter relevant to ecological concerns include the United States Environmental Protection Agency (U.S. EPA) ecological risk assessments for paraquat, public literature regarding toxicity of paraquat, an amphibian population monitoring report, and information about species ranges of endangered or threatened species that may be exposed to paraquat. The citations provided do not include new acute or chronic exposure studies for quantitative risk assessment but provide context and serve as weight of evidence for ecological risks from paraquat use in California. The following is a review of the references cited in the CBD letter relevant to ecological concern.

The CBD letter cites Badroo et. al. (2020) which examines the effects of paraquat exposure on the histology of vital organs of the freshwater fish *Channa punctatus*. The study found a number of adverse effects to the gills, liver, and kidney of exposed fish. These sublethal effects may contribute to the overall health of fish species exposed to paraquat, but the link between the observed histological effects and the claim in the letter that such effects are a serious threat to fish populations is somewhat unclear. The concentration tested is not necessarily a field realistic

dose that fish may be exposed to in the wild. In the study, fish were exposed to paraquat at a concentration of 32.93 mg/L for 96 hours. This is significantly higher than the expected environmental concentrations determined by modelling of 4.264 µg/L (Appendix I, Table 5). Monitoring data in California dating back to 2005 from DPR Surface Water Protection Program (2024) shows the highest detected concentration of paraquat as 3.6 µg/L. Based on both modelling and monitoring data, the effects listed in this study would not be expected in the field.

The CBD letter includes a reference to a report on the population status of several amphibian species, including the California red-legged tree frog in the Monterey Peninsula Regional Parks District (Anderson, 2016). The report recommends against applying herbicides such as paraquat to these habitats due to reduced larval survival and growth rates for these species. Further review of the cited studies in the report may be required to determine whether there is evidence supporting that registered uses of paraquat cause these effects to amphibian species.

The CBD letter states that several endangered or threatened species may be impacted by the currently registered applications of paraquat, citing references providing species ranges of endangered or threatened species. These species include birds, mammals, amphibians, fish, and aquatic and terrestrial invertebrates. According to the referenced species range information (California Department of Fish and Game, 1994; Cornell Lab of Ornithology. n.d.-a-b; NOAA, 2024a-b; U.S. EPA, 2009; U.S. FWS 2005; U.S. FWS (2010); U.S. FWS n.d.-a-h), the species identified have ranges in California that may overlap with areas where paraquat is applied, such as counties with significant agricultural industry such as Kern County. While the ranges overlap with areas of paraquat applications, the citations do not provide actual exposure data and it is unclear and speculative whether these species have been or are currently being exposed to paraquat at levels significant enough to cause harm. The information in the letter and the sources for the citations do not provide sufficient evidence to conclude that threatened or endangered species are harmed by applications of paraquat.

The CBD letter cites U.S. EPA (2019) which identifies potential risks to several taxa from currently registered uses. Toxicity data and application rates used for this assessment are comparable to those on file with DPR and are representative of paraquat use in California. U.S. EPA (2019) modelling results include several scenarios representing the registered use patterns for paraquat products. Taxa with significant risks identified included mammals, birds, reptiles, terrestrial-phase amphibians, bees, and benthic aquatic organisms. Risk quotients ranged from negligible (<0.01) to several times the Level of Concern (LOC), depending on taxa and application rate, though all registered use patterns had at least one LOC exceedance for birds and mammals. Modelling results indicate potential risks to non-target organisms from the currently registered uses of paraquat. In addition to quantitative modelling, U.S. EPA (2019) includes a survey of reported incidents in which non-target organisms may have been adversely affected by the application of paraquat products. The reported incidents include those involving birds, mammals (dogs), and fish. Four fish kill incidents have been reported and linked to paraquat, despite the low risks identified for aquatic organisms, possibly due to aquatic plant die-offs.

U.S. EPA (2019) also identifies data gaps for bees/terrestrial invertebrates including larval toxicity and chronic adult toxicity, that prevent quantifying risks beyond acute contact and oral

exposure. Additional higher tier honey bee toxicity studies may be required to fully assess risks to honey bees.

Ecotoxicology's modeling, summarized below, concurs with the U.S. EPA (2019). The ecological risk assessment accurately captures the general use patterns of paraquat, including those registered for use in California. There are significant risks, particularly for birds and small mammals, even from a single application at the highest rate for most agricultural uses (1.0 lbs/A), as well as from a single application at a reduced rate (0.5 lbs/A).

**Environmental Risks:**

According to the data on file, paraquat is moderately toxic to birds and mammals; practically non-toxic to slightly toxic to fish; moderately to highly toxic to aquatic invertebrates; and moderately toxic to honey bees on an acute exposure basis (Table 1). Chronic reproductive toxicity endpoints for mallard duck and bobwhite quail indicate that birds may be adversely affected from repeated exposure. There are no acute data on file for sediment dwelling organisms or chronic data for any aquatic organism on file with DPR. Sediment and chronic aquatic toxicity endpoints from U.S. EPA, 2019 were used in modelling for the purposes of this assessment. DPR does not have honey bee data on file for oral exposure to adult bees, acute exposure for larval bees, and chronic data for adult and larvae, so a full assessment of risks to bees could not be conducted.

**Table 2: Paraquat Dichloride Fish and Wildlife Toxicity Values. * Indicates Endpoints Used in Modelling.**

| Test Animal | Type of Study | Toxicity Value | Descriptive Toxicity |
|---|---|---|---|
| Rat | Acute Oral Toxicity | $LD_{50}$ (male) = 189 mg/kg<br>$LD_{50}$ (female) = 125 mg/kg | Moderately toxic |
| Rat [1] | Acute Oral Toxicity | $LD_{50}$ (female) = 93 mg/kg* | Moderately toxic |
| Rat [1] | Chronic Toxicity | NOEL = 7.5 mg/ kg-bw/day* | N/A |
| Mallard | Acute Oral Toxicity | $LD_{50}$ = 199 mg ai/kg | Moderately toxic |
| Zebra finch | Acute Oral Toxicity | $LD_{50}$ = 26.5 mg ai/kg* | Highly Toxic |
| Bobwhite quail | Acute Oral Toxicity | $LD_{50}$ = 176 mg ai/kg | Moderately toxic |
| Mallard | Dietary Toxicity | $LC_{50}$ = 4048 ppm ai | N/A |
| Bobwhite quail | Dietary Toxicity | $LC_{50}$ = 948 ppm ai* | N/A |
| Bobwhite quail | Dietary Toxicity | $LC_{50}$ = 981 ppm ai | N/A |
| Mallard | Reproductive toxicity | NOEC = 29.4 ppm* | N/A |
| Bobwhite quail | Reproductive toxicity | NOEC = 100 ppm | N/A |
| Bluegill sunfish | Acute toxicity | $LC_{50}$ = 156 ppm<br>(cation = 13 ppm) | Practically non-toxic |
| Rainbow trout | Acute Toxicity | $LC_{50}$ = 38 ppm*<br>(cation = 15 ppm) | Slightly toxic |
| Fathead Minnow (*P. promelas*) [1] | Chronic Toxicity | NOAEC = 740 µg ai/L* | N/A |
| Daphnia magna | Acute Toxicity | $LC_{50}$ > 2.51 ppm | Moderately toxic |
| Daphnia magna [2] | Acute Toxicity | $LC_{50}$ = 1.22 ppm | Moderately toxic |
| Daphnia magna [2] | Acute Toxicity | $EC_{50}$ = 8.0 mg ai cation/L [3] | Moderately toxic |
| Daphnia pulex [2] | Acute Toxicity | $EC_{50}$ = 4.0 mg ai cation/L [3] | Moderately toxic |
| Mysid shrimp [3] | Acute Toxicity | $LC_{50}$ = 0.31 mg ai/L*<br>(0.23 mg cation/L)<br>NOEC = 0.07 mg ai/L<br>(0.05 mg cation/L) | Highly toxic |
| Mysid shrimp [1] | Chronic Toxicity | NOEC = 38 µg ai/L* | N/A |
| Freshwater Amphipod (*Hyalella azteca*) [1] | 10-day Sediment Toxicity | NOAEC = 30 mg cation/kg-dw* | N/A |

| Test Animal | Type of Study | Toxicity Value | Descriptive Toxicity |
|---|---|---|---|
| Honey bee | Acute Contact Toxicity | LD50 = 6.4 µg ai/bee* | Moderately toxic |

N/A = not available (there are no descriptive toxicity categories for chronic toxicity tests)
Toxicity Values expressed as:
LD50 = Lethal dose that kills 50% of the test population
LC50 = Lethal concentration that kills 50% of the test population
EC50 = Concentration of a toxicant causing a defined non-lethal effect in 50% of the test population
NOEL = No observed effect level
NOEC = No observed effect concentration
[1] U.S. EPA Paraquat: Preliminary Ecological Risk Assessment for Registration Review. Dated: June 26, 2019.
[2] U.S. EPA Reregistration Eligibility Decision: Paraquat Dichloride. Dated August 1997; EPA 738-F-96-018
[3] DPR Ecotoxicology Evaluation Report. Track ID No. 264348-EA. Dated: February 7, 2019.

Data on file with DPR indicate that paraquat is highly persistent in the environment (DPR, 2024b). Paraquat is highly soluble with a solubility value of 62600 mg/L at 20 °C and stable to hydrolysis with a half-life of greater than 30 days at pH7 and 25 °C. It has a strong affinity for soil and is expected to bind highly to soil and sediment with a $K_d$ value of 10000 in loamy sand. Soil photolysis half-life ranges from 4140-5890 days. The aerobic and anaerobic soil metabolism half-lives are 620 and 644 days, respectively. The field dissipation half-life for paraquat ranges from 285 days to 1720 days.

Aquatic organisms may be exposed to paraquat products from off-site transport via drift or runoff to aquatic ecosystems. The registered products allow for aerial applications for many agricultural use-sites which has a higher potential for spray drift. Registered labels include restrictions and warnings intended to reduce spray drift, particularly from aerial applications, including, nozzle size, wind speed, and boom height. To assess the risks to aquatic organisms quantitatively, DPR reviewers used the U.S. EPA Pesticide in Water Calculator (PWC, v. 2.001) model. Estimated environmental concentrations (EEC) in aquatic ecosystems (Appendix I) were calculated form data on file and directions for use on currently registered product labels. Several scenarios were modeled to represent the variety of registered uses. The majority of agricultural use sites with the highest application rates all resulted in comparable EECs. Non-agricultural uses on the labels, including around commercial buildings, electric transformer stations, fence lines, pipeline pumping stations, public airports, storage yards and other installations, have the same maximum single application rate (1.0 lbs ai/A) but allow for more applications per year, up to 10 lbs ai/A. However, these uses are made by ground broadcast or spot treatment rather than aerial application and did not result in a significant increase to chronic exposure. The use scenario of 5 aerial applications resulted in the highest EECs of the scenarios tested. The “Small fruit trellised” scenario, representing registered use on grapes, resulted in the highest RQs and are presented here and in Appendix I. Other crop scenarios with the same application rate were modeled but resulted in lower, but comparable RQs. Based on the calculated EECs, the resulting risk quotients (RQ) for fish and water column invertebrates were below the level of concern (LOC) of 0.5 and 1.0 for acute and chronic risks (EPA, 2024), respectively. Fish and aquatic invertebrates in the water column are not expected to be adversely affected by applications of paraquat products when used in compliance with the currently registered labels. Due to the high

affinity for sediments and high stability in these environments, the EECs for sediments were significant and remained high throughout the simulation. The resulting RQs for benthic invertebrates exceeded the LOC for both acute (RQ =1.35) and chronic (RQ =1.35) exposure. The magnitude of this exceedance indicates applications of paraquat at the highest rates may result in some risks to benthic organisms. Sediment-dwelling invertebrates may be adversely affected by applications of paraquat.

Honey bees and other pollinators may be exposed to paraquat directly if foraging in the field during applications, or indirectly by consuming contaminated nectar and pollen. The currently registered labels include crops that are attractive to bees and other pollinators such as, citrus, brassica vegetables, and tree nuts (USDA, 2017). To assess the risks to bees from being exposed directly to paraquat, DPR reviewers used the U.S. EPA Bee Residue Exposure model (BeeREX, v. 1.0) using the maximum single application rate on the currently registered labels and the toxicity data on file (Appendix I). The resulting RQ (RQ = 0.42) for contact exposure was slightly above the LOC of 0.4 (EPA, 2014), indicating some potential risk to bees from contact exposure. The model is intended to be a conservative screening level assessment and risks may be lower in a field realistic scenario. RQs could not be calculated for acute or chronic dietary exposure due to the lack of toxicity data available. Paraquat is not systemic and is not expected to be transported from the soil to pollen or nectar, significantly reducing the amount of paraquat available to bees from dietary exposure. Paraquat may still be present in nectar and pollen but limited to the amount deposited directly from applications. Chronic risks and risks to larvae could not be determined due to lack of data available. The currently available data does not indicate that bees will be adversely affected via contact exposure to paraquat applications, however, additional data is needed to fully evaluate the risks to bees and other pollinators.

Birds and mammals may be exposed to paraquat from foraging in treated areas and consuming contaminated food items. To assess the risks to birds and mammals quantitatively, DPR reviewers used the U.S. EPA Terrestrial Residue Exposure model (TREX, v. 1.52) using the toxicity data on file and the highest application rates on the currently registered labels (Appendix I). Due to the lack of foliar degradation data on file, the default half-life of 35 days was used. However, based on other environmental fate data paraquat may be more stable in the environment, resulting in s potential underestimate of risk. DPR reviewers modeled several scenarios of currently registered uses. The highest application rate (10 applications of 1 lb ai/A) resulted in RQs that exceeded the acute (highest RQ = 54.63) and chronic (highest RQ = 47.30) LOCs of 0.5 and 1.0, respectively, for birds and mammals (Appendix I). Applications made at this rate are likely to result in risks to birds and mammals. The lower end of the range of single application rates for most agricultural use sites is 0.25 lbs paraquat/A and modelling with this rate indicated potential for significant risks to birds and mammals (highest acute RQ = 9.47, highest chronic RQ = 2.04). The overall lowest single application rate registered in California is 0.0456 lbs paraquat/A for pre-harvest use on cotton. A single application at this rate resulted in no RQs that exceeded the acute or chronic LOCs, indicating no significant risks. However, the currently registered labels allow for up to three applications per year for this use pattern; this resulted in acute RQs that exceeded the acute LOC for birds (RQ = 1.18) and chronic RQs that exceeded the chronic LOC for mammals (RQ = 1.66), indicating the potential for some risks to

birds and mammals from applications at this rate. The majority of currently registered uses of paraquat may adversely affect birds and mammals (see Table 3, below).

**Table 3. Summary of risk quotients for birds and mammals from registered uses of paraquat.**

| Scenario | Highest Acute RQ | Highest Chronic RQ |
|---|---|---|
| 1.0 lbs ai/A x 10 applications (Non-crop uses, maximum applications) | 54.63 (avian) | 80.43 (mammal) |
| 1.0 lbs ai/A (General ag crop maximum single application rate) | 9.81 (avian) | 13.88 (mammal) |
| 0.25 lbs ai/A (General ag crop minimum application rate, single application) | 9.47 (avian) | 3.47 (mammal) |
| 0.25 lbs ai/A x 5 applications (General ag crop minimum application rate, multiple applications) | 9.47 (avian) | 13.48 (mammal) |
| 0.0456 lbs ai/A x 3 applications (Lowest registered application rate, multiple applications) | 1.18 (avian) | 1.66 (mammal) |
| 0.0456 lbs ai/A (cotton harvest aid/defoliant use, single application) | 0.45 (avian) | 0.63 (mammal) |

## Conclusions:

The currently registered uses of paraquat may adversely affect non-target organisms, particularly birds, mammals, and sediment-dwelling aquatic organisms. The magnitude of risk for birds and mammals is higher than that for benthic organisms and is the primary concern. These risks are present for the majority of registered uses. A single application at the lowest application rate for use as cotton defoliant did not result in significant risks to non-target organisms. While reducing application rates for other uses may sufficiently mitigate the risks to non-target organisms, they may not be efficacious. Additional mitigation measures, while technically possible, may not be feasible for birds and mammals due to the nature of the exposure pathway. Mitigation would need to be centered on preventing birds or mammals from foraging on treated fields. Due to the environmental persistence of paraquat, the time-frame for exclusion would need to be significant.

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## Appendix I: Model Inputs and Outputs

**Table 1. Summary of PWC Model Inputs for paraquat**

| | |
|---|---|
| Scenario | 461871-17246-69_Small fruit trellised-r18-C |
| Cropped Area Fraction | 1 |
| Koc (ml/g) | 10000 |
| Water Half-Life (days) @ 20 °C | 0 |
| Benthic Half-Life (days) @ 20 °C | 0 |
| Photolysis Half-Life (days) @ 40°Lat | 1970 |
| Hydrolysis Half-Life (days) | 0 |
| Soil Half-Life (days) @ 20 °C | 620 |
| Foliar Half-Life (days) | 30 |
| Molecular Weight | 257.16 |
| Vapor Pressure (torr) | 0.0000001 |
| Solubility (mg/l) | 62600 |
| Henry's Constant | 2.21E-11 |

**Table 2. Application Schedule for paraquat, Maximum Agricultural use rate (1.0 lbs ai/A x 5 applications per year)**

| Day relative to emergence | Type | Amount (kg/ha) | Eff. | Drift |
|---|---|---|---|---|
| 0 | Above Crop (Foliar) | 1.121 | 0.95 | 0.0885 |
| 7 | Above Crop (Foliar) | 1.121 | 0.95 | 0.0885 |
| 14 | Above Crop (Foliar) | 1.121 | 0.95 | 0.0885 |
| 21 | Above Crop (Foliar) | 1.121 | 0.95 | 0.0885 |
| 28 | Above Crop (Foliar) | 1.121 | 0.95 | 0.0885 |

**Table 3. Estimated Environmental Concentrations (ppb) for paraquat based on PWC calculations and Table 2 application schedule.**

| **Water Column Values** | **ppb** |
|---|---|
| 1-day Avg (1-in-10 yr) | 4.874 |
| 4-day Avg (1-in-10 yr) | 4.264 |
| 21-day Avg (1-in-10 yr) | 4.159 |
| 60-day Avg (1-in-10 yr) | 4.106 |
| 365-day Avg (1-in-10 yr) | 4.035 |
| Entire Simulation Mean | 4.264 |
| **Sediment Values** | |
| 1-day Avg (1-in-10 yr) | 4.054 |
| 21-day Avg (1-in-10 yr) | 4.054 |
| **Pore Water Values** | |
| 1-day Avg (1-in-10 yr) | 40540 |
| 21-day Avg (1-in-10 yr) | 40540 |

**Table 4. Risk Quotients resulting from paraquat use to Aquatic Organism using PWC. Red highlights indicate RQ above the level of concern.**

| **Taxa** | **Acute toxic end-point (ppb)** | **Acute RQ** | **Chronic toxic end-point (ppb)** | **Chronic RQ** |
|---|---|---|---|---|
| **Fish** | 38000 | <0.01 | 740 [a] | <0.01 |
| **Water column invertebrate** | 310 | 0.01 | 38 [a] | 0.11 |
| **Benthic invertebrate*** | 30,00 µg cation/kg-dw [a] | 1.35 | 30,000 µg cation/kg-dw [a] | 1.35 |

* RQs presented are for sediment, which resulted in the highest values

[a] U.S. EPA, 2019.

**BeeREX Model Inputs and Outputs:**

**Table 5. User inputs (related to exposure) for BeeREX**

| Description | Value |
|---|---|
| Application rate | 1.0 |
| Units of app rate | lb a.i./A |
| Application method | foliar spray |
| Are empirical residue data available? | no |

**Table 6. Toxicity data**

| Description | Value (µg a.i./bee) |
|---|---|
| Adult contact LD50 | 6.4 |
| Adult oral LD50 | NA |
| Adult oral NOAEL | NA |
| Larval LD50 | NA |
| Larval NOAEL | NA |

**Risk Quotients for honey bees derived using BeeREX. Red highlights indicate RQ above the level of concern**

| Exposure | Adults | Larvae |
|---|---|---|
| Acute contact | 0.421875 | NA |
| Acute dietary | NA | NA |
| Chronic dietary | NA | NA |

**TREX Model Inputs and Outputs:**

**10 applications @ 1 lb ai/A (Highest registered application rate, non-crop uses)**

**Table 8. Model inputs**

| Use | Non-crop uses |
|---|---|
| %AI | 100 |
| Application Rate (lb ai/acre) | 1 |
| Half-life (days) | 35 |
| Application Interval (days) | 7 |
| Number of Applications | 10 |
| Assessing apps with variable rates? (Y/N) | N |
| Avian LD50 value (zebra finch) | 26.5 |
| Avian LC50 value (bobwhite quail) | 948 |
| Avian NOEL value (test species) | NA |
| Avian NOEC value (mallard) | 29.4 |
| Mammalian LD50 value | 93 |
| Mammalian NOEL value | 7.5 |

N/A = Toxicity endpoint not available

**Table 9. Risk quotients for mammals derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Small mammal (15 grams) Acute RQ | Small mammal (15 grams) Chronic RQ | Medium mammal (35 grams) Acute RQ | Medium mammal (35 grams) Chronic RQ | Large mammal (1000 grams) Acute RQ | Large mammal (1000 grams) Chronic RQ |
|---|---|---|---|---|---|---|
| Short Grass | 6.49 | 80.43 | 5.54 | 68.70 | 2.97 | 36.83 |
| Tall Grass | 2.97 | 36.86 | 2.54 | 31.49 | 1.36 | 16.88 |
| Broadleaf plants | 3.65 | 45.24 | 3.12 | 38.64 | 1.67 | 20.71 |
| Fruits/pods | 0.41 | 5.03 | 0.35 | 4.29 | 0.19 | 2.30 |
| Arthropods | 2.54 | 31.50 | 2.17 | 26.91 | 1.16 | 14.42 |
| Seeds | 0.09 | 1.12 | 0.08 | 0.95 | 0.04 | 0.51 |

N/A = Toxicity endpoint not available

**Table 10. Risk quotients for mammals resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Mammal Acute RQ | Mammal Chronic RQ |
|---|---|---|
| Short Grass | N/A | 9.27 |
| Tall Grass | N/A | 4.25 |
| Broadleaf plants | N/A | 5.21 |
| Fruits/pods/seeds | N/A | 0.58 |
| Arthropods | N/A | 3.63 |

N/A = Toxicity endpoint not available

**Table 11. Risk quotients for birds derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Avian Acute RQ (20 grams) | Avian Acute RQ (100 grams) | Avian Acute RQ (1000 grams) |
|---|---|---|---|
| Short Grass | 54.63 | 24.47 | 7.76 |
| Tall Grass | 25.04 | 11.22 | 3.56 |
| Broadleaf plants | 30.73 | 13.77 | 4.36 |
| Fruits/pods | 3.41 | 1.53 | 0.48 |
| Arthropods | 21.40 | 9.59 | 3.04 |
| Seeds | 0.76 | 0.34 | 0.11 |

N/A = Toxicity endpoint not available

**Table 12. Risk quotients for birds resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Avian Acute RQ | Avian Chronic RQ |
|---|---|---|
| Short Grass | 1.47 | 47.30 |
| Tall Grass | 0.67 | 21.68 |
| Broadleaf plants | 0.83 | 26.60 |
| Fruits/pods/seeds | 0.09 | 2.96 |
| Arthropods | 0.57 | 18.52 |

N/A = Toxicity endpoint not available

**1 application @ 1 lb ai/A (general maximum ag use single application rate)**

**Table 13. Model inputs**

| Use | Ag Use, One Application |
|---|---|
| %AI | 100 |
| Application Rate (lb ai/acre) | 1 |
| Half-life (days) | 35 |
| Application Interval (days) | 7 |
| Number of Applications | 1 |
| Assessing apps with variable rates? (Y/N) | N |
| Avian LD50 value (zebra finch) | 26.5 |
| Avian LC50 value (bobwhite quail) | 948 |
| Avian NOEL value (test species) | N/A |
| Avian NOEC value (mallard) | 29.4 |
| Mammalian LD50 value | 93 |
| Mammalian NOEL value | 7.5 |

N/A = Toxicity endpoint not available

**Table 14. Risk quotients for mammals derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Small mammal (15 grams) Acute RQ | Small mammal (15 grams) Chronic RQ | Medium mammal (35 grams) Acute RQ | Medium mammal (35 grams) Chronic RQ | Large mammal (1000 grams) Acute RQ | Large mammal (1000 grams) Chronic RQ |
|---|---|---|---|---|---|---|
| Short Grass | **1.12** | **13.88** | **0.96** | **11.86** | **0.51** | **6.36** |
| Tall Grass | **0.51** | **6.36** | **0.44** | **5.43** | **0.23** | **2.91** |
| Broadleaf plants | **0.63** | **7.81** | **0.54** | **6.67** | **0.29** | **3.58** |
| Fruits/pods | **0.07** | **0.87** | **0.06** | **0.74** | **0.03** | **0.40** |
| Arthropods | **0.44** | **5.44** | **0.37** | **4.64** | **0.20** | **2.49** |
| Seeds | **0.02** | **0.19** | **0.01** | **0.16** | **0.01** | **0.09** |

N/A = Toxicity endpoint not available

**Table 15. Risk quotients for mammals resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Mammal Acute RQ | Mammal Chronic RQ |
|---|---|---|
| Short Grass | N/A | **2.22** |
| Tall Grass | N/A | **1.02** |
| Broadleaf plants | N/A | **1.25** |
| Fruits/pods/seeds | N/A | **0.14** |
| Arthropods | N/A | **0.87** |

N/A = Toxicity endpoint not available

**Table 16. Risk quotients for birds derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Avian Acute RQ (20 grams) | Avian Acute RQ (100 grams) | Avian Acute RQ (1000 grams) |
|---|---|---|---|
| Short Grass | 9.81 | 4.39 | 1.39 |
| Tall Grass | 4.50 | 2.01 | 0.64 |
| Broadleaf plants | 5.52 | 2.47 | 0.78 |
| Fruits/pods | 0.61 | 0.27 | 0.09 |
| Arthropods | 3.84 | 1.72 | 0.55 |
| Seeds | 0.14 | 0.06 | 0.02 |

N/A = Toxicity endpoint not available

**Table 17. Risk quotients for birds resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Avian Acute RQ | Avian Chronic RQ |
|---|---|---|
| Short Grass | 0.25 | 8.16 |
| Tall Grass | 0.12 | 3.74 |
| Broadleaf plants | 0.14 | 4.59 |
| Fruits/pods/seeds | 0.02 | 0.51 |
| Arthropods | 0.10 | 3.20 |

N/A = Toxicity endpoint not available

**1 application @ 0.25 lbs ai/A (general minimum single application rate)**

**Table 18. Model inputs**

| Use | Ag Use, One Application |
|---|---|
| %AI | 100 |
| Application Rate (lb ai/acre) | 0.25 |
| Half-life (days) | 35 |
| Application Interval (days) | 7 |
| Number of Applications | 1 |
| Assessing apps with variable rates? (Y/N) | N |
| Avian LD50 value (zebra finch) | 26.5 |
| Avian LC50 value (bobwhite quail) | 948 |
| Avian NOEL value (test species) | N/A |
| Avian NOEC value (mallard) | 29.4 |
| Mammalian LD50 value | 93 |
| Mammalian NOEL value | 7.5 |

N/A = Toxicity endpoint not available

**Table 19. Risk quotients for mammals derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Small mammal (15 grams) Acute RQ | Small mammal (15 grams) Chronic RQ | Medium mammal (35 grams) Acute RQ | Medium mammal (35 grams) Chronic RQ | Large mammal (1000 grams) Acute RQ | Large mammal (1000 grams) Chronic RQ |
|---|---|---|---|---|---|---|
| Short Grass | **0.28** | **3.47** | **0.24** | **2.96** | **0.13** | **1.59** |
| Tall Grass | **0.13** | **1.59** | **0.11** | **1.36** | **0.06** | **0.73** |
| Broadleaf plants | **0.16** | **1.95** | **0.13** | **1.67** | **0.07** | **0.89** |
| Fruits/pods | **0.02** | **0.22** | **0.01** | **0.19** | **0.01** | **0.10** |
| Arthropods | **0.11** | **1.36** | **0.09** | **1.16** | **0.05** | **0.62** |
| Seeds | **0.00** | **0.05** | **0.00** | **0.04** | **0.00** | **0.02** |

N/A = Toxicity endpoint not available

**Table 20. Risk quotients for mammals resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Mammal Acute RQ | Mammal Chronic RQ |
|---|---|---|
| Short Grass | N/A | **0.56** |
| Tall Grass | N/A | **0.25** |
| Broadleaf plants | N/A | **0.31** |
| Fruits/pods/seeds | N/A | **0.03** |
| Arthropods | N/A | **0.22** |

N/A = Toxicity endpoint not available

**Table 21. Risk quotients for birds derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Avian Acute RQ (20 grams) | Avian Acute RQ (100 grams) | Avian Acute RQ (1000 grams) |
|---|---|---|---|
| Short Grass | **9.47** | **4.24** | **1.34** |
| Tall Grass | **4.34** | **1.94** | **0.62** |
| Broadleaf plants | **5.33** | **2.39** | **0.76** |
| Fruits/pods | **0.59** | **0.27** | **0.08** |
| Arthropods | **3.71** | **1.66** | **0.53** |
| Seeds | **0.13** | **0.06** | **0.02** |

N/A = Toxicity endpoint not available

**Table 22. Risk quotients for birds resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Avian Acute RQ | Avian Chronic RQ |
|---|---|---|
| Short Grass | **0.06** | **2.04** |
| Tall Grass | **0.03** | **0.94** |
| Broadleaf plants | **0.04** | **1.15** |
| Fruits/pods/seeds | **0.00** | **0.13** |
| Arthropods | **0.02** | **0.80** |

N/A = Toxicity endpoint not available

**5 applications @ 0.25 lbs ai/A (ag use multiple applications)**

**Table 23. Model inputs**

| Use | Ag Use, Multiple Applications |
|---|---|
| %AI | 100 |
| Application Rate (lb ai/acre) | 0.25 |
| Half-life (days) | 35 |
| Application Interval (days) | 7 |
| Number of Applications | 5 |
| Assessing apps with variable rates? (Y/N) | N |
| Avian LD50 value (zebra finch) | 26.5 |
| Avian LC50 value (bobwhite quail) | 698 |
| Avian NOEL value (test species) | N/A |
| Avian NOEC value (mallard) | 29.4 |
| Mammalian LD50 value | 93 |
| Mammalian NOEL value | 7.5 |

N/A = Toxicity endpoint not available

**Table 24. Risk quotients for mammals derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Small mammal (15 grams) Acute RQ | Small mammal (15 grams) Chronic RQ | Medium mammal (35 grams) Acute RQ | Medium mammal (35 grams) Chronic RQ | Large mammal (1000 grams) Acute RQ | Large mammal (1000 grams) Chronic RQ |
|---|---|---|---|---|---|---|
| Short Grass | **1.08** | **13.40** | **0.92** | **11.45** | **0.49** | **6.14** |
| Tall Grass | **0.50** | **6.14** | **0.42** | **5.25** | **0.23** | **2.81** |
| Broadleaf plants | **0.61** | **7.54** | **0.52** | **6.44** | **0.28** | **3.45** |
| Fruits/pods | **0.07** | **0.84** | **0.06** | **0.72** | **0.03** | **0.38** |
| Arthropods | **0.42** | **5.25** | **0.36** | **4.48** | **0.19** | **2.40** |
| Seeds | **0.02** | **0.19** | **0.01** | **0.16** | **0.01** | **0.09** |

N/A = Toxicity endpoint not available

**Table 25. Risk quotients for mammals resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Mammal Acute RQ | Mammal Chronic RQ |
|---|---|---|
| Short Grass | N/A | **2.15** |
| Tall Grass | N/A | **0.98** |
| Broadleaf plants | N/A | **1.21** |
| Fruits/pods/seeds | N/A | **0.13** |
| Arthropods | N/A | **0.84** |

N/A = Toxicity endpoint not available

**Table 26. Risk quotients for birds derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Avian Acute RQ (20 grams) | Avian Acute RQ (100 grams) | Avian Acute RQ (1000 grams) |
|---|---|---|---|
| Short Grass | 9.47 | 4.24 | 1.34 |
| Tall Grass | 4.34 | 1.94 | 0.62 |
| Broadleaf plants | 5.33 | 2.39 | 0.76 |
| Fruits/pods | 0.59 | 0.27 | 0.08 |
| Arthropods | 3.71 | 1.66 | 0.53 |
| Seeds | 0.13 | 0.06 | 0.02 |

N/A = Toxicity endpoint not available

**Table 27. Risk quotients for birds resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Avian Acute RQ | Avian Chronic RQ |
|---|---|---|
| Short Grass | 0.33 | 7.88 |
| Tall Grass | 0.15 | 3.61 |
| Broadleaf plants | 0.19 | 4.43 |
| Fruits/pods/seeds | 0.02 | 0.49 |
| Arthropods | 0.13 | 3.09 |

N/A = Toxicity endpoint not available

**1 application @ 0.0456 lbs ai/A (lowest registered rate, cotton harvest aid: defoliation and boll opening)**

**Table 28. Model inputs**

| Use | cotton harvest aid: defoliation and boll opening, single use |
|---|---|
| %AI | 100 |
| Application Rate (lb ai/acre) | 0.0456 |
| Half-life (days) | 35 |
| Application Interval (days) | 7 |
| Number of Applications | 1 |
| Assessing apps with variable rates? (Y/N) | N |
| Avian LD50 value (zebra finch) | 26.5 |
| Avian LC50 value (bobwhite quail) | 698 |
| Avian NOEL value (test species) | N/A |
| Avian NOEC value (mallard) | 29.4 |
| Mammalian LD50 value | 93 |
| Mammalian NOEL value | 7.5 |

N/A = Toxicity endpoint not available

**Table 29. Risk quotients for mammals derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Small mammal (15 grams) Acute RQ | Small mammal (15 grams) Chronic RQ | Medium mammal (35 grams) Acute RQ | Medium mammal (35 grams) Chronic RQ | Large mammal (1000 grams) Acute RQ | Large mammal (1000 grams) Chronic RQ |
|---|---|---|---|---|---|---|
| Short Grass | **0.05** | **0.63** | **0.04** | **0.54** | **0.02** | **0.29** |
| Tall Grass | **0.02** | **0.29** | **0.02** | **0.25** | **0.01** | **0.13** |
| Broadleaf plants | **0.03** | **0.36** | **0.02** | **0.30** | **0.01** | **0.16** |
| Fruits/pods | **0.00** | **0.04** | **0.00** | **0.03** | **0.00** | **0.02** |
| Arthropods | **0.02** | **0.25** | **0.02** | **0.21** | **0.01** | **0.11** |
| Seeds | **0.00** | **0.01** | **0.00** | **0.01** | **0.00** | **0.00** |

N/A = Toxicity endpoint not available

**Table 30. Risk quotients for mammals resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Mammal Acute RQ | Mammal Chronic RQ |
|---|---|---|
| Short Grass | N/A | **0.10** |
| Tall Grass | N/A | **0.05** |
| Broadleaf plants | N/A | **0.06** |
| Fruits/pods/seeds | N/A | **0.01** |
| Arthropods | N/A | **0.04** |

N/A = Toxicity endpoint not available

**Table 31. Risk quotients for birds derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Avian Acute RQ (20 grams) | Avian Acute RQ (100 grams) | Avian Acute RQ (1000 grams) |
|---|---|---|---|
| Short Grass | **0.45** | **0.20** | **0.06** |
| Tall Grass | **0.20** | **0.09** | **0.03** |
| Broadleaf plants | **0.25** | **0.11** | **0.04** |
| Fruits/pods | **0.03** | **0.01** | **0.00** |
| Arthropods | **0.18** | **0.08** | **0.02** |
| Seeds | **0.01** | **0.00** | **0.00** |

N/A = Toxicity endpoint not available

**Table 32. Risk quotients for birds resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Avian Acute RQ | Avian Chronic RQ |
|---|---|---|
| Short Grass | **0.01** | **0.37** |
| Tall Grass | **0.01** | **0.17** |
| Broadleaf plants | **0.01** | **0.21** |
| Fruits/pods/seeds | **0.00** | **0.02** |
| Arthropods | **0.00** | **0.15** |

N/A = Toxicity endpoint not available

**3 application @ 0.0456 lbs ai/A (lowest registered rate, cotton harvest aid: defoliation and boll opening)**

**Table 33. Model inputs**

| Use | cotton harvest aid: defoliation and boll opening, multiple applications |
|---|---|
| %AI | 100 |
| Application Rate (lb ai/acre) | 0.0456 |
| Half-life (days) | 35 |
| Application Interval (days) | 7 |
| Number of Applications | 3 |
| Assessing apps with variable rates? (Y/N) | N |
| Avian LD50 value (zebra finch) | 26.5 |
| Avian LC50 value (bobwhite quail) | 698 |
| Avian NOEL value (test species) | N/A |
| Avian NOEC value (mallard) | 29.4 |
| Mammalian LD50 value | 93 |
| Mammalian NOEL value | 7.5 |

N/A = Toxicity endpoint not available

**Table 34. Risk quotients for mammals derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Small mammal (15 grams) Acute RQ | Small mammal (15 grams) Chronic RQ | Medium mammal (35 grams) Acute RQ | Medium mammal (35 grams) Chronic RQ | Large mammal (1000 grams) Acute RQ | Large mammal (1000 grams) Chronic RQ |
|---|---|---|---|---|---|---|
| Short Grass | **0.13** | **1.66** | **0.11** | **1.42** | **0.06** | **0.76** |
| Tall Grass | **0.06** | **0.76** | **0.05** | **0.65** | **0.03** | **0.35** |
| Broadleaf plants | **0.08** | **0.94** | **0.06** | **0.80** | **0.03** | **0.43** |
| Fruits/pods | **0.01** | **0.10** | **0.01** | **0.09** | **0.00** | **0.05** |
| Arthropods | **0.05** | **0.65** | **0.04** | **0.56** | **0.02** | **0.30** |
| Seeds | **0.00** | **0.02** | **0.00** | **0.02** | **0.00** | **0.01** |

N/A = Toxicity endpoint not available

**Table 35. Risk quotients for mammals resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Mammal Acute RQ | Mammal Chronic RQ |
|---|---|---|
| Short Grass | N/A | **0.27** |
| Tall Grass | N/A | **0.12** |
| Broadleaf plants | N/A | **0.15** |
| Fruits/pods/seeds | N/A | **0.02** |
| Arthropods | N/A | **0.10** |

N/A = Toxicity endpoint not available

**Table 36. Risk quotients for birds derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dose-based EEC/LD50 or NOEL)**

| Food Item | Avian Acute RQ (20 grams) | Avian Acute RQ (100 grams) | Avian Acute RQ (1000 grams) |
|---|---|---|---|
| Short Grass | **1.18** | **0.53** | **0.17** |
| Tall Grass | **0.54** | **0.24** | **0.08** |
| Broadleaf plants | **0.66** | **0.30** | **0.09** |
| Fruits/pods | **0.07** | **0.03** | **0.01** |
| Arthropods | **0.46** | **0.21** | **0.07** |
| Seeds | **0.02** | **0.01** | **0.00** |

N/A = Toxicity endpoint not available

**Table 37. Risk quotients for birds resulting from paraquat use derived using TREX. Red highlights indicate RQ above the level of concern. (RQ = Dietary based EEC/LC50 or NOEL)**

| Food Item | Avian Acute RQ | Avian Chronic RQ |
|---|---|---|
| Short Grass | **0.03** | **0.98** |
| Tall Grass | **0.01** | **0.45** |
| Broadleaf plants | **0.02** | **0.55** |
| Fruits/pods/seeds | **0.00** | **0.06** |
| Arthropods | **0.01** | **0.38** |

N/A = Toxicity endpoint not available